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ADJUDICATIONS STAFF

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of:	)	August 17, 2007
AmerGen Energy Company, LLC	)	
(License Renewal for Oyster Creek Nuclear Generating Station)	)	Docket No. 50-219

AMERGEN ENERGY COMPANY, LLC
REBUTTAL STATEMENT OF POSITION

In accordance with 10 C.F.R. § 2.1207(a)(1) and the Atomic Safety and Licensing Board's ("Board") April 17, 2007 Memorandum and Order,[1] and August 9, 2007 Memorandum and Order,[2] AmerGen Energy Company, LLC ("AmerGen") hereby submits its Rebuttal Statement of Position ("Rebuttal") in response to Citizens'[3] Initial Written Submission. AmerGen's Rebuttal is supported by the attached six-part direct testimony and Exhibits 25 through 36.

This Rebuttal demonstrates that Citizens' arguments ignore reality and are based upon inappropriate technical analyses. Citizens ignore known average thickness measurements. They

[1] (Prehearing Conference Call Summary, Case Management Directives, and Final Scheduling Order) (unpublished).

[2] (Ruling on Motions in Limine and Motion for Clarification)

[3] "Citizens" are: 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.

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instead fabricate their own "representative" data and uncertainty for the internal UT grids. Citizens also ignore the fact that the external single-point UT measurement locations were selected as being the thinnest locations. Citizens argue, rather, that these locations should be considered as if they were selected at random. This is no surprise, as this is what they must do if their "modeling" of the data is to have any technical validity. This modeling is meaningless if the points are biased thin.

Citizens also ignore the fact that the epoxy coating system covering the external drywell shell is exposed to a relatively benign environment. They wrongly suggest that the environment is similar to the inside of an "oil field tubular" which is an environment of corrosive liquid or gas moving under high pressure. Finally, Citizens assume condensation could occur on the exterior drywell shell during operations. The temperature gradient during operations, however, makes condensation physically impossible.

Citizens' arguments, therefore, deserve little consideration and should be given little if any weight.

By negating Citizens' arguments, this Rebuttal demonstrates that Citizens' contention is without merit, and that AmerGen's Aging Management Program ("AMP") for the sand bed region of the Oyster Creek Nuclear Generating Station ("OCNGS") drywell shell provides reasonable assurance that the drywell shell will continue to perform its intended functions throughout the period of extended operation in accordance with the current licensing basis ("CLB") as required by 10 C.F.R. § 54.29(a).

This Rebuttal Statement of Position is organized as follows. Section I below identifies the specific locations in AmerGen's Rebuttal Testimony where AmerGen's experts address the 26 questions and answers in Dr. Hausler's direct testimony. Section II identifies the specific locations in AmerGen's Rebuttal Testimony where its experts respond to the specific questions posed by the Board in its August 9, 2007 Memorandum and Order. Finally, Section III summarizes AmerGen's Rebuttal Testimony in response to Citizens' direct testimony.

I. ROAD MAP TO AMERGEN'S RESPONSES TO DR. HAUSLER'S DIRECT TESTIMONY

Citizens rely solely upon Dr. Hausler to support their case. His testimony consists of 26 questions and answers, supported by three substantive attachments. The first 10 answers and the last answer provide only background and need not be addressed in rebuttal. AmerGen's testimony addressing the remaining answers is as follows. AmerGen's rebuttal testimony also addresses the arguments in the substantive attachments to Dr. Hausler's testimony:

Answer 11: This is Dr. Hausler's overall conclusion. The entirety of AmerGen's testimony refutes this conclusion.

Answer 12: Dr. Hausler opines that 95% confidence is the minimum one should require for the drywell shell. AmerGen addresses this answer throughout Rebuttal, Part 3, where its experts first discuss some general background on statistics and statistical terms (such as "uncertainty," "variability," and "confidence limit"), and then demonstrate that Citizens misapply statistics to both the internal and external UT data.

Answer 13: Dr. Hausler opines that, using a computer contouring program to manipulate the external UT data, there are at least two areas that exceed his version of the local buckling criterion. AmerGen addresses this answer throughout Rebuttal, Part 3, and in particular Section V (A.37 through 52) where its experts demonstrate that Dr. Hausler's statistical treatment of the external UT data is flawed. In addition, Dr. Hausler does not use the local buckling criterion (0.536" in the tray configuration) established in the current licensing basis. Rather, he uses 0.636" without any transition back to 0.736".

Answer 14: Dr. Hausler opines that AmerGen is required to "show that it has 95% confidence that it is meeting the acceptance criteria" and that it cannot show this for the external UT data in Bays 1, 13, and 19 due to "uncertainty attached to each point and the lack of measurements to bound the area." Thus, he concludes AmerGen exceeds the local buckling criterion even if it included a transition to 0.736" (for a total of nine square feet). AmerGen's response to this is the same as for Question 13 (above), because Dr. Hausler relies on flawed statistical treatment of the external UT data.

Answer 15: Dr. Hausler lists five other reasons why AmerGen lacks 95% confidence in the external UT data that the drywell shell meets the acceptance criteria. Each of these reasons, however, is based on the same flawed statistical treatment of the external UT data. Thus, AmerGen's response to this is the same as for Question 13 (above). Dr. Hausler also opines that the uncertainty of the external UT data points is +/- 0.090". AmerGen addresses this claim in Rebuttal, Part 3, Section V (A.47 through 49).

Answer 16: Dr. Hausler provides an overall conclusion that the four-year UT measurement interval is too infrequent. He claims that AmerGen should use: (a) the lower 95% confidence limit for the internal UT grid data, which would result in a bounding margin of 0.034", not 0.064"; (2) a future annual corrosion rate of 0.039" for the exterior and 0.002" for the interior; and (3) an alleged "industry standard" of measuring at half the interval in which it is possible to have lost margin. AmerGen addresses this answer in Rebuttal, where its experts demonstrate that: (a) the ASME Code does not require the use of a 95% confidence limit (Part 3, A.21 and 22); (b) even if AmerGen used that confidence limit, the standard error is an order of magnitude lower than that suggested by Citizens (Part 3, A.24 through 31); (c) the postulated future corrosion rates are not realistic (Part 6); and (d) there is no such industry standard (Part 1).

Answer 17: Dr. Hausler opines about the potential sources of water that could come into contact with the exterior drywell shell both during refueling outages and during operations. AmerGen addresses these opinions in Rebuttal, Part 4.

Answer 18: Dr. Hausler argues that AmerGen's approach of monitoring the sand bed drains for water is not adequate. AmerGen also addresses this argument in Part 4.

Answer 19: Dr. Hausler opines about the need for continuous UT monitoring. In its August 9 Order, the Board excluded this answer as inadmissible, so no response is required or provided.

Answer 20: Dr. Hausler opines on the importance of using the external UT measurements, and concludes that they are the only data that "allow us to estimate the areas that are corroded beyond acceptance thresholds." AmerGen addresses the first part of this argument in Rebuttal, Part 3, Sections IV and V (A.32 through A.53). In its August 9 Order, the Board excluded the conclusory sentence as inadmissible, so no response is required or provided.

Answer 21: Dr. Hausler presents many reasons why he believes the epoxy coating does not protect the exterior of the shell from further corrosion. For those reasons that relate to performance or inspection of the coating itself, AmerGen's responses are provided in Part 5. For those reasons that relate to the corrosion mechanism and future corrosion rate, AmerGen's responses are provided in Part 6.

Answer 22: Dr. Hausler opines on AmerGen's methods for evaluating current margin, and future changes in margin both to the internal and external surface of the drywell shell in the sand bed region. AmerGen addresses how it evaluated current margin in Rebuttal, Part 3, A.24 through 36. AmerGen addresses the issue of evaluating margin on the exterior in Rebuttal, Part 3, A.37 through 39, and in Part 6. AmerGen addresses the issue of corrosion from the interior in Part 6.

Answer 23: Dr. Hausler opines about AmerGen's evaluation of the external UT data points against the local buckling criterion in the three versions of the 24 Calc. AmerGen responds to this answer in Rebuttal, Part 3, A.50 through 53.

Answer 24: Dr. Hausler opines why he believes the local buckling criterion is not appropriate to evaluate the "long grooves" that he identifies in Bays 1 and 19, and the irregular shape he identifies in Bay 13. He then argues that AmerGen's use of 0.636" (as an administrative limit) rather than the local buckling criterion (0.536" in the tray configuration) is more appropriate. AmerGen responds to the first part of this answer throughout Rebuttal, Part 3, and in particular A.37 through 53. AmerGen believes that the second part of this answer is an impermissible attack on the current licensing basis and, therefore, no responsive testimony is required.

Answer 25: This essentially repeats Dr. Hausler's overall conclusion. The entirety of AmerGen's testimony refutes this conclusion.

II. ROAD MAP TO AMERGEN'S ANSWERS TO THE BOARDS' 12 QUESTIONS

The Board asked 12 questions in its August 9 Order. The answers to those questions can be found in AmerGen's testimony as described below.

1. Define as used in the presented statistical analyses (a) population mean, (b) population variance, (c) sample mean, and (d) sample variance.

AmerGen's answer to this question is provided in Part 3, A.4.

2. Explain the relationship between (a) population mean and sample mean, and (b) population variance and sample variance.

AmerGen's answer to this question is provided in Part 3, A.8.

3. Define confidence as used in the analysis of the thickness data in AmerGen's prefiled Exhibit 20, Calculation No. C-1302-187-E310-041, Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006.

AmerGen's answer to this question is provided in Part 3, A.9.

4. Discuss confidence interval and how the interval relates to the sample and population means and variances.

AmerGen's answer to this question is provided in Part 3, A.10.

5. What is the students t distribution and what is its significance relative to estimation of the mean thickness?

AmerGen's answer to this question is provided in Part 3, A.14.

6. What is the F statistic used in the regression model of corrosion and its significance relative to the corrosion data?

AmerGen's answer to this question is provided in Part 3, A.18.

7. The SER lists ten sources of systematic error (SER at 4-53 to 4-55), but AmerGen's direct testimony does not appear to discuss all ten sources (AmerGen's Prefiled Direct Testimony Part 3, Available Margin at 21-23). Estimates and explanations for the all ten sources should be provided, or, if they are insignificant, it should be so stated.

AmerGen's answer to this question is provided in Part 3, A.6.

8. Explain in greater detail how systematic error is accounted for in estimating the thickness and corrosion rate.

AmerGen's answer to this question is provided in Part 3, A.20.

9. AmerGen's prefiled Exhibit 20 provides a statistical analysis of all the data obtained to date. AmerGen shall provide the Board with a table that summarizes the data contained in this exhibit. The table shall be arranged as follows:

LOCATION	MEAN THICKNESS (DATE) (1992, 1992, 1996, and 2006) for all locations where available)	95% CONFIDENCE INTERVAL

AmerGen's answer to this question is provided in Part 3, A.17 and in the table attached as Applicant's Exhibit 25. Note, however, that AmerGen provides estimates in the table for the 95% confidence interval only for the internal UT grid data, and does so only for the 2006 data because the previous calculations (for 1992, 1994 and 1996) did not estimate these intervals.

Moreover, the 95% "confidence interval" for each sampling event is *not* the best estimate of the uncertainty in the data. That is captured by the standard error, which is an estimate of the uncertainty corrected for multiple sampling events (referred to in the Table as the "Grand

Standard Error"). Accordingly, AmerGen is also supplying the Grand Standard Error for each grid as calculated using the data from the 1992 through the 2006 refueling outages.

10. This Board understands that UT thickness measurements are commonly used to determine pipe wall thickness and plate thickness in other industries (see, e.g., Attachment to Citizens Answer (Selected Papers by Dr. Hausler)). To enhance the Board's general understanding and thereby enable it to make a more informed decision, the parties should discuss other applications of UT thickness measurement and identify the best practices recommended by National Association of Corrosion Engineers or other professional organizations, if any, with particular attention to the determination of the thicknesses of corroded plates and the rate of corrosion. The discussion should include use of mean versus extreme value statistics and the Analysis of Variance used in these cases.

AmerGen's answer to this question is provided in Part 3, A.54.

11. One criterion for issuance of the renewal license is that the Commission must find that there is reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the [current licensing basis] (10 C.F.R. § 54.29(a)). In the NRC Staff's prefiled testimony, it explains that the objective of the GE analyses performed in 1991-1992 was to provide reasonable assurances that the structural integrity of the as-built shell would be maintained under refueling conditions, by showing that the stresses do not exceed ASME Section III Subsection NE limits (NRC Staff Initial Statement at 14).

(a) The parties shall describe in detail how the term reasonable assurance has been defined and applied in the instant case. They shall also explain whether the NRC has a practice or policy for applying the reasonable assurance standard in cases where there are measurements of a particular physical condition that vary over a particular component or system and, therefore, must be statistically interpreted. In particular, the parties shall address whether a mean or average has been traditionally used by the NRC to determine reasonable assurance, and whether a mean or average was used in the instant case. If neither is used, what criteria has been (and, in the instant case, is) actually applied.[4]

AmerGen's answer to this question is provided in Part 3, A.21.

12. It is the Board's understanding that the original GE analysis of the response of the drywell shell to loads that might lead to buckling failure employed a model that broke the shell into "elements of certain discrete sizes and shapes over which physical properties (such as shell

[4] In our July 11 Order, the Board made reference to the 95% confidence level used by AmerGen. The parties should not assume the Board adopted the 95% confidence or use of the lower bound as strict criterion for purposes of defining reasonable assurance. Rather, the reference was made to provide the parties with an illustrative example.

thickness) are averaged. Assuming the Board's understanding is correct (if the Board's understanding is incorrect, the parties should so state):

(a) The parties shall describe the sizes and shapes of those elements.

(b) They shall indicate whether the average properties used in any of those elements would be different if the corrosion pattern had been as described by the contour plots proposed by Dr. Hausler (see Hausler Testimony, Att. 4), and if so, the magnitude of those differences.

(c) They shall indicate the source and sizes of the conservatisms built into the original properties used for those elements and whether any of those conservatisms would be reduced if the elements properties were computed based on the pattern of corrosion indicated by the contour plots rather than those used by AmerGen.

(d) If the elements properties would be affected by the contour of corrosion as depicted by the contour plots, assuming the contour plots presented by Dr Hausler are accurate (and if they are not, so state), how should the existing buckling failure criteria be applied to the indicated extent of sub-threshold area in those bays?

(e) Because Oyster Creek's current licensing basis ("CLB) is based on the GE methodology and explicit elementization of the model for the drywell shell (see Licensing Board Memorandum and Order (Denying Citizens Motion for Leave to Add a Contention) at 3 n.6 (Apr. 10, 2007) (unpublished)), discuss whether consideration of a different modeling or elementization would constitute, under NRC regulations, a challenge to the CLB.

AmerGen's answer to this question is provided in Part 2.

III. SUMMARY OF AMERGEN'S REBUTTAL TESTIMONY

AmerGen's Rebuttal Testimony is comprised of six parts.

A. Part 1 (Background)

In Part 1 of AmerGen's direct testimony, we provided background information on: (1) the key physical characteristics of the OCNGS drywell shell and sand bed region, including its size, shape, location in the OCNGS facility, materials of construction and operating environment; (2) the history of issues associated with corrosion of the external surface of the drywell shell in the sand bed region, including actions taken to prevent further corrosion; and

(3) AmerGen's current docketed commitments to the NRC regarding preventing, monitoring, and controlling any future corrosion of the sand bed region of the drywell shell.

In Citizens' direct testimony, Dr. Hausler argues that the industry standard for UT monitoring "is to measure at half the interval in which it is possible to have lost margin." (Dr. Hausler's A.16).

In rebuttal, AmerGen demonstrates that the industry standard is set by American Society of Mechanical Engineers ("ASME") Code requirements which authorize AmerGen to use engineering evaluations to determine the inspection frequency. Because the evaluations are specific to the component being evaluated and the conditions/environments to which it is exposed, inspection frequency is determined on a case-by-case basis. AmerGen's frequency of every UT measurements every four years is appropriate under the ASME Code. AmerGen's experts on rebuttal for Part are Messrs. Gallagher, O'Rourke, and Polaski.

B. Part 2 (Acceptance Criteria)

In Part 2 of AmerGen's direct testimony, we identified the established acceptance criteria for determining whether the sand bed region of the drywell shell maintains sufficient thickness to meet applicable ASME Code and NRC regulatory requirements, and to perform its intended functions during the extended period of OCNGS operation under a renewed license. These acceptance criteria are part of the CLB.

In Citizens' Statement, they argue that something other than the OCNGS CLB local buckling criterion is appropriate. Citizens Statement at 29-30. This is an impermissible attack on the CLB and, thus, AmerGen is not providing rebuttal testimony in Part 2 to refute it. AmerGen relies on its direct testimony in Part 2 to provide the necessary background for the CLB acceptance criteria.

AmerGen is using Part 2 to respond to Board Question 12 which relates to the GE analyses that were used to derive the acceptance criteria. AmerGen's experts on rebuttal for Part 2 are Messrs. Gallagher, Ouaou, and Dr. Hardayal Mehta.

C. <u>Part 3 (Available Margin)</u>

In Part 3 of AmerGen's direct testimony, we addressed how AmerGen estimates available margin by comparing ultrasonic testing ("UT") data from the sand bed region of the drywell shell to the CLB acceptance criteria. This part of the testimony also identified the available margin of 0.064" and demonstrated why the margin is not smaller.

In Citizens' direct testimony, Dr. Hausler makes a number of inappropriate assumptions and performs a number of inappropriate calculations. For the internal UT grid data, he first asserts that AmerGen does not take into account the lower bound of the 95% confidence interval for the data. *See e.g.* Hausler A.15. He claims that the appropriate statistical evaluation of the internal UT data would result in an available margin of 0.034" rather than 0.064". Hausler A.16. He then asserts that the internal UT data are not representative of the worst areas of corrosion of the drywell shell, and that only the external UT data are representative of the worst areas. *See e.g.* Citizens' Exhibit 12 at 3-4.

As for the external UT data that are collected as single points (106 total points over the ten bays in 2006), Dr. Hausler asserts that these data are representative of the overall thickness of the drywell shell in the sand bed region. *See e.g.* Citizens' Exhibit 13, at 5-6, 9-11. He bases this on his working assumption that the shell between these UT data points should be *assumed* to be the same thickness as these points, despite the fact that the points were selected as the thinnest points in each bay. Citizens Initial Statement at 14 ("the best approach . . . is to regard the external readings as representative, even though they might actually be biased to the thin side by their method of selection"); Citizens' Exhibit 12 at 6 ("I believe that when assessing the extent of severe corrosion, reviewers should assume that the measured points connect unless other measurements show this not to be the case."). He then statistically evaluates these thin data and concludes that there may be areas of the drywell shell that already exceed the buckling acceptance criteria. Citizens Exhibit 13 at 9-11.

In rebuttal, AmerGen demonstrates that: (1) Dr. Hausler's overall conclusions are flawed because he bases them on inappropriate treatment of the UT data and use of the wrong local buckling criterion; (2) Dr. Hausler ignores the averages of the data for the internal UT grid, instead focusing on the lower 95% confidence interval which is not required to meet ASME Code requirements; (3) Dr. Hausler's argument that the internal grid data are not representative of the bounding condition of the drywell shell in the sand bed region is based on calculations that ignore an entire grid of 49 UT data points from Bay 17 which, if included, refute his conclusion; (4) Dr. Hausler cannot statistically reevaluate the external UT data points as "representative" of the entire drywell thickness because there are too few locations, and they are biased toward the thin side; (5) Dr. Hausler improperly applies his own buckling criteria to the single-point UT data from the drywell shell's exterior surface. AmerGen's experts on rebuttal for Part 3 are Messrs. Polaski, Tamburro, McAllister, Abramovici, and Dr. Harlow.

D. <u>Part 4 (Sources of Water)</u>

In Part 4 of AmerGen's direct testimony, we addressed why leakage from the reactor cavity is the only known source of water on the exterior of the drywell shell in the sand bed region, and explained that AmerGen's commitments effectively eliminate the potential for water leakage from the refueling cavity onto the drywell shell exterior when the reactor cavity is filled with water. This part of the testimony also demonstrated that condensation on the exterior of the drywell shell in the sand bed region during normal operations is not credible, that condensation during outages is entirely speculative.

In Citizens' direct testimony, they argue that "it has not been established that the only source of water is the reactor fueling cavity." (Citizens' Statement at 21.) In rebuttal, AmerGen demonstrates that each of Citizens' "supporting" references do not support their conclusions, and that Dr. Hausler's speculation on this topic is based on a fundamental lack of understanding of the facts. AmerGen's experts on rebuttal for Part 4 are Messrs. O'Rourke, Ouaou, and Ray.

E. Part 5 (Epoxy Coating System)

In Part 5 of AmerGen's direct testimony, we addressed the characteristics and excellent condition of the multi-layer epoxy coating system that has covered the exterior of the drywell shell in the sand bed region since the 1992 refueling outage. This part demonstrated that corrosion could not occur beneath the epoxy coating system and remain undetected during the period of extended operation.

In Citizens' direct testimony, Dr. Hausler states, among other things, that it is "not reasonable to assume that visual inspection could detect the early stages of coating failure," and that the "lifespan of the coating has been estimated at anything from ten to twenty years" Hausler, A.21. He also attempts to analogize between defects discovered in the sand bed epoxy *floor* in 2006 and the potential for deterioration of the epoxy coating system covering the exterior drywell shell. *Id.*

In rebuttal, AmerGen demonstrates that: (1) Dr. Hausler is poorly qualified to testify about the epoxy coating system on the exterior of the drywell; (2) visual inspection to detect coating failures is based on established industry practice, is consistent with ASME Code Section XI requirements, endorsed by the NRC, and should detect the early stages of coating failure; (3) the epoxy coating system should last for the life of the plant, including the extended period of operation; and (4) the defects found in the sand bed floor epoxy coating have no bearing on the drywell shell epoxy coating system. AmerGen's experts on rebuttal for Part 5 are Messrs. Ouaou and Cavallo.

F. Part 6 (Future Corrosion)

In Part 6 of AmerGen's direct testimony, we presented AmerGen's analysis of the potential for corrosion of the drywell shell in the sand bed region during the period of extended operation. That analysis takes into account, among other things, the OCNGS operating environment, the refueling schedule, drywell shell characteristics, and the potential for water to come into contact with the metal surface of the drywell shell in order to establish the amount of corrosion that theoretically could occur during the period of extended operation.

In Citizens' direct testimony, they discuss the potential for future corrosion of the exterior drywell shell in the sand bed region and for corrosion of the interior embedded surface of the drywell shell. Dr. Hausler testifies, among other things, that the corrosion rate "in pitting situations . . . increases exponentially with time" (Hausler, A. 21) and he estimates a total potential future corrosion rate for both sides of the drywell shell of 0.041" per year. Hausler, A.16.

In rebuttal, AmerGen demonstrates that: (1) Dr. Hausler is poorly qualified to testify about the relevant corrosion mechanisms; (2) he confuses "pitting" corrosion with general corrosion (which is the relevant corrosion mechanism for the drywell shell); (3) the rate of general corrosion typically *decreases* exponentially over time; (4) there is no significant potential for corrosion on the interior embedded drywell surface; and (5) Dr. Hausler's estimate of a potential future corrosion rate is unreasonable and unrealistic for numerous reasons.

In summary, Dr. Hausler's testimony on the topic of potential future corrosion is based on inapplicable analyses and incorrect assumptions. AmerGen has taken into account the actual conditions of the drywell shell in the sand bed region, and the actual potential corrosion mechanisms. Based on this, we conclude that AmerGen has established an appropriate aging management program. AmerGen's experts on rebuttal for Part 6 are Messrs. Gallagher, Gordon and Tamburro.

IV. CONCLUSIONS

The scheduled frequency every other refueling outage of UT measurements in the sand bed region, in conjunction with the other drywell aging management program commitments, provides reasonable assurance that the drywell shell will continue to perform its intended functions during the proposed period of extended operation. Nothing in Citizens' Initial Statement or supporting testimony calls this into question. Thus, Citizens' contention lacks substantive merit and the Board should issue an initial decision dismissing it in its entirety.

Respectfully submitted,

Donald J. Silverman, Esq.
Kathryn M. Sutton, Esq.
Alex S. Polonsky, Esq.
MORGAN, LEWIS & BOCKIUS, LLP
1111 Pennsylvania Avenue, N.W.
Washington, DC 20004
Phone: (202) 739-5502
E-mail: dsilverman@morganlewis.com
E-mail: ksutton@morganlewis.com
E-mail: apolonsky@morganlewis.com

J. Bradley Fewell
Associate General Counsel
Exelon Corporation
4300 Warrenville Road
Warrenville, IL 60555
Phone: (630) 657-3769
E-mail: Bradley.Fewell@exeloncorp.com
COUNSEL FOR
AMERGEN ENERGY COMPANY, LLC

Dated in Washington, D.C.
this 17th day of August 2007

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of:	)	August 17, 2007
AmerGen Energy Company, LLC	)	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear Generating Station)	)	

AMERGEN'S PRE-FILED REBUTTAL TESTIMONY PART 1 INTRODUCTION, DRYWELL PHYSICAL STRUCTURE, HISTORY, AND COMMITMENTS

I. WITNESS BACKGROUND

Q. 1: Please state your names and current titles. The Board knows that a description of your current responsibilities, background and professional experience was provided in Part 1 of AmerGen's Pre-Filed Direct Testimony on July 20, 2007, so there is no need for you to repeat that information here.

A. 1: (JFO) My name is John F. O'Rourke. I am a Senior Project Manager, License Renewal, for Exelon, AmerGen Energy Company, LLC's ("AmerGen") parent company.

(FWP) My name is Frederick W. Polaski. I am the Manager of License

Renewal for Exelon.

(MPG) My name is Michael P. Gallagher, and I am the Vice President for License Renewal for Exelon.

Q. 2: Would you please summarize the purpose of this Rebuttal Testimony?

A. 2: (All) The purpose is to respond to the Pre-Filed Direct Testimony of Dr. Rudolf Hausler (A.16) that discusses the "industry standard" for "monitoring intervals" of potentially corroding components. In summary, the applicable ASME Code requirements authorize AmerGen to use engineering evaluations to determine the inspection frequency. Those evaluations are specific to the component being evaluated and the conditions/environment to which it is exposed. In other words, inspection frequency is determined under the ASME code on a case-by-case basis. That is the industry standard.

II. COMPLIANCE WITH THE ASME CODE IS THE INDUSTRY STANDARD

Q. 3: Dr. Hausler has stated, in Answer 16 of his Direct Testimony, that,

> The margin AmerGen has claimed to have is 0.064 inches . . . . *The industry standard is to measure at half the interval in which it is possible to have lost margin.* Given a total corrosion rate of 0.041 inches per year, a margin of 0.034 inches could be lost in less than a year. Thus, the monitoring interval would have to be more than once every six months.

Do you agree with Dr. Hausler's statement about the "industry standard"?

A. 3: (All) No. Dr. Hausler's statement is incorrect as applied to the drywell shell. Under 10 C.F.R. § 50.55a, the drywell shell is governed by ASME Code, Section XI, Subsection IWE-3512.3, which requires the following:

> Containment vessel examinations that reveal material loss exceeding 10% of the nominal containment wall thickness . . . shall be documented. Such areas shall be accepted by engineering evaluation or corrected by repair or replacement . . . . Supplemental examinations . . . shall be performed when specified as a result of the engineering evaluation.

AmerGen's regulatory commitments in its Primary Containment Inspection Program comply with these ASME Code requirements because, if sand bed region UT thickness examinations reveal statistically-significant deviations from previous results, then AmerGen will conduct an engineering evaluation to assess the extent of condition and to determine if additional inspections are required to assure drywell integrity. In other words, the engineering evaluation determines whether the inspection frequency is adequate, or if it needs to be accelerated. For example, following AmerGen's engineering evaluation of the 2006 external data, AmerGen further enhanced its ASME Section XI, Subsection IWE Program to require UT measurements of the locally thinned areas in 2008 and periodically throughout the period of extended operation. (Applicant's Exhibit 3, p. 6-18).

Q. 4: Does this conclude your testimony?

A. 4: (All) Yes.

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

8-15-2007	
John F. O'Rourke	Date
8/15/2007	
Frederick W. Polaski	Date
8-15-2007	
Michael P. Gallagher	Date

UNITED STATES OF AMERICA
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AMERGEN'S PRE-FILED REBUTTAL TESTIMONY PART 2 ACCEPTANCE CRITERIA

I. WITNESS BACKGROUND

Q. 1: Please state your names and current titles. The Board knows that a description of your current responsibilities, background and professional experience was provided in Parts 1 and 2 of AmerGen's Pre-Filed Direct Testimony on July 20, 2007, so there is no need for you to repeat that information here.

A. 1: (MPG) My name is Michael P. Gallagher, and I am Vice President of License Renewal for Exelon.

(AO) My name is Ahmed Ouaou, and I am a registered Professional Engineer specializing in civil structural design. I am an independent contractor.

(HM) My name is Dr. Hardayal S. Mehta, and I am a Chief Consulting Engineer-Mechanics with GE-Hitachi Nuclear Energy Co. My résumé is attached as Applicant's Exhibit 36.

Q. 2: Would you please summarize the purpose of your testimony?

A. 2: (All) The purpose of our testimony is to respond to Question 12 of the Atomic Safety and Licensing Board's ("Board") Memorandum and Order of August 9, 2007. We are not responding to Citizens' Direct Testimony because we believe AmerGen's Direct Testimony addresses Citizens' misconceptions about the acceptance criteria.

II. RESPONSE TO QUESTION 12

Q. 3: In Question 12 of its Order, the Board states:

> It is the Board's understanding that the original GE analysis of the response of the drywell shell to loads that might lead to buckling failure employed a model that broke the shell into elements of certain discrete sizes and shapes over which physical properties (such as shell thickness) are averaged.

Is the Board's understanding correct?

A. 3: (All) Yes, with the exception that the shell thickness was not averaged over each element. Rather, a uniform thickness of 0.736" was assumed and the analysis was performed using this assumed uniform thickness. GE used a finite element model that modeled one 36 degree, pie-slice of the entire vertical length (*i.e.*, height) of the drywell shell. The pie-slice is representative because the drywell shell and sand bed are symmetrical with respect to the 10 torus vent lines. A discussion of GE's modeling is in Applicant's Exhibit 3, beginning on page 6-7.

Q. 4: Question 12 includes five discrete parts. Part A asks the parties to describe the sizes and shapes of the elements used in the GE analysis. Please provide this information.

A. 4: (All) The elements used to confirm the stability of the drywell in the sand bed region are 3" x 3" in size and quadrilateral in shape, with a uniform thickness of 0.736" for the entire sand bed region model. The other element properties, such as yield strength, density, Poisson's ratio, and modulus of elasticity, are as specified in ASME Code for the drywell material of construction, SA-212 grade B carbon steel plate.

GE's sensitivity analyses included the 3" x 3" quadrilateral elements in modeling a local area of 12" x 12" having an assumed thickness of 0.536" with a transition to the uniform thickness of 0.736" on all sides as shown on Applicants' Exhibit 11. GE modeled this 12" x 12" area in the location of the highest buckling stress, which is midway between the torus vent lines.

Q. 5: Part B asks the parties to "indicate whether the average properties used in any of those elements would be different if the corrosion pattern had been as described by the contour plots proposed by Dr. Hausler (see Hausler Direct Testimony, Att. 4), and if so, the magnitude of those differences." Please provide this information.

A. 5: (All) No. The average properties such as element size and material properties, as described above, would not be different. The only difference would be thickness of the element because GE conservatively modeled the shell with a uniform thickness of 0.736" in the sand bed region.

Q. 6: Part C asks the parties to "indicate the source and sizes of the conservatisms built into the original properties used for those elements and whether any of those conservatisms would be reduced if the elements' properties were computed based on the pattern of corrosion indicated by the contour plots rather than those used by AmerGen." Please provide this information.

A. 6: (All) We used 0.736" for each element. Accordingly, the conservatism "built into the original properties used for those elements" is the use of the conservative value of 0.736" because it was known from UT thickness measurements that the shell was on average significantly thicker than 0.736". This conservatism would not be reduced by Dr. Hausler's modeling which, for reasons demonstrated in Part 3 of AmerGen's Rebuttal testimony, is based on an inappropriate statistical treatment of the external UT data.

There are other sources of conservatism for the modeling on a whole. First, the Torus vent pipes, which are present in each Bay, and the reinforcing plates for their penetrations, stiffen the shell. This results in a stress reduction of the shell in their influence zone which would allow uniform and local shell thickness to be below the values modeled by GE and still satisfy ASME requirements. The areas of most significant corrosion are beneath or near the torus vent pipes.

The second area of conservatism is that the local buckling criterion assumes that the rest of the drywell shell in the sand bed region has a uniform thickness of 0.736". This is because the local buckling criterion was derived through sensitivity analyses using the 0.736" uniform thickness modeling. Thus, an area could thin to 0.536" (as shown in Applicants' Exhibit 11) and still meet the ASME code so long as the remainder of the shell was uniformly thicker than 0.736".

The third area of conservatism is driven by the ASME Code itself, and is related to how the allowable buckling stress is calculated. The theoretical elastic instability stress, based on the grade of the plate material used for the OCNGS drywell is 46,590 psi; but the ASME Code allowable buckling stress is 15,180 psi. The reduction is required by the Code to account for potential geometric imperfections and non-linear material behavior. In addition, the Code requires a factor of safety of 2 for the controlling load combination (refueling).

Q. 7: Part D asks, "If the elements' properties would be affected by the contour of corrosion as depicted by the contour plots, assuming the contour plots presented by Dr Hausler are accurate (and if they are not, so state), how should the existing buckling failure criteria be applied to the indicated extent of sub-threshold area in those bays?" Please answer this question.

A. 7: (All) The contour plots presented by Dr Hausler are not accurate. The contours generated by Dr. Hausler show drywell shell thinning that has not been observed or measured by AmerGen. In addition, there will be no change on how the existing criteria are applied. The general buckling criterion remains valid and will be compared to the average thickness calculated based on internal grid UT measurements. The local buckling criterion will be used to evaluate local thinning.

Q. 8: Part E asks "Because Oyster Creek's current licensing basis (CLB) is based on the GE methodology and explicit elementization of the model for the drywell shell (see Licensing Board Memorandum and Order (Denying Citizens' Motion for Leave to Add a Contention) at 3 n.6 (Apr. 10, 2007) (unpublished)), discuss whether consideration of a different modeling or elementization would constitute, under NRC regulations, a challenge to the CLB." Please answer this question?

A. 8: (All) Yes, the use of different modeling would constitute, under NRC regulations, a challenge to the CLB. The GE analysis is the basis for acceptance of the drywell shell under the CLB. Any new analysis that alters the acceptance criteria, if adopted by AmerGen, will constitute a change to the CLB and require NRC approval.

Q. 9: Does this conclude your testimony?

A. 9: (All) Yes.

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

Michael P. Gallagher	08-16-07
Michael P. Gallagher	Date
Ahmed M Ouaou	08-16-07
Ahmed Ouaou	Date
Dr. Hardayal S. Mehta	Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

Michael P. Gallagher — Date

Ahmed Ouaou — Date

Dr. Hardayal S. Mehta — Aug. 16, 2007

Date

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of:	)	August 17, 2007
AmerGen Energy Company, LLC	)	
	)	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear Generating Station)	)	

AMERGEN'S PRE-FILED REBUTTAL TESTIMONY
PART 3
AVAILABLE MARGIN

I. WITNESS BACKGROUND AND CONCLUSIONS

Q. 1: Please provide the Licensing Board with your names and current titles. The Board knows that a description of your current responsibilities, background and professional experience was provided in Parts 1, 2 and 3 of AmerGen's Pre-Filed Direct Testimony on July 20, 2007, so there is no need for you to repeat that information here.

A. 1: (FWP) My name is Frederick W. Polaski. I am the Manager of License Renewal for Exelon.

(DGH) My name is Dr. David Gary Harlow. I am a Professor in the Mechanical Engineering and Mechanics Department at Lehigh University located in Bethlehem, Pennsylvania.

(JA) My name is Julien Abramovici. I am a consultant with Enercon Services, Inc. located in Mt. Arlington, New Jersey, but formerly worked for the Oyster Creek Nuclear Generating Station ("OCNGS").

(PT) My name is Peter Tamburro. I am a Senior Mechanical Engineer in the OCNGS Engineering Department.

(MEM) My name is Martin E. McAllister. I am an American Society of Mechanical Engineers ("ASME") Non-Destructive Examination ("NDE") Level III Inspector at Oyster Creek Nuclear Generating Station ("OCNGS").

Q. 2: Please summarize the purpose of your testimony and overall conclusions.

A. 2: (All) The purpose of our testimony is to respond to the Pre-Filed Direct Testimony of Dr. Rudolf Hausler that discusses available margin and statistical treatment of the ultrasonic testing ("UT") data taken from the drywell shell in the sand bed region. Our overall conclusions, as stated below, are that Dr. Hausler's statistical treatment of the UT data is inappropriate and that Citizens are using the wrong acceptance criteria for buckling.

Internal UT Data Conclusions. For the internal UT grid data – upon which AmerGen determines available margin – Dr. Hausler inexplicably ignores the averages of the data. For example, the average of the 49 UT measurements from grid 19A was 0.800" in 1992. Therefore, 0.800" is deemed to be representative of that 6" x 6" grid. Dr. Hausler, however, throughout his testimony focuses on the lowest values from the 49 points and inexplicably assumes that those values are representative of the grid. There is no valid scientific support for this approach, which ignores reality. We believe that Dr. Hausler applies a type of "extreme value" statistics which is improper here because he uses extreme value statistics to look at the thinnest single points, whereas buckling is not a phenomenon that is dependent on very local thickness, but instead on the average thickness over a larger area. Thus, the averages of these data, not the thinnest extremes, are representative of each grid.

Dr. Hausler also argues that the internal grid data are not representative of the condition of the drywell shell in the sand bed region, and that the external single-point UT data should be used instead. (Citizens' Exhibit 12, at 3-4.) Dr. Hausler's argument is based on a comparison of internal, external, and trench UT data from Bay 17. (Citizens' Exhibit 12, at 3-4.) Whether on purpose or by error, his underlying calculation ignores an entire grid of 49 UT data points from Bay 17. (Citizens' Exhibit 12, at 3-4.) Dr. Hausler's argument falls apart when those data points are included. In other words, the internal UT data are indeed representative of the condition of the drywell shell in the sand bed region.

External UT Data Conclusions. Dr. Hausler also inappropriately statistically treats the external UT data. These data cannot represent the thickness of the drywell shell. First, there are too few of them for the points to be statistically representative of the shell as a whole. Second, they are biased toward the thin side (*i.e.*, they historically were selected as the thinnest locations). Dr. Hausler, however, ignores the limited number of data points and performs his calculations and computer "contouring" assuming that these external locations were selected at random and, thus, are representative of the condition of the drywell shell in the sand bed region. (Citizens' Exhibit 13, at 5-6, 9-11.)

Finally, Dr. Hausler relies upon an incorrect local buckling criterion. (Citizens' Exhibit 13, at 11-12.) He then improperly applies that criterion and the general buckling criterion to the single-point UT data collected from the exterior surface of the drywell shell to erroneously conclude that the drywell shell thickness currently is not in compliance with the ASME code.

Q. 3: What is your ultimate conclusion?

A. 3: (All) The bounding remaining available margin of the OCNGS drywell shell in the sand bed region for the period of extended operation remains 0.064".

II. BACKGROUND NEEDED TO UNDERSTAND CITIZENS' STATISTICAL ARGUMENTS

Q. 4: Please define the terms (a) "population mean," (b) population variance," (c) "sample mean," and (d) "sample variance" as used in the presented statistical analyses [Board Question 1].

A. 4: (DGH, JA, PT) In order to understand "population mean," you must first understand the term "population." "Population" is the set of all possible outcomes. In the case of the thickness of the drywell shell in the sand bed region, the "population" is a range that could be zero—if there was a hole in the shell—up to approximately 1.154", which is the nominal designed thickness.

(a) For the drywell shell thickness, the "population mean" can only be estimated, not actually measured. The more precise answer is that "population mean," which is symbolized by "μ", is the expected value for the population being considered. For random variables defined on real numbers, the technical definition is as follows:

$$\mu = \int_{-\infty}^{\infty} x f(x)\, dx,$$

where $f(x)$ is the probability density function that characterizes the randomness of the random variable. The "population mean" cannot be determined unless you know the probability of each of the values in the population.

(b) Variance is the amount of scatter that characterizes the randomness in the variable, for example, thickness of the drywell shell. The more precise answer is that "population variance," symbolized by "σ^2", is the expected value of the second moment about the population mean μ for the population being considered. For random variables defined on the real numbers, the technical definition is as follows:

$$\sigma^2 = \int_{-\infty}^{\infty} (x-\mu)^2 f(x)\, dx,$$

where $f(x)$ is the probability density function that characterizes the randomness of the random variable.

(c) "Sample" is the set of all observations, for example, UT measurements. The "sample mean," symbolized by "$\bar{x}$" or more appropriately the "sample average," is the arithmetical average of the physical measurements made from a population being considered. If the observations are $x_1, x_2, \ldots, x_n$, where n is the sample size or number of measurements, then the technical definition is as follows:

$$\bar{x} = \sum_{k=1}^{n} x_k / n .$$

This is analogous to measuring a limited amount of points over a 6" by 6" area (*i.e.*, 49 points), summing each measured value, and then dividing by the number of measurements that were taken. It is impossible to measure the thickness of the entire surface of the 6" by 6" area, or for that matter, the drywell shell, even by scanning the entire area. However, the more measurements that are taken, the better the sample average will approximate the population mean.

(d) The "sample variance," symbolized by "s^2" is the second arithmetical moment about the sample average $\bar{x}$ for the measurements from a population being considered. If the observations are x_1, x_2, …, x_n, as above, where n is the sample size, then the technical definition is as follows:

$$s^2 = \sum_{k=1}^{n} (x_k - \bar{x})^2 / (n-1) .$$

This is analogous to measuring a limited amount of points over a 6" by 6" inch area (*i.e.,* 49 points), summing the square of the difference between each measured value minus the sample average, and then dividing by the number of measurements minus one. As above, it is impossible to measure the thickness of the entire surface of the 6" by 6" area, or for that matter of the drywell shell. However, the more measurements that are taken, the better the sample variance will approximate the population variance.

If you knew the population mean and the population variance for the drywell shell thickness, no measurements would be needed. Because they are not known, however, measurements are needed to estimate them. It should also be noted that the "standard deviation" for either the population σ or sample s is the square root of the variance.

Q. 5: Where does the term "uncertainty" fit into all this?

A. 5: (DGH, JA, PT) "Uncertainty" refers to the level of assurance that a measurement is accurate. Uncertainty is caused by things that are typically outside of your control. For example, the UT technicians are competent and qualified but cannot locate the *exact* measurement location each time; the accuracy of the UT equipment is excellent but still not 100%; and different technicians take the measurements in very slightly different ways.

Q. 6: The Board has asked the following question regarding uncertainty: "The SER lists ten sources of systematic error (SER at 4-53 to 4-55), but AmerGen's direct testimony does not appear to discuss all ten sources (AmerGen's Prefiled Direct Testimony Part 3, Available Margin at 21-23). Estimates and explanations for the all ten sources should be provided, or, if they are insignificant, it should be so stated." Please respond to this question. [Board Question 7]

A. 6: (PT, FWP) We provide each of the ten sources of systematic error (*i.e.*, uncertainty) below, with a brief explanation as to their significance.

a) **UT Instrumentation Uncertainties.** The uncertainty for each UT measurement is approximately +/- 0.010". However, as described below, this uncertainty is not significant for the internal UT grid data once these data are averaged over multiple sampling events.

b) **Actual Drywell Surface Roughness and UT Probe Location Repeatability.** The uncertainty associated with this factor is not quantifiable. It is not significant for the internal UT grid data due to the use of a template that constrains the UT probe and because these data are averaged.

c) **Actual Drywell Surface Roughness and UT Probe Rotation.** The uncertainty associated with this factor is not considered significant because inspection procedures require that NDE personnel performing the UT inspection place the probe in the same orientation.

d) **Temperature Effects.** The uncertainty associated with this factor is not considered significant. Significant temperature differences between inspections may result in a shift in the material thickness. Therefore, the inspection procedure ER-AA-335-004 requires that NDE personnel performing the inspection record the surface temperature and verify that the temperature is within manufacturer tolerances. The procedure also requires that the calibration block be within 25°F of the surface which is being inspected.

e) **Batteries.** The uncertainty associated with this factor is not considered significant. The inspection procedure requires the technician to install new batteries prior to each series of inspections.

f) **NDE Technician.** The uncertainty associated with this factor is not considered significant. Inspection specifications require that personnel conducting UT examinations be qualified in accordance with Exelon Procedure ER-AA-335-004.

g) **Calibration Block.** The uncertainty associated with this factor is not considered significant. Exelon Procedure ER-AA-335-004 requires that the UT technician use only calibration blocks that meet applicable specifications.

h) **Internal Surface Cleanliness** – The uncertainty associated with this factor is not considered significant. The interior UT grid locations are protected by grease between UT inspections. The failure to remove grease from the interior drywell shell surface may have affected the internal UT data measurements collected during the 1996 refueling outage. The UT inspection protocol at that time did not specify the removal of the grease prior to performing UT measurements. Therefore it is possible that the requirement to remove the grease was not communicated to the contractor, and that the contractor who performed the 1996 inspection may have not removed the grease. Tests performed in April and May of 2006 show that the presence of the grease could increase the readings as much as 0.012".

i) **UT Unit Settings**. The uncertainty associated with this factor is not considered significant. It is possible that the ultrasonic unit can be set in a "high gain" setting which may bias the machine into including the external coating as part of the thickness. AmerGen used modern "state of the art" UT units that do not have gain settings during the 2006 refueling outage, and intends to use the same or similar equipment for future inspections.

j) **Identification of the Physical Inspection Location.** The uncertainty associated with this factor is not considered significant. This is not an issue for the internal UT grid locations which are marked on the drywell itself. However, the external UT locations are identified by the area that was prepared (*i.e.*, ground) to make them suitable for UT measurements. The exact location within that prepared area is identified on the UT data sheets by X and Y coordinates from known plate welds, but locating the exact point within the prepared area over the uneven drywell surface is difficult.

Q. 7: Please explain why the systematic error (*i.e.*, uncertainty) is not significant for the internal UT grid data after those data are averaged over multiple sampling events (*i.e.*, 1992, 1994, 1996 and 2006).

A. 7: (DGH, PT, JA) The short answer is that systematic error is negligible for sufficiently large numbers of measurements collected over time. So the more measurements you have, for example, 49 points within a 6" x 6" area, and the more times you collect those measurements, the less significant systematic error becomes.

The more precise answer is that "systematic error" may be considered to be part of the overall uncertainty encountered in measuring the drywell thickness. Although it is not taken into account directly, it is considered indirectly as follows. Let x_k be the thickness measurement at position k, and let ε_k be the error associated with that position. Since ε_k is difficult to quantitatively characterize, the common practice is to assume that it is a normal random variable with mean zero and variance σ^2, which is typically small because the measurement error is minimized by constantly improving the techniques for observations. Thus, the average should be written as

$$\bar{x} = \sum_{k=1}^{n}(x_k + \varepsilon_k)/n$$
$$= \sum_{k=1}^{n} x_k / n + \sum_{k=1}^{n} \varepsilon_k / n,$$

where the last sum is the cumulative error per measurement. The Law of Large Numbers in probability theory implies $\sum_{k=1}^{n} \varepsilon_k / n$ approaches zero as n increases. Thus, the effect of the systematic error is negligible for sufficiently large numbers of measurements. Furthermore, assuming that the errors ε_k, for all k, are statistically independent, then the variance of $\sum_{k=1}^{n} \varepsilon_k / n$ is σ^2/n, which also approaches zero as n increases.

Consequently, the overall effect of systematic error is assumed to be negligible.

Q. 8: Please explain the relationship between "population mean and sample mean" and "population variance and sample variance." [Board Question 2]

A. 8: (DGH, JA, PT) The population mean (μ) and population variance (σ^2) cannot be computed explicitly. They must be estimated, *i.e.*, expressed by a function of the observations $x_1, x_2, \ldots, x_n$ from the population. There are several ways to estimate μ and σ^2; however, the best estimates statistically are the sample average and the sample variance, respectively. In technical jargon,

$$\hat{\mu} = \bar{x} \text{ and } \hat{\sigma}^2 = s^2,$$

where the carat (^) indicates estimate.

Most of the statistical analysis in this discussion focuses on the normal distribution which is completely characterized by two parameters μ and σ^2 which are the mean and variance of the normal distribution. It can be proven, using maximum likelihood estimation, that the best estimates for μ and σ^2 are

$$\hat{\mu} = \bar{x} \text{ and } \hat{\sigma}^2 = (n-1)s^2 / n.$$

It should be noted that if n is sufficiently large, $(n - 1)/n$ is essentially one.

Therefore, for 49 points that are normally distributed, the sample variance is essentially the best estimate for the population variance.

The confidence interval, defined below, for the population mean is a measure of how well the sample average estimates the population mean.

Q. 9: Please define "confidence" as used in the 41 Calc. [Board Question 3]

A. 9: (DGH, JA, PT) "Confidence," symbolized by "$(1 - \alpha)$" is the degree of assurance that a particular statistical statement is correct under specified conditions. The confidence in the data used for the statistical analyses in the 41 Calc is 0.95. However, as stated in A.10 and A.13 below, there is a difference between confidence in the data and a "confidence interval."

Q. 10: Please discuss "confidence interval" and how the interval relates to the sample and population and means and variances. [Board Question 4]

A. 10: (DGH, JA, PT) First, we note that the term "confidence interval" implies that you can statistically treat the data. If the data cannot be statistically treated—such as the external UT data from the drywell shell in the sand bed region—then you cannot determine a confidence interval for that data.

A confidence interval bounds an unknown parameter, such as the population mean μ, so that its probability is the desired level of confidence, $1 - \alpha$. Assuming a normal distribution, the interval is estimated by including the uncertainty and variability in the data. The more uncertainty and variability in the data, the greater is the range of the confidence interval for the parameter.

The technical answer to the question is as follows: Let $f(x; \theta)$ be the probability density function for a population where θ is a parameter in the density function which is unknown. In order to estimate θ observations $x_1, x_2, \ldots, x_n$ must be collected from the population. The statistics L and U, *i.e.*, functions of the samples $x_1, x_2, \ldots, x_n$, determine the $100(1 - \alpha)\%$ confidence interval (L, U) for the parameter θ, if $\Pr\{L \leq \theta \leq U\} \geq 1 - \alpha$. In order to compute the probability $\Pr\{L \leq \theta \leq U\}$ which defines the confidence interval, the probability density for the parameter θ must be known.

By far the usual assumption is that θ is well characterized by a normal distribution. It is for the normal distribution that formulae are given in textbooks for statistics. If any other distribution is operable for a parameter, then the standard textbook formulae are not applicable. Note that all of the internal UT grid data were normally distributed as analyzed in the 41 Calc.

Most often θ is to be taken as the mean μ. For the drywell statistics, this is the primary parameter for which a confidence interval is required. The first task was to establish that the data for drywell thickness were well characterized by a normal distribution for areas defined by the sampling grid. Furthermore, the Central Limit Theorem of probability theory indicates that the sample average can be characterized by a normal distribution for sufficiently large numbers of data. Thus, the confidence interval of concern is

$$\Pr\{L \leq \mu \leq U\} \geq 1 - \alpha.$$

Again, the population mean μ is not known. It is estimated by the sample average $\bar{x}$. Furthermore, the population variance σ^2 is unknown, and an estimate for it is also needed. Under these conditions the interval estimate for μ is computed by the following statistic:

$$t = \frac{\bar{x} - \mu}{s / \sqrt{n}},$$

where the statistic t has the t-distribution with $n - 1$ degrees of freedom. Specific values for the t-distribution are contained in standard statistical tables. The confidence interval for the statistic t is

$$\Pr\{-t_\alpha \leq t \leq t_\alpha\} \geq 1 - \alpha,$$

where $\pm t_\alpha$ are the two-tail α values, for the upper U and lower L interval values. Substituting for t and doing straightforward algebraic manipulation leads to the confidence interval for population mean μ when the population standard deviation σ is unknown. Thus,

$$\Pr\{\bar{x} - \frac{st_\alpha}{\sqrt{n}} \leq \mu \leq \bar{x} + \frac{st_\alpha}{\sqrt{n}}\} \geq 1 - \alpha,$$

and $L = \bar{x} - \frac{st_\alpha}{\sqrt{n}}; U = \bar{x} + \frac{st_\alpha}{\sqrt{n}}$.

Thus, *L* and *U* are the upper and lower confidence intervals.

Q. 11: What is a "standard deviation"?

A. 11: (DGH, JA, PT) A standard deviation is the square root of the variance. Confidence intervals for the mean μ for the normal distribution are determined as a multiple of the sample standard deviation. A standard deviation provides an estimate of the variability of readings within the measured UT grid. It does not provide a reasonable estimate of the uncertainty of the average of that grid, and it can not provide an estimate of the uncertainty or variability of the data outside the grid.

Q. 12: How does a 95% confidence interval relate to "standard deviation"?

A. 12: (DGH, JA, PT) Citizens refer to a 95% confidence interval for the mean μ (for example, in A.11). A 95% confidence interval is almost equal to two standard deviations divided by the square root of the sample size, *i.e.*, the standard error, defined below, higher and lower than the difference in the sample average and the population mean μ, assuming the data are normally distributed. We say *almost* equal, because 1.96 standard errors produce a 95% confidence interval; two standard errors produce a 95.5% confidence interval.

Q. 13: Is there a difference between a "confidence interval" and simply having "confidence" in the data?

A. 13: (DGH, JA, PT) Yes. For example, there is a difference between a 95% confidence interval for the population mean in UT data and the fact that 95% of a particular UT grid's data, when normally distributed, falls within +/- two standard deviations of the average. The latter 95% value is not a confidence interval and has nothing to do with statistical confidence interval estimation for the mean.

Q. 14: What is the student's "t distribution" and what is its significance relative to estimation of the mean thickness? [Board Question 5]

A. 14: (DGH, JA, PT) The significance is that this method is necessary if you are trying to calculate the confidence interval, and if you do not know the population variance (which we do not), you must use the "t test" to compute the confidence interval for the mean. The "student t-distribution" or simply "t-distribution" is the distribution function for the random variable $t = \frac{\bar{x} - \mu}{s / \sqrt{n}}$. It is used primarily for interval estimation of the population mean μ when the data are normally distributed and when the population variance σ^2 is unknown.

Specifically, for the drywell thickness the confidence is 0.95, and the degrees of freedom depend on the sample size. The most frequent sample sizes used in the analyses are grids of 49 and 7 points, so that the corresponding degrees of freedom are 48 and 6, respectively. The values of t_α for these cases are 2.010 and 2.447, respectively.

To illustrate this computation, let $\bar{x}$ = 800 mils, s = 62.4 mils, for 49 observations, then

$$\Pr\{\bar{x} - \frac{st_{\alpha}}{\sqrt{n}} \leq \mu \leq \bar{x} + \frac{st_{\alpha}}{\sqrt{n}}\} \geq 1-\alpha$$

$$\Pr\{800mils - \frac{(62.4mils)(2.010)}{\sqrt{49}} \leq \mu \leq 800mils + \frac{(62.4mils)(2.010)}{\sqrt{49}}\} \geq 1-0.05$$

$$\Pr\{781.3mils \leq \mu \leq 818.7mils\} \geq 0.95.$$

Even though the population variance σ^2 is unknown, often investigators will use the two-tail α values z_{α} from the normal distribution, which are not dependent on sample size. For α equal to 0.05, z_{α} is 1.96. For practical purposes using a value of 2 is adequate except for small sample sizes where the degrees of freedom have a significant impact on the estimation of the confidence interval.

Q. 15: Is there a more reasonable estimate of the uncertainty of the average of the UT grid data than the standard deviation?

A. 15: (DGH, JA, PT) Yes. A more reasonable estimate (than standard deviation) of the variability of the average of the UT grid data is the "standard error." Assuming a normal distribution, the standard error estimates the variability of the average thickness by accounting for the standard deviation of the distribution *and* the number of samples. The standard error is calculated by dividing the standard deviation by the square root of the number of data points. Thus, the more data you have, the less the variability and the lower the standard error.

Q. 16: Can you provide an example?

A. 16: (DGH, JA, PT) Yes. An understanding of the UT grid averages over time can be developed by reviewing the standard error after the 1992 outage, when corrosion was arrested. At the bounding grid (19A), the 1992, 1994, 1996 and 2006 refueling outage averages (and standard errors) were 0.800" (0.0084"), 0.806"

(0.0099"), 0.815" (0.0096"), and 0.806" (0.0086"), respectively. This illustrates that the average thickness of this 6" by 6" grid has varied between 0.800" and 0.815" in four inspections over about 15 years, and the standard error has varied between 0.0084" and 0.0096".

But you can refine the sample variability even further, assuming no corrosion, through the standard error. AmerGen calculated the sample variability of the average of the data from this grid (through the standard error) over the four sampling events to achieve about +/- 0.005". (Applicant's Exhibit 25)

Q. 17: The Board requested that we provide a table of the location, mean thickness (by date), and the 95% confidence interval of the internal UT grid data. [Board Question 9]

A. 17: (PT, FWP) That table is provided as Applicant's Exhibit 25. Note, however, that AmerGen estimates the 95% confidence interval only for the internal UT grid data, and does so only for the 2006 data because the previous calculations (for 1992, 1994 and 1996) did not include these intervals.

Moreover, as explained above, the 95% confidence interval for each sampling event is not the best estimate of the uncertainty in the data. That is captured by the standard error, which is an estimate of the uncertainty corrected for multiple sampling events (referred to in the Table as the "Grand Standard Error"). Accordingly, AmerGen is also supplying the Grand Standard Error for each grid as calculated using the data from the 1992 through the 2006 refueling outages.

Q. 18: What is the "F statistic" used in the regression model of corrosion and its significance to the corrosion data? [Board Question 6]

A. 18: (DGH, JA, PT) The primary use of the "F statistic" is to test the ratios of two sample variances when it is reasonable to assume that (a) the population variances are equal and (b) the data are normally distributed. Specifically, the F statistic is

$$F = s_1^2 / s_2^2,$$

where s_1 and s_2 are sample standard deviations from the two samples with sample sizes of n_1 and n_2, respectively. Note that there are two degrees of freedom, one for each sample size. The specific values for the F distribution are found in standard statistical tables.

The application of the F test for the drywell is to determine if the variances from two samples of thickness measurements are equal.

Q. 19: Does AmerGen use the "F test," and if so, for what purposes?

A. 19: (PT, DGH, JA) AmerGen has only used the "F test" to evaluate potential corrosion rates. In the 41 Calc., AmerGen used the "F test" in an attempt to identify a corrosion rate. The data, however, failed that test because there were too few inspections (*i.e.*, only 1992, 1994, 1996, and 2006) and the data variability was too large.

Therefore, AmerGen modeled what corrosion rate would be required to pass the "F test" with the existing limited data and large variability. Based on these results, as stated in Applicant's Exhibit 3, page 6-17:

> AmerGen cannot statistically confirm that the sandbed region has a corrosion rate of zero. This is because of the high variance in UT data within each 49-point grid (standard within a range of

> deviation 60 to 100 mils), the relatively limited number of data sets that have been taken and the time frame over which data has been collected since the sand was removed in 1992. The high variance in UT data within the grids is a result of the drywell exterior surface roughness caused by corrosion that occurred prior to 1992. However, AmerGen continues to believe that corrosion of the exterior surface of the drywell shell in the sandbed region has been arrested as evidenced by little change in the mean thickness of the 19 monitored (grid) locations and the observed good condition of the epoxy coating during the 2006 inspection.

Q. 20: Explain how systematic error is accounted for in estimating the thickness and corrosion rate. [Board Question 8]

A. 20: (DGH, JA, PT) Systematic error is not accounted for in estimating the thickness of the UT data for the reasons described above in Answer 7. Systematic error equals uncertainty. The ten sources of uncertainty were provided in Answer 6.

Q. 21: Please describe in detail how the term "reasonable assurance" has been defined and applied in the instant case. [Board Question 11]

A. 21: (All) AmerGen has demonstrated reasonable assurance through its aging management program for the drywell shell as a whole. For the UT inspection component of that program, AmerGen has demonstrated that: (a) the average, as an estimate of the mean, of the normally distributed UT data from each internal grid, is thicker than the general buckling criterion, (b) no grouping of external UT data points exceed the local buckling criterion, and (c) no single UT reading from either inside or outside the drywell shell exceeds the pressure criterion. AmerGen does not need to meet its burden to demonstrate reasonable assurance under 10 C.F.R. § 54.29(a) with 95% confidence.

ASME Code, Section XI, Subsection IWE, provides rules for inspection and evaluation of the drywell shell. The Code requires that UT measurements be taken in grids established by the Owner. There is no requirement that the data be evaluated using 95% confidence. The current approach was reviewed by the NRC Staff. The methodology is appropriate for UT data evaluation and is part of the current licensing basis.

Having said that, AmerGen has calculated the 95% confidence interval for the data collected from the internal UT grids in 2006. These intervals are presented in Applicant's Exhibit 25, in response to Board Question 9.

Q. 22: On page 28 of their Initial Statement, Citizens have interpreted the Board's July 11, 2007, Order as requiring AmerGen to demonstrate that "it currently has margin with 95% confidence." Dr. Hausler says the same thing in A.11. Alternatively, Citizens believe they can prevail "either by showing that at 5% confidence the drywell thickness is already below the established acceptance criteria, or that the thickness could go beyond any established margin within four years." Are Citizens correct?

A. 22: (DGH, JA, PT) Citizens are not correct. First, Citizens appear to be confused about what a confidence interval really does. The confidence interval does not provide any information about failure of a component, or compliance with a Code or regulation. Second, Citizens appear to be arguing that AmerGen is required to show that that it has 95% confidence that the drywell shell thickness meets acceptance criteria. (See A.11 "there is less than 95% confidence that the drywell shell currently meets the area acceptance criteria and other acceptance criteria.")

This is inappropriate. AmerGen is primarily interested in the data within a grid which are between ± two sigma about the sample average because this region accounts for 95% of normally distributed data. If there is relatively little scatter in these data, which has been demonstrated elsewhere, so that they are also reasonably close to the sample average, then the sample *average* is the quantity that should be used in comparison to the general buckling criterion. The 5% of the data outside ± two sigma about the sample average pose no threat to buckling; however, these data are considered relative to the pressure criterion.

Q. 23: Is there anything else you would like to add about these statistical issues?

A. 23: (All) Yes. AmerGen's statistical evaluations have been internally and externally reviewed by qualified people, in accordance with objective industry standards. The 41 Calc., for example, was reviewed internally by another senior mechanical engineer, and reviewed externally by consultants. This level of review provides a greater degree of certainty that the data are treated appropriately. Dr. Hausler's statistical treatment of the data does not appear to have been subject to any review, either internal or external, until now. And the many problems we will discuss later in this testimony demonstrate that Dr. Hausler has not treated the data appropriately.

III. DR. HAUSLER USES THE WRONG DATA AND THE WRONG METHODS TO EVALUATE THE INTERNAL UT GRID MEASUREMENTS

Q. 24: Citizens conclude that 0.064" is not the bounding available margin for the OCNGS drywell shell in the sand bed region. How do they arrive at that conclusion?

A. 24: (All) They appear to rely solely upon the opinion of Dr. Hausler, and Dr. Hausler reaches that conclusion only by manipulating the internal and external UT data in a manner that is not statistically appropriate. He also makes some mathematical errors.

Q. 25: Please explain how Dr. Hausler manipulates the data, and why his approach is inappropriate.

A. 25: (All) We will discuss the internal UT grid data first. In order to understand how Dr. Hausler manipulates the data, some background discussion is required. As we previously discussed in Part 3, Answer 12 of AmerGen's Direct Testimony, the internal UT data are collected from nineteen "grids" located throughout all ten drywell bays. Twelve of these grids are six inches square, each consisting of a total of forty-nine individual UT thickness measurement points. The remaining seven grids are rectangular—one inch by seven inches—consisting of a total of seven individual UT points.

As discussed in Part 3, Answer 24, the normally-distributed data from these grids are averaged and compared to the general buckling criterion of 0.736". As discussed in Part 3, Answer 31, the bounding margin of the drywell shell in the sand bed region of 0.064" is based on a 49-point grid in Bay 19 (19A), which had a general average thickness in 1992 of 0.800".

For the internal UT grid data – upon which AmerGen determines available margin – Dr. Hausler inexplicably ignores the averages of the data.

Q. 26: Can you provide some examples?

A. 26: (All) Yes. The average of the 49 UT measurements from grid 19A in 1992 was 0.800." The averages from this UT grid have varied little over time: 0.800" (1992), 0.806" (1994), 0.815" (1996) and 0.807" (2006). As part of the license renewal review process, AmerGen conservatively reported the smallest of these four values (0.800") to the Advisory Committee on Reactor Safeguards (ACRS) to document the minimum available margin in the sand bed region (*i.e.*, 0.800" - 0.736" = 0.064"). (Applicants' Exhibit 3, page 6-2)

Q. 27: Do Citizens agree?

A. 27: (All) No. Citizens claim that the remaining margin for buckling should not be 0.064" but rather 0.034". (Dr. Hausler Answer 16; Citizens Initial Statement at 2). They claim that AmerGen must subtract 0.030" from the measured average of 0.800" in grid 19A (0.064" – 0.030" = 0.034") in order for the average to be compared to the general buckling criterion (*i.e.*, 0.736"). Citizens derive the 0.034" value from an AmerGen response to an NRC Information Request in which AmerGen agreed to take action if the future average of any of the internal grid data collected during an outage was +/- 0.021" different than previous readings. (See Citizens' Direct Answer 16; Citizens' Initial Statement at 11 citing Ex. 10 at 2 and SER at 3-121). This 0.021" value was based on the standard deviation of internal UT data of 0.011" plus uncertainty associated with instrument accuracy of 0.010".

But Citizens believe this value is too low. They claim that 0.011" is based on only one standard deviation and that AmerGen is required to achieve two standard deviations (which, as explained above approximately equals 95% of the distribution for normally distributed data). Citizens conclude that the uncertainty should be approximately 0.030". Dr. Hausler's testimony does not show how he derived that value. We can only assume that Citizens derived this uncertainty as follows, (which would be the proper way to derive the uncertainty): assuming that the randomness in thickness and the measurement error are independent, then the overall standard deviation is $\sqrt{(0.011in)^2 + (0.01in)^2} = 0.0149in.$ Two standard deviations would be 0.0297", which Citizens appear to have rounded up to 0.030". To determine the lower limit of the 95% interval for the data, they argue that AmerGen must subtract 0.030" from the available margin of 0.064", thus concluding that only 0.034" remain.

Q. 28: What are your concerns with how Dr. Hausler manipulated these data?

A. 28: (All) There are several problems with Dr. Hausler's manipulation of the data. First, Citizens miss the point of AmerGen's response to the NRC. AmerGen was identifying an action limit. If AmerGen had selected two standard deviations as Citizens suggest, then it would not take action until the difference in the average of data was approximately +/- 0.030". For an action limit, however, it is appropriate and conservative to assume only one standard deviation. Again, Citizens demonstrate that they do not understand basic information relevant to AmerGen's Aging Management Program.

Second, the actual standard error for grid 19A over time is about 0.005", not 0.030". The standard error for the grid 19A data is about 0.010" *each time* this 49-point grid was measured. (Applicant's Exhibit 25.) But AmerGen has four data sets to work with. If we assume no corrosion, then we can combine the four data sets for 1992, 1994, 1996 and 2006, which results in a standard error of about 0.005". Accordingly, the variability in the grid 19A data is an order of magnitude lower than cited by the Citizens (*i.e.*, 0.005" vs. 0.030"). That is no surprise, since the uncertainty that Citizens cite was taken out of context in the first place.

Q. 29: Doesn't Citizens' method ignore thicker metal that AmerGen has actually measured?

A. 29: (All) Yes. Subtracting 0.030" from the calculated grid average thickness ignores data. For example, the bounding grid (19A) had an average thickness of 0.800" in 1992. If you subtract 0.030" and conclude that the average is 0.770", then review of the 1992 data (41 Calc., Appendix 10, page 6) shows that Dr. Harlow ignores 32 of the 45 UT valid readings from that grid (because 32 were greater than 0.770"). (Four of the readings in 19A are located over a newer metal plug and are not considered valid for calculating the grid average).

The best confidence for the thickness is from the internal UT data. More specifically, it is the repetitive and consistent results for the internal grids in 1992, 1994, 1996 and 2006, and the known standard error which is an order of magnitude lower than that irresponsibly identified by Citizens.

Finally, the ASME Code and acceptance criteria do not require AmerGen to bound the condition of the drywell shell with 95% confidence. AmerGen has to determine a reasonable and conservative measure of the drywell and compare it to the Code-based criteria. By assuming that the bounding available margin is uniformly 0.800" thick, AmerGen has demonstrated that it has developed a conservative measure of the actual condition.

Q. 30: Does AmerGen ignore the lowest readings?

A. 30: (All) No. Each single point within the grid was compared with the pressure criterion to assure that it surpassed that test.

Q. 31: Is there anything else you would like to add before we move on to the topic of whether the internal UT data are representative of the drywell shell?

A. 31: (DGH) Yes. On page 7 of his April 25, 2007 memorandum, Dr. Hausler states that "if an average of ten measurements over a specific area results in a thickness of 0.750 inches with a variability (standard deviation) for the average of 0.03 inches, the lower 95% confidence limit for this average would be 0.690 (0.75 – 0.06)." In other words, Dr. Hausler concludes that the 95% confidence interval would be +/- 0.060".

I have attempted to replicate this value and can only do so if, within basic statistical equations, I fail to divide the standard deviation by the square root of $n = 10$. If Dr. Hausler had calculated the statistical equation properly, then the 95% confidence interval for the difference between the sample average and the population mean would have been approximately +/- 0.019", not 0.060". This means that the confidence interval in Dr. Hausler's example is much tighter than Dr. Hausler states.

IV. THE INTERNAL UT DATA ARE REPRESENTATIVE OF THE BOUNDING DRYWELL SHELL CONDITION IN THE SAND BED REGION

Q. 32: Dr. Hausler spends much of his April 25, 2007 memorandum alleging that the internal grid data are not representative of the condition of the drywell shell in the sand bed region, and that the external single-point UT data should be used instead. He compares the trench, internal grid, and external point data from Bay 17 to support his allegation. What is your response to that allegation?

A. 32: (All) Whether on purpose or by error, Dr. Hausler's underlying calculations ignore an entire grid of 49 UT data points from Bay 17. Dr. Hausler's argument falls apart when those data points are included. In other words, Dr. Hausler reaches his conclusion by conveniently ignoring data that contradict his position. Moreover, it is the omitted data that AmerGen relies upon for purposes of calculating the available margin in Bay 17. Accordingly, Dr. Hausler's calculations do nothing to undermine the fact that the internal UT data are indeed representative of the bounding condition of the drywell shell in the sand bed region.

Dr. Hausler's conclusion on page 4 of his April 25, 2007 memorandum (Citizens' Exhibit 12) states that "only the trench measurements and outside measurements come close to represent [sic] the most severe corrosion at the highest elevations." Dr. Hausler also concludes that the internal data are not representative of the worst corrosion in the sand bed. (Citizens' Exhibit 12, at 3-4.) Dr. Hausler's conclusion is based on evaluation of the data as presented in figures 3 and 4 on pages 15 and 16 of his memorandum. The figures attempt to show the relationship between the internal Bay 17 thickness data, the external Bay 17 data points of which there were only 10 points, and the Bay 17 trench data. All of these data were collected during the 2006 refueling outage.

Q. 33: What are the data that Dr. Hausler ignored that contradict his position?

A. 33: (PT FP) AmerGen routinely monitors only two internal grids that are entirely within Bay 17: 17A and 17D. 17A had a 2006 average thickness of 1.015". 17D had a 2006 average thickness of 0.818". Dr. Hausler uses the data from the 17A grid, but ignores the data from 17D.

Q. 34: What grid from Bay 17 does AmerGen use for license renewal?

A. 34: (PT FP) Oyster Creek considers grid 17D—not 17A—as the representative thickness value of the worst corrosion for Bay 17, and has used the average from that grid for purposes of license renewal. For example, the following values have been reported to the NRC and the ACRS as part of the license renewal process for grid 17D: 1992 – 0.817", 1994 – 0.810", 1996 – 0.848", and 2006 – 0.818" (page 94 of the January 18, 2007 ACRS Presentation – Applicant's Exhibit 26. The 1994 value of 0.810" was used in the ACRS presentation to document 0.074" of margin in Bay 17 (page 95 of the January 18, 2007 ACRS Presentation). It is also shown in Applicant's Exhibit 3 at 6-2 & Table 18. That value was achieved by subtracting the 0.736" general buckling criterion from 0.810".

Therefore, using Dr. Hausler's methodology and grid 17D supports the conclusion that this internal grid is representative of the worst corrosion in Bay 17. This should not be a surprise since the internal grids were originally selected based on a much more extensive set of UT inspections in the mid 1980's which identified the thinnest areas.

Q. 35: Before we move on to discuss the external UT data, there is one other issue that Citizens raise regarding the uncertainty of the internal UT data. Citizens claim that AmerGen uses an uncertainty for the internal UT data of 0.020", and that AmerGen "subtracted 0.020 inches before it compared the mean to the acceptance criterion." (Citizens' Initial Statement at 13.) Citizens cite to AmerGen's Exhibit 19, page 8, for support. Does AmerGen subtract 0.020" from the mean/average of the internal UT grids before comparing the mean to the general buckling criterion?

A. 35: (PT, FP) No. The document that Citizens rely upon (Applicant's Exhibit 19.) is Technical Evaluation AR A2152754 E09, which documented AmerGen's *preliminary* evaluation of the UT data collected in 2006 from the *internal* surface of the drywell shell in the sand bed region. The purpose of that Technical Evaluation was not to support license renewal. Rather, the Technical Evaluation documented why there was adequate margin of the drywell shell in the sand bed region to operate until the next refueling cycle in 2008, to support exiting the 2006 refueling outage.

Q. 36: Is this Technical Evaluation conservative in nature?

A. 36: (PT, FP) Yes. The Technical Evaluation reviewed the internal UT grid data as well as data collected from the two internal trenches. It was a preliminary analysis because we had not at that time had the opportunity to perform statistical analyses of those data. AmerGen, therefore, used extremely conservative factors, including an uncertainty of +/- 0.020", for its preliminary evaluation. Systematic error (*i.e.*, uncertainty) is not accounted for in estimating the final thickness of the UT data for the reasons described above in Answer 7.

V. DR. HAUSLER USES THE WRONG DATA AND THE WRONG METHODS TO EVALUATE THE EXTERNAL UT GRID MEASUREMENTS

Q. 37: Does AmerGen statistically treat external UT data for purposes of demonstrating compliance with the acceptance criteria?

A. 37: (All) No. As we testified in Direct Part 3 Answer 27, AmerGen does not statistically treat the external UT data for purposes of demonstrating compliance with the acceptance criteria. Rather, the raw UT data are compared against the relevant acceptance criteria without any statistical treatment.

Q. 38: Why?

A. 38: (All) Because AmerGen does not use the external UT data points to determine margin. AmerGen only uses that data to demonstrate compliance with the ASME Code. As stated in Part 3, A.29, the single-point UT measurements can tell you that you meet the applicable ASME Code, but not by how much. This is the case because there are an insufficient number of UT measurements over large areas to evaluate a representative average thickness over each area. So Citizens are performing statistical analyses on the external UT data that AmerGen does not perform.

Q. 39: Citizens claim in their response to AmerGen's Motion in Limine, however, that external UT data have in the past been used to estimate available margin.

Citizens cite to Applicant's Exhibit 17, p. 7, which is the original 24 Calc performed in 1993. What is your response to this allegation?

A. 39: (PT, FWP, JA) Citizens are taking that discussion out of context. The top of page 7 confirms that the external UT locations inspection "focused on the thinnest areas of the drywell . . . [thus] the inspection did not attempt to define a shell thickness suitable for structural evaluation." You cannot calculate available margin from a buckling perspective using biased thin points. Second, the evaluation *assumed* a *uniform thickness* of 0.800" for purposes of evaluation against the general buckling criterion. As stated on page 8, however, "In reality, the remainder of the shell is much thicker than 0.800" inches." This external UT data provide useful information that can help you determine that you meet the applicable ASME Code, but they cannot tell you by how much.

Q. 40: Please explain how Dr. Hausler manipulates the external UT data, and why it is inappropriate to do so.

A. 40: (All) As we will demonstrate below, Dr. Hausler statistically treats the external UT data in an inappropriate manner. These data cannot represent the average thickness of the drywell shell because there are too few of them and they are biased toward the thin side (*i.e.*, they historically were selected as the thinnest locations). Dr. Hausler, however, ignores the limited number of external data points and performs his calculations and computer "contouring" assuming that these external locations were selected at random and, thus, are representative of the condition of the drywell shell in the sand bed region. This is an improper assumption which necessarily leads to inappropriate conclusions. (Note that Dr.

Hausler does not appear to account for the UT thickness measurements from internal grids that overlap his contour map area. These are actual measurements that, if considered, would demonstrates that he has significantly underestimated the thickness of the shell).

We can best demonstrate Dr. Hausler's inappropriate techniques through an analogy. If you wanted to know the average weight of people walking along 5th Avenue in New York City, then you would make an inference that if you weighed enough people randomly from that street that their weights would be representative of all the people on that street (*i.e.*, you would have a statistically representative sample). You would not want to select only ten people (too few) or people who biased the sample population by, for example, purposefully selecting those who looked thin. You would then determine if you had a normal distribution of the individuals' weights. With a normal distribution, you would then calculate the average weight, which would be representative of the people on that street. You could then calculate the 95% confidence interval of those weights.

Dr. Hausler glosses over the fact that there are not enough UT measurements to statistically treat the external data in the first instance. He acknowledges there are not enough data when he states that "the paucity of data, particularly in the heavily corroded Bays makes definite conclusions very difficult and an assessment of the extent of the corroded areas somewhat intuitive," (July 18 memorandum at 2). We believe he goes beyond intuition, to speculation when he nevertheless statistically treats those data.

Q. 41: Are there any other reasons why Dr. Hausler is wrong?

A. 41: (All) Yes. Dr. Hausler also acknowledges, but then ignores the fact that the external UT data were selected because they were determined to be the thinnest points. For example, Citizens state on page 14 of their Initial Statement that "the best approach . . . is to regard the external readings as representative, even though they might actually be biased to the thin side by their method of selection." Dr. Hausler's rationale for this statement appears to be his April 25, 2007 memorandum on page 6: "I believe that when assessing the extent of severe corrosion, reviewers should assume that the measured points connect unless other measurements show this not to be the case."

Dr. Hausler then averages these thinnest points and improperly identifies a 95% confidence interval. He then focuses on the thinnest of these readings. Not surprisingly, he declares that the drywell shell, in some cases, already has exceeded the general and local buckling criteria.

Using our analogy, what Dr. Hausler does is similar to biasing the sample population from 5th Avenue by selecting too few people, and only those who are waif-like. Needless to say, it is statistically inappropriate to average biased thin measurements and treat them as representative of the population, whether it is the weight of people or the thickness of the drywell shell. These data simply are not representative of the average since the shell between these UT locations is thicker. It is similarly statistically inappropriate to take the thinnest of these biased thin areas (*i.e.*, the lower 2.5% of this biased sample) and claim that these extreme values could be representative of the average. Using our analogy, such statistics would lead to the absurd conclusion that only people with anorexic qualities walk on 5th Avenue.

Dr. Hausler is confusing extreme value behavior with averaging. If your sample population is biased thin, then the way to evaluate the data is through extreme value statistics. You would not use an averaging technique because averaging implies a normal distribution. Dr. Hausler argues that the average of the thinnest points is representative of the whole drywell shell, but it can only be representative of the extreme values.

Q. 42: What is the basis for your opinion that the external UT locations were selected because they were the thinnest locations?

A. 42: (JA, PT) During the 1992 refueling outage, OCNGS did not identify UT measurement points on the exterior of the drywell shell to identify the average thickness. Rather, it specifically looked for the thinnest areas. This is documented in Applicant's Exhibit 27 (TDR1108):

> The corroded vessel shell resembled a cratered golf ball surface. The areas where the heaviest corrosion had taken place appeared obvious from a visual inspection since the inside shell wall was relatively uniform. The GPUN metallurgist (S. Saha) identified on a sketch, areas to be prepared for UT readings. At a later time he reviewed the surface preparation and thickness data and identified additional locations to ensure that the thinnest areas were surveyed. [page 15]
>
> It was reasoned that since the inside surface of the vessel shell is smooth and not corroded, any thin area on the outer surface should represent the minimum thickness in that region. It was further reasoned that if six to twelve scattered spots, located in the area of worst corrosion, are ground smooth and the thickness of each spot is measured by UT method we will have a high level of confidence that we have identified the thinnest shell thickness for a bay. This approach is conservative since, (a) we are forcing

> a statistical bias in choosing only the thinnest areas and (b) grinding of the selected spots to obtain a flat surface for reliable UT readings will remove additional good metal. [page 16]

This is also discussed in other documents, including, Applicant's Exhibit 12 on p. 14, Applicant's Exhibit 16 on p.4, and Applicant's Exhibit 17 on page 7.

In addition, Dr. Hausler's own analysis has independently confirmed that these external points are biased thin. In Citizens' Exhibit 12 on page 4, Dr. Hausler states that "the average outside measurements are significantly lower at comparable elevations [than the interior measurements]. This is probably because the choice of location for the external measurements was deliberately biased towards thin spots."

The fact that the external UT locations are biased towards the thinnest locations is also demonstrated by comparison of those data to the data taken from the internal UT grids. Some of the external UT locations coincide with internal grid locations, as shown on the comprehensive map of all 2006 UT inspection results that AmerGen provided to the ACRS for a public meeting in February 2007. The map is located on Page 14 of AmerGen's presentation, which is attached as Applicant's Exhibit 28. We will refer to this map as the "2006 map" as we next discuss three illustrative examples.

Three of the thinnest external readings in Bay 19 (points 9, 10 and 11) were 0.728", 0.736", and 0.712", respectively, in 2006. The 2006 map shows that these points are located within inches of internal grids 19A and 19B, which had averages thicknesses of 0.807" and 0.848", respectively, in 2006.

The thinnest of all the external readings was from Bay 13 (point 7) at 0.602" in 2006. The 2006 map shows that this external point is located within inches of internal grid 13D, in which the top half of the grid averaged 1.047" in 2006 and the bottom half of the grid averaged 0.904" in 2006.

One of the thinnest readings in Bay 17 (point 2) was 0.663" in 2006. This point is located within inches of internal grid 17A, in which the top half of the grid averaged 1.112" in 2006 and the bottom half of the grid averaged 0.935" in 2006.

The thinnest reading in Bay 11 (point 1) was 0.700" in 2006. This point is located within inches of internal grid 11A, which has an average thickness of 0.822" in 2006.

The thinnest reading in Bay 1 in 2006 (point 3) was 0.665". This point is located within inches of internal grid 1D, which had an average thickness of 1.122" in 2006.

These data, from multiple bays, unambiguously demonstrate that the external locations are biased thin compared to their surroundings. To statistically treat these data as representative of the drywell shell in the sand bed region is, therefore, inappropriate.

Q. 43: But on Page 10 of their Initial Statement, Citizens discuss the measurements taken in 2006 from 0.25" around the coordinates for certain external UT points in Bays 7, 15, 17, and 19. They state that those measurements are thinner than the designated external UT data point. Are Citizens correct that these external measurement locations are, therefore, not the thinnest?

A. 43: (FP, PT, JA) No, they are not correct. They confuse the measured "points" with the "ground UT locations." The external measurement "point" is located within a 2-inch diameter area that was ground smooth during the 1992 refueling outage to allow for the UT probe to sit flat against the shell. Examples of these ground locations are shown in Applicant's Exhibits 29, which are two presentation slides from AmerGen's meeting with the ACRS in January 2007. These *locations* were selected because they were the thinnest locations in the sand bed region for each bay.

The coordinates on the UT data sheets direct the UT technician to a spot within a specific ground location. But that specific spot is not itself marked and UT data from that location is, therefore, not precisely reproducible from sampling event to sampling event. These nuances, however, in no way undermine that these ground *locations* are the thinnest locations in each bay. Indeed, the fact that UT readings 0.25" around the center reading were lower, further supports that these ground areas are the thinnest locations.

Q. 44: Did AmerGen ignore these thinner UT readings 0.25" around the center reading if they were lower?

A. 44: (PT) No. When I performed my evaluation of the external UT data, I used the thinnest UT value from each of the ground areas measured in 2006. This is shown in Rev. 2 of the 24 Calc. for data points from Bays 7, 15, 17, and 19.

Q. 45: Is there anything else wrong with Dr. Hausler's evaluation of the external UT data?

A. 45: (All) Yes. Dr. Hausler relies upon an incorrect local buckling criterion (*e.g.*, A.13). He compares the external UT data to a criterion consisting of a one square foot area with a thickness of 0.636", without any transition back to 0.736". The actual criterion—AmerGen's local buckling criterion—has a thickness of 0.536" in a tray configuration, with a transition back to 0.736". That criterion is shown on AmerGen's Exhibit 11. Using the wrong criterion compounds his errors, and affects his ultimate conclusions about whether the drywell shell thickness meets the ASME Code.

Q. 46: Dr. Hausler argues that there are severely corroded areas that are shaped "like long grooves" or are irregular in shape, that call into question AmerGen's use of a square-shaped, local buckling criterion. (A. 24) What is your response to this argument?

A. 46: (All) Dr. Hausler is wrong. This argument can only be based on Dr. Hausler's improper statistical treatment of the external UT data, and his assumption that "the measured points connect unless other measurements show this not to be the case." (April 25 memorandum, page 6) The bath tub ring is irregular in shape, but the corrosion in that ring is only relevant to buckling if the resulting thickness is less than 0.736". And AmerGen has evaluated as acceptable those locations within the bath tub ring with UT readings that are less than 0.736". Additionally, the thinnest average grid reading taken from inside the drywell is in the bath tub ring, supporting our position that there is adequate margin to buckling.

A. Uncertainty in External UT Data

Q. 47: Dr. Hausler claims that the uncertainty of each external point is approximately +/- 0.090". (A.15) The basis for this claim is from Section IV (page 3) and Section VII (pages 8 and 9) of his July 18, 2007 memorandum (Citizens' Exhibit 13). Is Dr. Hausler correct?

A. 47: (All) No. In order to understand why Dr. Hausler is wrong, you first need to understand how he derived his level of uncertainty. Dr. Hausler derives 0.090" as follows. He identifies locations in Bays 5, 15, and 19 where measurements were taken during the 2006 refueling outage in a 0.25"-diameter area around the designated external measurement point. (On Page 9 of his July 18 memorandum, Dr. Hausler refers to these measurement locations as "identical coordinates," when in fact, they were taken in an area 0.25" around the specified coordinate.)

He assumes that the external data are representative of the thickness of the shell in these three bays, so he averages the data from these locations. (See the last column of the table on page 9 of his July 18 memorandum.) He then assumes the external data are normally distributed, and calculates the standard deviations for each bay, arriving at 0.033", 0.050" and 0.043" for the points in Bays 5, 15, and 19, respectively. (Citizens' Exhibit 13, at 3.) He then inexplicably "pools" these three values to arrive at 0.045", which he argues applies as a representative thickness for all areas in all of the bays. He then doubles that value (0.045" x 2) to account for the two standard deviations required to identify the 95% confidence interval.

Q. 48: What is wrong with this use of the data?

A. 48: (All) In arriving at 0.090", Dr. Hausler completely ignores reality and proper statistical techniques. As discussed above, he ignores that the external data are biased thin and that the locations were deliberately chosen to be the thinnest locations in each bay; that the data are not normally distributed (as shown by Kurtosis of the three data sets); and that there are not enough data to establish a representative sample population of these very large areas. As to the last point, there are only eight external points in Bays 5 and 15, and nine in Bay 19, to represent three areas *each of which* is about 3.5 feet by 15 feet wide. He also conveniently ignores the Bay 7 standard deviation he calculates on the same table (page 9) which would have reduced his number from 0.090" to 0.075".

Dr. Hausler then assumes this 0.090" value can be applied globally to any one reading or set of readings throughout the sand bed region of the drywell shell. This is unsupported and suggests that Dr. Hausler's testimony in this area should be given little, if any, weight.

Using the analogy of people on 5th Avenue, what Dr. Hausler does by pooling these thin points is akin to selecting the thin-looking people from 1st Avenue, 3rd Avenue, and 5th Avenue, and concluding that everyone in New York City is underweight.

Q. 49: What do you mean by the use of the term "kurtosis" in your previous answer?

A. 49: (PT, DGH) For ease of discussion here, we have rescaled Kurtosis, so that it equals zero for a normal distribution. Distributions that are greater or less than zero are not normally distributed.

For Bay 5, the 2006 external points were 0.948, 0.955, 0.989, 0.948, 0.88, 0.981, 0.974, and 1.007 with a calculated Kurtosis of 2.43.

For Bay 15, the 2006 external points were 0.711, 0.777, 0.935, 0.791, 0.817, 0.715, 0.805, and 0.76, with a calculated Kurtosis of 1.65.

For Bay 19, the 2006 external points were 0.867, 0.85, 0.894, 0.883, 0.82, 0.721, 0.728, 0.736, and 0.721 with a calculated Kurtosis of -2.2.

B. <u>Evaluation Thickness</u>

Q. 50: On pages 6 and 7 of his July 18 memorandum, Dr. Hausler raises many allegations about the "Evaluation Thickness," which is discussed in the various revisions of the 24 Calc. He concludes on page 7 that, "We can, therefore, not accept the evaluation done by AmerGen using the 'evaluation thickness.'" Please explain what the "Evaluation Thickness" is and its use.

A. 50: (FP, PT) As explained on pages 17-19 of Rev 2 of the 24 Calc. (AmerGen's Exhibit 16), the Evaluation Thickness is a representative average thickness in an area of 2" in diameter surrounding the external points that were less that 0.736" as measured by UT in 1992. During the 1992 refueling outage, micrometer readings were taken in a 2" diameter area around each external UT point that measured less than 0.736" (*i.e.*, about 20 points). This uniform depth was generated from actual measurements which had surface roughness variability of 0.200" from the micrometer readings for the two thinnest points in Bay 13 (see 24 Calc, Rev 2, p. 19). The Evaluation Thickness method is the UT thickness reading, plus the average depth of the area relative to its surroundings, minus 0.200" (referred to in the Evaluation Thickness method as "T roughness").

Dr. Hausler assumes the Evaluation Thickness method is to "correct for the fact that due to the roughness the UT probe may not have 'coupled' well with the metal surface and therefore detect less metal (thinner wall) than was actually there." (July 18 memorandum, page 7). He also assumes that "T-roughness" was to correct for roughness under the UT probe, and that it therefore should *not* have been used in 2006 when the epoxy coating would have created a smooth surface for the probe.

Q. 51: Is Dr. Hausler correct?

A. 51: (PT, FP) Dr. Hausler is wrong. The purpose of the method—as stated in Applicant's Exhibit 16— is to evaluate a 2-inch diameter area around the UT location, and estimate the average thickness of that 2-inch diameter area, not to account for the ability of the UT probe to properly couple. The purpose of "T-roughness" is to account for the roughness under the micrometer's straight edge, not roughness under the probe.

In addition, Dr. Hausler does not understand the implication of his argument. If AmerGen had *not* used T-roughness in 2006, as Dr. Hausler suggests, then the value would have been *thicker* by 0.200", which would not have been conservative.

Q. 52: On page 7 of his July 18 memorandum, Dr. Hausler quotes a document that you, Mr. Tamburro, wrote in 2006, suggesting that the Evaluation Thickness ought not to be used. Can you please respond to this?

A. 52: (PT). Yes. I did indeed submit a document to the OCNGS corrective action system (Citizens Exhibit 3), raising a concern with Rev 0 of the 24 Calc.

(Applicant's Exhibit 17). However, my concern was limited to inadequate documentation. I identified approximately 11 items that required additional documentation in that calculation. All of the items were related to *documentation* of assumptions, methods, and data. This included an item about documentation of the methodology and justification for the Evaluation Thickness method. In other words, the deficiencies could be resolved with additional documentation. My concern about the Evaluation Thickness method was properly and thoroughly resolved through AmerGen's corrective action process and pages 17-19 of Rev 2 of the 24 Calc. document the resolution of the deficiency that I had identified.

I believe the method is appropriate to use, and I employed that method to evaluate data from the 2006 refueling outage.

VI. AMERGEN'S EVALUATION OF THE LOCAL BUCKLING CRITERION IN THE 24 CALC. IS APPROPRIATE

Q. 53: Dr. Hausler calls into question AmerGen's evaluation of the external UT data in Rev. 2 of the 24 Calc by challenging AmerGen's assumptions about the size of the historically corroded areas. (A. 23) Please respond to this.

A. 53: (PT) I performed the evaluations that are documented in Rev. 2 of the 24 Calc., and am very familiar with the prior revisions. For Rev. 1 (which he calls the second revision), he states that AmerGen "assumed, contrary to the visual observation, that all the severely areas measured were less than 2" in diameter." Dr. Hausler does not cite a specific page in the calculation so I cannot determine what precisely he is referring to. However, he is not correct. AmerGen identified the thinnest areas within the severely corroded areas, and then ground the metal around those points for a 2" diameter.

Dr. Hausler also states that, for Rev. 2 (which he calls the third revision), "AmerGen has taken an approach of drawing squares by eye on plots of the external data points." (A.23). On page 5 of his July 17 memorandum, he states that this was a "one-dimensional analysis." These too are incorrect. I did not draw squares by "eye on plots." I entered each of the external UT points using the x and y coordinates provided on the UT data sheets into Microsoft Excel. I then used Excel to create a 36" x 36" square, to represent the boundaries of the tray configuration that comprises the local buckling criterion. For points that measured less than 0.736" in 2006, I used Excel to move the square around to ensure that it encompassed, *in three dimensions*, the external points that were thinner than 0.736". Some of the points that measured less than 0.736" were evaluated using the Evaluation Thickness method described above.

Q. 54: Please address the following Board question, "This Board understands that UT thickness measurements are commonly used to determine pipe wall thickness and plate thickness in other industries (see, e.g., Attachment to Citizens Answer (Selected Papers by Dr. Hausler)). To enhance the Board's general understanding and thereby enable it to make a more informed decision, the parties should discuss other applications of UT thickness measurement and identify the best practices recommended by National Association of Corrosion Engineers or other professional organizations, if any, with particular attention to the determination of the thicknesses of corroded plates and the rate of corrosion. The discussion should include use of mean versus extreme value statistics and the Analysis of Variance used in these cases." [Board Question 10]

A. 54: (MEM, PT, JA) The Board's understanding that UT thickness measurements are commonly used is correct. For power plant applications, UT inspection has been the predominant technique used to measure wall thickness and flaws in pressure vessels, piping, tanks and heat exchanger shells and tube sheets. It is the most widely used method in the power industry as well as the nuclear industry. Recommended practices are provided in codes and standards such as ASME Code Section V (NDE) and ASTM E797: Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method.

The ASME codes used in power plants, ASME Section III (Nuclear), Section VIII (Unfired Pressure Vessels), and Section XI (Inservice Inspections) specify UT as the examination method of choice for thickness, particularly for operating plants. In a similar fashion, other codes such as American Petroleum Institute (API) also predominantly use the UT technique to determine thickness and flaws. National Association of Corrosion Engineers (NACE) in its "Corrosion Basics" publication identifies ultrasonics as a method to measure "metal losses caused by corrosion and erosion" and states that "the measurements can be made from the outside of the vessels or pipelines during operation."

In general, these codes and standards do prescribe rigid UT inspection methodology, but do not prescribe data evaluation methodology (including whether to evaluate the data using the mean, extreme values, or analysis of the variance). Rather, they recommend that the owner specify the methodology on a case-by-case basis. To our knowledge, NACE does not require or suggest that the data be statistically evaluated using any particular method.

Typical power plant applications of UT include:

- <u>Evaluation of Degraded Piping.</u> Evaluation Methodology is prescribed by ASME Section XI, and applicable code cases (such as Code Case N513). UT measurement and subsequent evaluations focus on the average thickness of the degraded areas and the size of the degraded areas and not on extreme thickness values.
- <u>Erosion-Corrosion (FAC) Prone Piping.</u> Inspection practices were developed to identify the problems in regard to Erosion/Corrosion monitoring programs as they relate to NRC Bulletin 87-01, "Thinning of Pipe Wall in Nuclear Power Plants" and NRC Generic Letter 89-08 "Erosion/Corrosion-Induced Wall Thinning, and EPRI TR-106611." Components are examined both to ensure equipment reliability and personnel safety. EPRI has developed software (TR-106611), and workgroups have been established to incorporate the best practices and to share industry experience and technology development. UT measurements and evaluations use grids of points to determine the average thicknesses of the piping. The average of these grid readings is used for evaluation and determination of corrosion rates.
- <u>Pressure Vessel Shell Inspection.</u> Components are examined in accordance with ASME Section VIII to identify degradation of the vessel shells in order to ensure both equipment reliability and

personnel safety. Inspection practices for feedwater heaters, for example, are developed to identify the degraded area due to steam impingement wear. In this case, UT measurements and subsequent evaluation focus on the average thicknesses of pressure retaining sections of the Feedwater Heater Shell.

- Tanks. Inspection practices are developed to identify degraded tank walls and floors. Components are examined in accordance with ASME Code Section XI and/or API 650 and 653. UT measurements and subsequent evaluation focus on the average thicknesses of degraded areas and not extreme values.

Q. 55: Does this conclude your testimony?

A. 55: (All) Yes.

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

F Polaski	8/15/07
Frederick W. Polaski	Date
David Gary Harlow	Date
Julien Abramovici	Date
Peter Tamburro	Date
Martin E. McAllister	Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

______________________________ ____________________

Frederick W. Polaski   Date

David Gary Harlow   August 14, 2007

David Gary Harlow   Date

______________________________ ____________________

Julien Abramovici   Date

______________________________ ____________________

Peter Tamburro   Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

Frederick W. Polaski	Date
David Gary Harlow	Date
Julien Abramovici	8-15-07 Date
Peter Tamburro	Date
Martin E. McAllister	Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

______________________ ______________

Frederick W. Polaski Date

______________________ ______________

David Gary Harlow Date

______________________ ______________

Julien Abramovici Date

Peter T[illegible] 8/16/07

Peter Tamburro Date

______________________ ______________

Martin E. McAllister Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

______________________________ ______________________

Frederick W. Polaski Date

______________________________ ______________________

David Gary Harlow Date

______________________________ ______________________

Julien Abramovici Date

______________________________ ______________________

Peter Tamburro Date

M McAllister 8-16-07

______________________________ ______________________

Martin E. McAllister Date

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of:	)	August 17, 2007
AmerGen Energy Company, LLC	)	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear Generating Station)	)	

AMERGEN'S PRE-FILED REBUTTAL TESTIMONY PART 4 SOURCES OF WATER

I. WITNESS BACKGROUND

Q. 1: Please state your names and current titles. The Board knows that a description of your current responsibilities, background and professional experience was provided in Parts 1 and 4 of AmerGen's Pre-Filed Direct Testimony on July 20, 2007, so there is no need for you to repeat that information here.

A. 1: (JFO) My name is John F. O'Rourke. I am a Senior Project manager, license Renewal, for Exelon, AmerGen Energy Company, LLC's ("AmerGen") parent company.

(AO) My name is Ahmed Ouaou. I am a registered Professional Engineer specializing in civil/structural design and an independent contractor.

(FHR) My name is Francis H. Ray. I am the Engineering Programs Manager at Oyster Creek Nuclear Generating Station ("OCNGS").

II. KNOWN SOURCES OF WATER IN THE SAND BED REGION

Q. 2: What is the purpose of this Rebuttal Testimony?

A. 2: (All) The purpose of this Rebuttal Testimony is to respond to the information provided in Citizens' Initial Statement Regarding Relicensing of Oyster Creek Nuclear Generating Station ("Statement") and in the Pre-Filed Direct Testimony of Dr. Rudolf H. Hausler, regarding the sources of water in the sand bed region.

Q. 3: Please summarize your conclusion.

A.3: We have reviewed Citizens' Statement and Dr. Hausler's testimony. These documents conclude that "it has not been established that the only source of water is the reactor fueling cavity." (Citizens' Statement at 21). This conclusion is based on a lack of knowledge of the subject matter and a lack of understanding of the available documents. Nothing in Dr. Hausler's testimony or Citizens' Statement contradicts our previous conclusion that AmerGen has identified and eliminated the potential sources of water in the sand bed region.

Q. 4: What is the basis for your previous conclusion?

A. 4: (All) As we described in our Direct Testimony (Part 4, A.13) and discuss further in this Rebuttal Testimony, the evaluations that took place in the 1980s and 1990s essentially ruled out other components as potential sources of water. Thus, "the only known source of water on the exterior of the drywell shell in the sand bed region is the reactor cavity liner . . . ." (Part 4, A.4) Further, "[o]bservation of the exterior of the drywell shell in the sand bed region and the sand bed drains during the 2006 refueling outage[] confirms that the use of metal tape and strippable coating on the reactor cavity liner during outages can eliminate the presence of water from the exterior sand bed region." (Part 4, A.4)

Q. 5: Are there documents that support your conclusions?

A. 5: (All) Yes. Citizens' Exhibit 21, Attachment III; page 6-3 of Applicant's Exhibit 3; and portions of the transcripts of AmerGen's meetings with the ACRS license renewal subcommittee on October 3, 2006 and January 18, 2007, all discuss the historical investigations. The relevant portions of the ACRS transcripts are attached as Applicant's Exhibits 30 and 31.

Q. 6: Is there other evidence that the only known source of water is the refueling cavity?

A. 6: (All) Yes. During inspections, no new water has been found in the plastic bottles that are connected to the sand bed drains. This includes the quarterly inspections during operations that resumed in March 2006, and daily inspections while the reactor cavity was filled with water during the 2006 outage. Thus, these inspections provide additional confirmation that the only known source of leakage is the reactor cavity liner.

Q. 7: Citizens have submitted, as their Exhibit 21, a December 5, 1990 letter from OCNGS to the NRC. Attachment III to that letter describes past actions to "investigate, identify, and correct leak paths into the drywell gap . . . ." Are you familiar with this document?

A. 7: (All) Yes.

Q. 8: What does that document discuss?

A. 8: (All) It discusses the extensive investigations undertaken in the 1980s and early 1990s to identify the sources of water in the sand bed region and it reports the results of those investigations to the NRC.

Q. 9: On page 21 of their Statement, Citizens cite their Exhibit 21, Attachment III, at 4 in support of the claim that "the equipment pool has also leaked." What is your opinion regarding this statement?

A. 9: (All) The passage cited by Citizens has nothing to do with leakage on the drywell shell. The discussion of equipment pool leaks on page 4 of Citizens' Exhibit 21, Attachment III describes "[e]vidence of leakage" on both the floor and wall of the equipment pool and in the reactor cavity wall," and "water stains on the underside of the equipment pool." The leakage described is isolated from the drywell shell and, based on the physical configuration of OCNGS, there is no credible leakage path from the underside of the equipment pool to the drywell shell.

Tellingly, this passage is part of a discussion of "actions [that have] also been taken to address the potential impact of leakage on *other* structures and equipment." Citizens' Exhibit 21, Attachment III at 4 (emphasis added). The cited passage *comes after* a description of the licensee's "thorough program for managing leakage that could affect drywell integrity," and is not part of the cited description. Citizens' Exhibit 21, Attachment III, at 4.

Q. 10: Dr. Hausler also has testified on the topic of equipment pool leakage. He states, in A.17, that there "are a number of potential sources of water that have been identified by the reactor operator, including . . . the equipment pool." What is your opinion regarding this statement?

A. 10: (All) OCNGS historically identified a number of potential sources of water, including the equipment pool, but investigations in the 1980s and 1990s eliminated the equipment pool as a source of water leakage onto the external drywell shell. Further, to the extent Dr. Hausler is relying on the "reactor operator," then we can only assume that he relies on the conclusions documented in Citizens' Exhibit 21, Attachment III, which are that, with respect to leakage "into the drywell gap" (page 2), "no leaks have been found related to the equipment pool. Preventively, the equipment pool will be protectively coated similar to the refueling cavity. Drains from the leak detection system are monitored on a periodic basis to detect any changes" (page 3).

Further, there is no potential for water from the equipment pool to reach the external sand bed region. The equipment pool is filled with water during outages when it is utilized to store reactor components for shielding purposes during their disassembly. During this period, the water in the equipment pool can mix with the water in the reactor cavity. Prior to plant restart the equipment pool is drained down, eliminating the potential for water from the equipment pool to provide a source of leakage into the sand bed region.

Q. 11: Citizens also have submitted TDR 964, dated March 3, 1989, as Citizens' Exhibit 22. Are you familiar with this document?

A. 11: (All) Yes.

Q. 12: Please summarize the purpose and contents of the document.

A. 12: (All) TDR 964 describes the clearing of the sand bed drains that took place in 1988 and recommends further corrective actions to monitor sand bed leakage.

Q. 13: On page 21 of Citizens' Statement, Citizens cite to page 3 of TDR 964, to support the statement that "fuel pool water that did not originate from the reactor cavity has been found in the sand bed region." Does the citation support Citizens' Statement?

A. 13: (All) No. Citizens' conclusion is *not* supported by this citation. The cited passage in TDR 964 states,

> On Oct 26, 1988 during the cathodic protection core bore operation . . . it was noted that hole 2 in bay 11 was filled with standing water. This water when tested by O.C. chemistry was found not to be core bore water used during the drilling operation but rather it had the characteristics of "old" fuel pool water.
>
> Since the reactor cavity had not been filled with fuel pool water for the "upcoming refueling" it was postulated that this entrapped water could be "old" fuel pool water.

This document simply does not support the conclusion Citizens draw from it (*i.e.*, that fuel pool water that did not originate from the reactor cavity has been found in the sand bed region). The author of TDR 964 proposes that the water discovered might have been "old" fuel pool water, *i.e.*, water left over from a previous refueling outage, when the reactor cavity was filled with water. There is no basis upon which Citizens can then jump to the conclusion that there is some source of water in the sand bed region *other than the reactor cavity*. TDR 964 offers no support for this leap of logic. Ultimately, on page 5, the conclusion reached is that "[w]ater samples were collected from each bay drain and analysis proved to be inconclusive."

Also, following this TDR, the licensee conducted extensive investigations to determine the source of leakage into the sand bed region. As documented in Citizens' Exhibit 21, Attachment III, those investigations ultimately found no source of leakage other than the reactor cavity liner. There is nothing in TDR 964 that contradicts these later findings.

III. REFUELING CAVITY LEAKAGE

Q. 14: Dr. Hausler has testified, in A.17, that "AmerGen has not managed to devise a method to ensure that the refueling cavity will not leak in the future . . . ." Is this correct?

A. 14: (All) This is correct, but irrelevant. Leakage from the reactor cavity is not relevant unless it exceeds the capacity of the trough drain. As we explained in Part 4, A.9 of our Direct Testimony, the use of metal tape and strippable coating has "drastically reduced the amount of reactor cavity liner leakage" to a level that is "well within the capacity of the reactor cavity trough drain system." Moreover, the trough drain is inspected during each outage. Thus, it is mere speculation to assume that leakage at the trough drain equates to undetected water on the exterior of the drywell shell.

IV. CONDENSATION

Q. 15: Dr. Hausler has testified, in A.18, that "small droplets of condensation . . . would likely not cause observable flow in the sand bed drains." What is your response to this statement?

A. 15: (All) We would first point out that, as we testified on direct, "[c]ondensation on the exterior of the drywell shell in the sand bed region during normal operations is not credible," and even during outages, "the potential for condensation is entirely speculative." (Part 4, A.17) Direct visual observation during the 2006 outage in all ten bays did not identify condensation.

Next, relying on Ed Hosterman's testimony in Part 6 of AmerGen's Direct Testimony, we understand that any water that might condense on the drywell shell during an outage "would evaporate in a couple of hours" following start-up at the end of the outage. Also, the potential future corrosion calculations of Barry Gordon in Part 6 of AmerGen's Direct and Rebuttal Testimony conservatively assume that water from the reactor cavity is present for the entire 30-day period of a refueling outage, once every 24 months. Thus, even if Dr. Hausler's testimony is correct, condensation already is accounted for in AmerGen's potential future corrosion analysis.

Q. 16: Dr. Hausler has testified, in A.17, that "AmerGen has [not] been able to definitively trace the source of water found most recently in the drains from the drywell," so "it is not possible to rule out the potential for water from other sources to enter during operation."

A. 16: (All) Dr. Hausler is referring to the water found in early 2006 in three of the five plastic bottles in the Torus Room that collect leakage from the sand bed drains. As explained in Part 1 of AmerGen's Direct Testimony, water from the sand bed drains "is diverted through plastic tubing where it is collected in five-gallon plastic bottles." (A.10) There is no evidence that this water "enter[ed]" the sand bed region "during operation," as Dr. Hausler speculates. Instead, as we testified in Part 4, A.12, the presence of water in these bottles "is consistent with the failure to apply strippable coating during past refueling outages." The fact that AmerGen cannot "definitively trace the source" of this water does not mean that the water came from a source other than the refueling cavity. Again, the fact that no water has been identified in these bottles since inspections resumed in March 2006, and the fact that no water was found in any portion of the sand bed region during the 2006 outage inspections, provides additional support that there are no other sources of water reaching the sand bed region during operations or outages.

Q. 17: On page 21 of Citizens' Statement, they cite to Citizens' Exhibit 23 (an AmerGen e-mail) for the fact that "no activity" was detected in the water found in the plastic bottles in March 2006. They conclude, therefore, that "some water will result from condensation during outages." Are Citizens correct?

A. 17: (All) No. The reference to "no activity" refers to no gamma radioactivity. However, the sample was not analyzed for tritium. Analytical results from prior samples taken from the sand bed region, identified in Citizen's Exhibit 22, also have no gamma radioactivity but still exhibited tritium at concentrations that are consistent with water from the primary cooling system. Thus, the fact that "no activity" was detected in the water sample taken in March 2006 does not prove that the water came from condensation. In addition, no condensation was observed during visual inspections of the exterior sand bed region during the 2006 outage. At best, that analytical result is inconclusive.

Furthermore, as we testified on direct, the temperature differential between the "hotter drywell interior" and the "cooler external sand bed region. . . . will prevent condensation from forming on the exterior of the drywell shell." (Part 4, A.14.) Although condensation is "theoretically possible" during outages (Part 4, A.15.), "[t]here was no evidence of condensation on the exterior of the drywell shell" during the 2006 outage. (Part 4, A.16.) "Qualified NDE [non-destructive examination] visual inspectors examined each individual bay during the 2006 refueling outage and their reports did not identify any condensation or other moisture." (Part 4, A.16.)

V. CRACKS IN THE EPOXY FLOOR

Q. 18: Dr. Hausler has testified, in A.18, that if "defects in the floor coating recur, water could run down into those defects, rather than running to the [sand bed] drains" leading to "a failure to detect corrosive conditions." Do you agree with this statement?

A. 18: (All) No. Once again, Dr. Hausler is speculating and does not understand the facts. Dr. Hausler is assuming that water would run down the shell, onto the floor, and into cracks that would have to be present between each of the sand bed drains and the shell, thereby preventing water from reaching the sand bed drains. This is speculation. Past defects in the floor were not in locations that would permit the scenario Dr. Hausler assumes to take place. The defects were primarily at the interface between the concrete shield wall and the floor, on the opposite side of the sand bed floor from the drywell shell. Those that were not at this interface were small defects that could not prevent water from reaching the drains. Further, as described in Applicant's Exhibit 3, at 7-3, no defects were found in the seal between the drywell shell and the concrete floor. Thus, Dr. Hausler's statement is best characterized as speculation that is based on a misunderstanding of the geometry and drainage design of the external sand bed region and the configuration of the floor defects.

VI. CLOGGED DRAINS

Q. 19: Dr. Hausler has testified, in A.18, that "in the past the [sand bed] drains have clogged and it is reasonable to assume that this situation could recur." Do you agree?

A. 19: (All) No. Dr. Hausler argues that the drains could become totally blocked so that no water can pass through them. This is total speculation, because the sand bed region drains were historically clogged with sand. That sand was removed during the 1992 refueling outage. This is described in Applicant's Exhibit 3, at 6-3. In the 2006 outage, as described in Applicant's Exhibit 3, at 4-7, some solid debris was found in two of the sand bed drains, but the debris would not have prevented flow. The debris was removed from both of these drains. Further, the sand bed drains are verified to be clear during each refueling outage. Applicants' Exhibits 32 and 33. Thus, there is no reason to "assume" that the sand bed drains will ever prevent drainage.

Q. 20: Dr. Hausler concludes, in A.17, that "it appears likely that some water will be present on the surface of the drywell during refueling outages, and it is not possible to rule out the potential for water from other sources to enter during operations." Do you agree?

A. 20: (All) No. Leakage from the reactor cavity is the only known source of water on the exterior of the drywell shell in the sand bed region. Moreover, AmerGen's commitments effectively eliminate the potential for water leakage from the refueling cavity onto the drywell shell exterior, during the only time when the reactor cavity is filled with water. Furthermore, the 2006 outage inspections clearly demonstrate that with these commitments in place, water is not expected to enter the external sand bed region. Nothing in Dr. Hausler's Direct Testimony or Citizens' Statement demonstrates anything to the contrary.

Q. 21: Does this conclude your testimony?

A. 21: (All) Yes.

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

John F. O'Rourke 8-15-2007

John F. O'Rourke Date

Ahmed N. Ouaou 8/15/2007

Ahmed Ouaou Date

Francis H. Ray Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

______________________________ ____________________

John F. O'Rourke Date

______________________________ ____________________

Ahmed Ouaou Date

______________________________ 8/15/07

Francis H. Ray Date

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of:	August 17, 2007
AmerGen Energy Company, LLC	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear Generating Station)	

AMERGEN'S PRE-FILED REBUTTAL TESTIMONY
PART 5
THE EPOXY COATING

I. WITNESS BACKGROUND

Q. 1: Please state your names and current titles. The Board knows that a description of your current responsibilities, background and professional experience was provided in Parts 4 and 5 of AmerGen's pre-filed Direct Testimony on July 20, 2007, so there is no need for you to repeat that information here.

A. 1: (JRC) My name is Jon R. Cavallo. I am Vice President of Corrosion Control Consultants and Labs, Inc., and Vice-Chairman of Sponge-Jet, Inc.

(AO) My name is Ahmed Ouaou. I am a registered Professional Engineer specializing in civil/structural design and an independent contractor.

Q. 2: What is the purpose of this Rebuttal Testimony?

A. 2: (All) The purpose of this Rebuttal Testimony is to specifically address the information provided in Citizens' Initial Statement of Position Regarding Relicensing of Oyster Creek Nuclear Generating Station ("OCNGS"), and in the Pre-Filed Direct Testimony of Dr. Rudolf H. Hausler, regarding the epoxy coating system installed on the exterior of the OCNGS drywell shell in the sand bed region.

Q. 3: Please summarize your conclusions.

A. 3: (All) We have reviewed Citizens' Statement and Dr. Hausler's testimony. First, we conclude that the Board should accord very little, if any, weight to Dr. Hausler's testimony on the epoxy coating system, because his professional expertise and qualifications are lacking with respect to such systems. Second, we address the specific allegations in Dr. Hausler's testimony. These include, among other things, his allegations that visual inspections will not detect the early stages of coating failure, and that the lifespan of the coating system is ten to twenty years. We show that those allegations are either speculative or incorrect, and were in most cases addressed in our Direct Testimony.

II. DR. HAUSLER IS POORLY QUALIFIED TO TESTIFY ABOUT THE EPOXY COATING SYSTEM

Q. 4: Mr. Cavallo, what is your opinion regarding Dr. Hausler's qualifications in the field of epoxy coating systems?

A. 4: (JRC) I have reviewed the materials that Citizens have submitted related to Dr. Hausler's professional qualifications, and I have found no clear evidence or documentation to support his specific expertise on the subject of epoxy coatings or the use of coatings to protect carbon steel substrates from corrosion.

In particular, I have reviewed Dr. Hausler's description, in his July 29 memorandum (at 2), of his work on "oil field tubulars" which "are frequently internally coated." He implies that he is familiar with coatings "based on epoxy chemicals (Tuboscope's TK-7, for instance)." July 29, 2007 Memorandum at 2.

Q. 5: Is Dr. Hausler's experience relevant to the OCNGS exterior drywell shell epoxy coating system?

A. 5: (JRC) It does not appear to be. The experience Dr. Hausler describes is fundamentally inapplicable to the issue of exterior drywell shell corrosion in the sand bed region for two reasons. First, the operating environment of the external drywell shell in the sand bed region is entirely different from that of the "oil field tubulars" that Dr. Hausler describes. Based on Dr. Hausler's own publications, such oil field applications generally involve continuous immersion service with highly corrosive pressurized fluids, corrosive gases and continuous fluid flow. In contrast, the sand bed region is exposed to a relatively benign non-immersion environment. As described by Barry Gordon in his Direct Testimony (Part 6, A.10), any fluids which may occasionally be present in the sand bed region would be relatively non-corrosive. Such fluids also would not be pressurized. In addition, there is no potential for high-velocity fluid-flow across the external OCNGS drywell shell in the sand bed region.

Second, Dr. Hausler's primary area of expertise is clearly in the field of chemical corrosion inhibitors, *i.e.*, fluid additives, and specifically in oil and gas production facilities – – and not in epoxy coating systems. The Tuboscope TK-7 product that he describes (July 29, 2007 Memorandum at 2) is a thin-film, modified phenolic coating specifically formulated for use in high-temperature and high-pressure gas production environments containing carbon dioxide and hydrogen sulfide. (Applicant's Exhibit 34). It is not chemically similar to the epoxy coating system applied to the OCNGS drywell shell. Thus, in my opinion Dr. Hausler has shown little, if any, expertise or experience applicable to the OCNGS epoxy coating system.

III. COATING SYSTEM ROBUSTNESS AND EXPECTED LIFE SPAN

Q. 6: Dr. Hausler states, in A.21, that, "it is not reasonable to assume that visual inspection could detect the early stages of coating failure." Do you agree?

A. 6: (All) No. There is no factual support for this statement. The use of visual inspections to detect coating failures is not based upon simple "assumptions" but is based, instead, on established industry practice. Dr. Hausler's statement contradicts current industry and regulatory practices for in-service inspections of nuclear power plant coatings, including ASME Code Section XI requirements and practices. ASME Section XI, Subsection IWE is mandated by 10 CFR 50.55a. ASME Section XI, Subsection IWE recognizes that containments are coated and requires a visual inspection of the coating to identify ongoing corrosion of the containment vessel under the coating. NRC has endorsed these practices in the GALL Report (NUREG-1801, Vol. 2, Appendix xi.S8).

(JRC) Thus, as I described in my Direct Testimony, "VT-1 inspections performed by qualified inspection personnel are the ASME Code-approved means of assessing the condition of a coating system." (Part 5, A.11) Further, as I previously testified (Part 5, A.3), I also have served as principal investigator in a recent Electric Power Research Institute ("EPRI") study which confirms that visual inspections would detect the early signs of coating system failure, contrary to Dr. Hausler's opinion.

Q. 7: How are the early stages of coating failure detected?

A. 7: (JRC) I would expect early indications of epoxy coating failure to include pinpoint rusting and rust staining, long before widespread coating failure in the form of cracking and delamination. In a benign non-immersion environment, such as the OCNGS external sand bed region, such indications would develop at a very slow rate, over a period of years. Thus, based on my years of experience analyzing failure in epoxy coating systems, Dr. Hausler's speculation about the inability of visual inspections to "detect the early stages of coating failure" is simply not technically credible. Instead, I would expect visual inspections, at the four-year interval required by AmerGen's commitments, to detect the early stages of coating failure.

Q. 8: Citizens claim that the "lifespan of the coating has been estimated at anything from ten to twenty years." (A.21) For support, Citizens cite to your testimony (Mr. Ouaou) before the Advisory Committee on Reactor Safeguards ("ACRS") License Renewal Subcommittee. (Dr. Hausler testimony, Attachment 5, page 17) Do you agree with Citizens' estimate of the epoxy coating system lifespan?

A. 8: (AO) No. The estimated coating system life of ten to twenty years that I provided in my ACRS testimony was based on conservative engineering judgments undertaken by OCNGS personnel in the 1990s, around the time that the epoxy coating was installed. (Citizens' Exhibit 16 at 61:12-22). As I also explained to the ACRS, further research, including discussions with the coating system vendor, led AmerGen to the conclusion that the life span limit for the epoxy coating system is not limited to ten to twenty years in the sand bed region environment. (Citizens' Exhibit 16 at 61:12-22).

Jon Cavallo's Direct Testimony (Part 5, A.8 and A.9) addresses the life span of the epoxy coating system and reaches the same conclusions. First, based on my engineering experience, I agree with Mr. Cavallo that the OCNGS "epoxy coating system is in a relatively benign environment in terms of exposure to elevated temperature, mechanical damage, submersion in water, radiation, and UV light. Thus, none of the factors that would be most likely to contribute to deterioration of the coating over time are present." (Part 5, A.9) Second, I agree that the "short life-span estimates [provided in the 1990s], particularly in this environment, are overly conservative." (Part 5, A.9) Third, I also agree that "AmerGen's inspection program" should "identify the early signs of deterioration, long before widespread coating failure could take place." (Part 5, A.9)

(All) Thus, based on our experience, we both believe that "[t]he epoxy coating system should last for the life of the plant, including the extended period of operation, provided that proper inspections are conducted and, in the unlikely event that defects are identified, necessary corrective maintenance is performed. With appropriate inspections and proper maintenance, the coating system should last decades." (Part 5, A.8)

Q. 9: Dr. Hausler, in A.21, and Citizens, on page 21 of their Statement, draw an analogy between the defects discovered in the sand bed region epoxy floor in 2006 and the potential for deterioration of the epoxy coating system covering the exterior drywell shell. Specifically, Citizens state that these defects show "that the potential for the epoxy coating [on the exterior drywell shell] to deteriorate is not mere speculation." What is your opinion of this analogy?

A. 9: (JRC) It is Dr. Hausler and Citizens who are speculating as to the cause of the deterioration of the floor coating, based on limited understanding of the evidence. In order to explain why their statements lack a factual basis, some background on the application of epoxy to the sand bed region floor is required.

When the sand was removed in the early 1990s, the sand bed concrete floor was found to be cratered and unfinished. The concrete floor was repaired, finished, and built up to permit proper drainage of the sand bed region, using the same epoxy that was used to coat the drywell shell. This is described in Applicant's Exhibit 3, at 4-3 and 6-13.

During the 2006 outage, OCNGS personnel discovered that in isolated areas, the epoxy coating on the sand bed region floor had separated from its interface with the concrete shield wall. This discovery and repair is described in Applicant's Exhibit 3, at 7-3. These defects have no bearing on the epoxy coating system covering the drywell shell. First, the curing of epoxy poured thickly onto the concrete floor of the exterior sand bed to build up the floor, and the mechanism behind isolated cracking of that thickly poured epoxy are different than for the comparatively thinly-coated drywell shell. Second, the adherence of the epoxy to concrete is different than for prepared metal. Finally, the epoxy coating system applied to the carbon steel shell includes a pre-prime sealer that "soaks and penetrates into the semi-irregular surface of the steel substrate and promotes coating system adhesion." (Part 5, A.6) No such pre-primer was applied to the concrete. Thus, no analogy can be drawn between the defects discovered at the concrete shield wall and on the sand bed region floor and speculative deterioration of the epoxy coating system on the drywell shell.

IV. APPLICATION OF THE COATING SYSTEM

Q. 10: Dr. Hausler has testified that "[i]t is likely that there were defects in the coating when it was applied, because no electrical testing of the applied coating was performed." (Part 5, A.21) In previous testimony, he has claimed that "there are always holidays present, albeit perhaps few." (Citizens' Exhibit 12 (April 25, 2007 Memorandum at 8)) Do you agree with these statements?

A. 10: (JRC) No. First, it must be noted that the mere fact that there was no electrical testing does not *cause* defects in the coating, nor does it make such defects "likely." Also, as I explained in my Direct Testimony, the "three-layer system chosen by OCNGS and the techniques and tools used in the application provide reasonable assurance that such potential pinholes or holidays would not extend through the three layers to expose the underlying metal substrate." (Part 5, A.14)

Second, as I further explained in my direct testimony, Part 5, A.14:

> [P]inholes or holidays would have existed since the coating was applied during the 1992 refueling outage. And water was reported to be present in the external sand bed region when strippable coating was not used on the reactor cavity liner during the 1994 and 1996 refueling outages. The

corrosion that would have resulted from that water entering pinholes or holidays would be visible today due to the volume of corrosion products (iron oxides) and surface rust staining caused by the corrosion process.

Q. 11: In Part 5, A. 7 of your direct testimony, you state that "as described in the manufacturer's data sheet, [the epoxy coating] is designed for continuously submerged environments such as water tank bottoms." What data sheet were you referring to?

A. 11: (JRC) I was referring to the Devoe Coatings data sheets for the "Devran 184, 100% Solids Epoxy Tank Coating" and "Pre-Prime 167, Rust Penetrating Sealer" that were attached to the materials that AmerGen submitted to the ACRS in December 2006. The specific data sheets are available on the NRC's website (ML063490343, beginning at page 299). They are also attached as Applicant's Exhibit 35. That Devran 184 data sheet clearly describes that the coating—two coats of which were applied to the exterior of the drywell shell in the sand bed region—is designed for continuously submerged environments.

V. OSMOTIC DIFFUSION

Q. 12: Dr. Hausler also alleges it is possible for "slow diffusion of water and corrosive gases across the epoxy boundary" that could cause "delamination, blister formation and subsequent breaking of the bubble and rapid attack of the metal." (Letter from R. Hausler to R. Webster, July 29, 2007). He makes a similar allegation in Citizens' Exhibit 12 (April 25, 2007 Memorandum) at 7. Can water or corrosive gases diffuse through the drywell shell epoxy coating system to cause corrosion in this manner?

A. 12: (JRC) No. The osmotic diffusion phenomenon Dr. Hausler describes is inapplicable to the present situation, because there is no potential for long-term or continuous immersion of the epoxy coating system in the OCNGS exterior sand bed region. Without such continuous immersion, osmotic diffusion and blistering cannot occur. And there are no corrosive gases present in the exterior OCNGS sand bed region, so diffusion of such gases is not an issue here.

Q. 13: Does this conclude your testimony?

A. 13: (JRC, AO) Yes.

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

Jon R. Cavallo — August 15, 2007

Jon R. Cavallo | Date

Ahmed Ouaou | Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

Jon R. Cavallo Date

Ahmed M Ouaou 8/15/2007

Ahmed Ouaou Date

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of:	)	August 17, 2007
AmerGen Energy Company, LLC	)	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear Generating Station)	)	

AMERGEN'S PRE-FILED REBUTTAL TESTIMONY PART 6 FUTURE CORROSION

I. WITNESS BACKGROUND

Q. 1: Please state your names and current titles. The Board knows that a description of your current responsibilities, background and professional experience was provided in Parts 1, 2 and 6 of AmerGen's Pre-Filed Direct Testimony on July 20, 2007, so there is no need for you to repeat that information here.

A. 1: (BG) My name is Barry Gordon. I am an Associate with Structural Integrity Associates, Inc. ("SIA"), located in San José, California.

(MPG) My name is Michael P. Gallagher, and I am Vice President of License Renewal for Exelon.

(PT) My name is Peter Tamburro, and I am a Senior Mechanical Engineer in the Engineering Department at the Oyster Creek Nuclear Generation Station ("OCNGS").

Q. 2: Would you please summarize the purpose of this Rebuttal Testimony?

A. 2: (All) The purpose of this testimony is to respond to the Pre-Filed Direct Testimony of Dr. Rudolf Hausler that discusses the potential for future corrosion of the exterior drywell shell in the sand bed region, and to address the potential for corrosion of the interior embedded surface of the drywell shell.

Q. 3: What is your overall conclusion?

A. 3: (All) Our overall conclusion is that Dr. Hausler's experience and expertise is extremely limited in this area. His testimony is based on inapplicable analyses and mistaken assumptions about corrosion mechanisms. Dr. Hausler appears to be using analyses developed from his experience in oil field applications that, from the limited information he provides, appear inapplicable to the actual conditions of the drywell shell in the sand bed region at OCNGS. In addition, potential corrosion on the interior embedded surface of the drywell shell is insignificant for purposes of license renewal.

II. DR. HAUSLER IS POORLY QUALIFIED TO TESTIFY ABOUT POTENTIAL CORROSION MECHANISMS

Q. 4: What is your opinion regarding Dr. Hausler's expertise in corrosion? In particular, please address his expertise in corrosion of carbon steel in environments similar to the exterior sand bed region at OCNGS.

A. 4: (BG) I have reviewed Dr. Hausler's résumé and the other materials submitted in support of his qualifications, and some of his publications. From that review, it appears that Dr. Hausler's experience is primarily in oil-field applications, where the corrosion mechanism may be pitting corrosion, erosion-corrosion, corrosion fatigue, etc. in high temperature, highly aggressive environments containing hydrogen sulfide, carbon dioxide, organic acids, etc. This contrasts with general corrosion of carbon steel in stagnant wet oxygenated environments, such as the historical conditions in the exterior sand bed region at OCNGS, where the corrosion rate is expected to decrease with time, for the reasons I describe below.

Q. 5: Dr. Hausler has testified that "the corrosion rate (rate of deterioration) in pitting situations as well as on coated materials, increases exponentially with time. Hence, past performance is no indication of what may happen in the future." (A.21) Why is that statement incorrect for the exterior sand bed region at OCNGS?

A. 5: (BG) It is incorrect because the relevant corrosion mechanism for the drywell shell in the OCNGS sand bed region is general corrosion not pitting corrosion. Dr. Hausler's misconception that the OCNGS corrosion rate "increases exponentially with time" appears to be based on experience that is simply inapplicable to the exterior sand bed region.

Q. 6: What is the relevant difference between general and pitting corrosion?

A. 6: (BG) General corrosion is a form of corrosion that occurs fairly uniformly over a metal surface, while pitting is localized corrosion experienced only on materials that form a protective passive film on the surface. The rate of general corrosion typically decreases exponentially over time, *i.e.*, in proportion to the square root of time. This is due to the diffusion-limiting control of the kinetics of the corrosion reaction, *i.e.*, the outward diffusion of metal ions and/or the inward diffusion of dissolved oxygen through the corrosion film to the metal surface. In other words, the corrosion products formed on the surface form a barrier film that inhibits the corrosion reaction. Thus, as well documented in the laboratory and in the field, the general corrosion rate of carbon steel in oxygenated water will decrease, not increase with time.

Q. 7: So, Dr. Hausler has confused pitting vs. general corrosion?

A. 7: (BG) Yes. Dr. Hausler incorrectly describes the corrosion mechanism associated with the drywell shell as "pitting." Pitting corrosion is the localized, accelerated dissolution of metal that occurs as a result of a breakdown of the otherwise protective passive film on the metal surface. Many alloys, such as stainless steel and aluminum alloys, are useful for industrial purposes because of the passive films (which are thin, nanometer scale, oxide layers) that form naturally on the metal surface. Such passive films, however, are often susceptible to localized breakdown resulting in accelerated dissolution of the underlying metal. If the attack initiates on an open surface, it is called pitting corrosion and if the attack initiates at an occluded site, it is called crevice corrosion. The corrosion film formed on carbon steel exposed to low-temperature oxygenated water is not passive, and so the drywell shell is susceptible to general corrosion, *not* pitting corrosion. And the rate of general corrosion does not increase with time, much less increase at an exponential rate.

Finally, in pitting corrosion, the change in pit depth usually slows with time. A typical exponent for pit growth is the same for general corrosion, *i.e.,* 0.5, which is the ideal value for pit growth. Sometimes the exponent is greater than 0.5, but it is often less than 0.5, and usually between 0.3 and 0.5.

Additionally, I reviewed core samples from the OCNGS drywell shell taken during the 1980s when I worked at GE, and the corrosion mechanism was classic general corrosion.

Q. 8: If pitting corrosion would not occur on the carbon steel drywell shell, can you explain the reference to minor "pitting" on the interior of the drywell in the AmerGen email which was attached to Citizens' Direct Testimony as Citizens' Exhibit 26?

A. 8: (BG) General corrosion often has the general appearance of "pitting," *i.e.*, a bunch of overlapping indentations or "pits," especially to someone who is not a corrosion engineer. The statements by the person characterizing the corrosion in Citizens' Exhibit 26 do not support a conclusion that pitting corrosion is occurring or has occurred on the inside of the drywell shell.

III. INTERNAL DRYWELL SHELL SURFACE

Q. 9: Is there a potential for corrosion on the interior embedded drywell surface?

A. 9: (BG) Not anything that would be significant for purposes of license renewal. Any corrosion would be vanishingly small and of no engineering concern.

Q. 10: What is the basis for that opinion?

A. 10: (All) First, AmerGen removed the concrete from a portion of the embedded drywell shell in the sand bed region in Bay 5 during the 2006 outage. This portion of the shell had been embedded in concrete since construction of OCNGS. There was no measurable corrosion on the surface of this newly-exposed shell. This demonstrates that the conditions inside the drywell will not lead to significant corrosion during the period of extended operation because interior drywell conditions over the next 22 years are expected to be the same as over the past 38 years.

(BG) Second, any water that would be in contact with the interior surface of the embedded drywell shell would have a high pH caused by its contact with the concrete and/or concrete pore water. This high pH is caused by the abundant amounts of calcium hydroxide, and relatively small amounts of compounds of alkali elements sodium and potassium, in the concrete. Water samples collected from the inside of the drywell shell during the 2006 outage were measured to have a pH of approximately 8.4 to 10.2 and low levels of chloride and sulfate, which is consistent with NRC Generic Aging Lessons Learned (GALL) Report (Vol. 2, Rev. 1, at II A.1 through 5) and EPRI embedded steel guidelines for an environment that poses no aging management concerns. These water samples also had high levels of calcium which indicate slow migration through the concrete. Any subsequent water ingress into the concrete floor will also become high pH concrete pore water. That is why, based on commonly accepted scientific principles and my decades of experience, any corrosion of the embedded carbon steel drywell shell due to this water would be vanishingly small and of no engineering concern.

(PT, MPG) In addition, the air inside the drywell shell is inerted with nitrogen during operations, severely reducing the oxygen available to allow corrosion.

Q. 11: What do you mean that the inside of the drywell is inerted with nitrogen during operations?

A. 11: (PT, MPG) The interior of the drywell is air tight during operations. Ambient air is present in the drywell during outages, but is replaced with nitrogen for operations. AmerGen is permitted to operate OCNGS with up to 4% oxygen inside the drywell (which is slightly lower than the value provided in Citizens Exhibit 27). However, the drywell is typically operated with an oxygen concentration of less than 2%.

Q. 12: What is the impact on potential corrosion of the interior embedded drywell shell of this reduced oxygen concentration?

A. 12: (BG) There would be an order of magnitude less oxygen available to support corrosion. In any event, oxygen is not the limiting factor for potential corrosion of the interior embedded drywell shell surface where the presence of the concrete itself provides a protective pH of any water that would be adjacent to the drywell shell. Thus, the amount of oxygen has less importance here than it would for carbon steel not embedded in concrete.

Q. 13: Citizens' Exhibit 36, which includes an email from MPR Associates to AmerGen, states that "the protective pH cannot be presumed to exist during outages anywhere below 10'3" level in the [drywell]. [Structural Integrity] should evaluate the effect of combined oxygen and lower pH on corrosion during outages to estimate how much corrosion will occur during each outage, and show by calculation that it is insignificant." Can you explain what you did, if anything, in response to this recommendation?

A. 13: (BG) I do not recall performing any additional analyses in response to MPR's comment. In fact, I disagree with the comment that protective pH cannot be assumed to exist during outages beneath the interior drywell floor. In my opinion, the concrete will leach calcium hydroxide shortly after the water comes into contact with the concrete floor. Significant corrosion during outages or operations is not expected and has not been observed. If it had occurred, those who observed the internal surface of the drywell shell for the first time (it had previously been embedded in concrete) would have noticed it. Rather, their descriptions of the condition of the shell, as provided in Citizens' Exhibit 26, for example, do not support significant corrosion over the operating history of OCNGS, let alone just during outages.

IV. POTENTIAL CORROSION RATE

Q. 14: Dr. Hausler estimates a potential future corrosion rate for both sides of the drywell shell of 0.041" per year (A.16). Is this reasonable?

A. 14: (BG) No. I would first point out that Dr. Hausler appears to entirely ignore the limited exposure period (time of wetness = T_w) which, as I previously estimated based on Part 6 of my Direct Testimony, is limited to "approximately 30 days every 24 months." (A.13)

In my Direct Testimony, I applied the rate cited by Citizens of 0.017" per year to derive a total amount of potential corrosion expected during a month-long refueling outage at approximately 0.001". (A.15) Even if I were to adopt Dr. Hausler's speculative assumption that 0.002" per year of interior corrosion can take place (Hausler Direct, A.16), it would only result in a total expected corrosion of 0.005" (0.001" + 0.002" + 0.002") over two years. I must emphasize, however, that 0.002" per year interior corrosion is unrealistic for the reasons I describe above.

That being said, Dr. Hausler's Direct Testimony now estimates the potential total corrosion rate to be 0.039" per year, which I previously cited in my Affidavit Supporting Summary Disposition as the highest estimate of historical corrosion ever measured in the exterior OCNGS sand bed region.

Q. 15: Is it realistic to use a corrosion rate of 0.039" per year?

A. 15: (BG) No. In my Affidavit, I did not state that a future annual corrosion rate of 0.039" is realistic. In fact, I described a future scenario using this high rate as "unrealistic and overly conservative." This is because the conditions that existed at the time of this measurement are no longer present and would not be replicated there again. So even if the epoxy coating were to fail and water were to contact the underlying metal drywell shell, I would not expect corrosion to take place at the highest rate measured historically.

Nevertheless, if I assumed that the highest levels of corrosion ever experienced in the sand bed region could recur, the total potential corrosion during a refueling outage would be calculated as follows: I would divide 0.039" by 365 days to get a daily corrosion rate of 0.0001069" per day. I would then multiply this corrosion rate by 30 days to compute the total corrosion expected during a month-long refueling outage over two years, which is about 0.003". Even if we also account for Dr. Hausler's speculation about corrosion from the interior, we still only have slightly more than 0.007" (0.003" + 0.002" + 0.002") of potential corrosion over two years.

Q. 16: Dr. Hausler claims, in A.22, that AmerGen has not accounted for the high historical corrosion rates experienced in the sand bed region in its "latest acceptance calculations." Is this correct?

A. 16: (All) He is correct. However, the historical conditions that permitted these levels of corrosion are no longer present at OCNGS. It would be unreasonable and contrary to existing conditions to apply the high historical corrosion experienced when there was sand and essentially standing water in the sand bed.

Further, Dr. Hausler's analysis assumes that the exterior coating fails *and* that water would be present at all times. (A17, A21). Since AmerGen has taken multiple steps to mitigate water ingress into the region, the probability of water entering the sand bed region is very low. And the probability of such water entering the sand bed region undetected is even lower.

More importantly, Dr. Hausler fails to address the possible exposure period of the water, *i.e.*, the time of wetness. Since the known source of water on the exterior drywell shell occurs only when the reactor cavity is filled, the possible time of wetness is limited to approximately 30 days every 24 months. And Mr. Hosterman explained in his Direct Testimony that any water that might exist on the surface of the drywell shell at the end of an outage "would evaporate in a couple of hours." (Part 6, A.19)

Thus, there is no credibility to Dr. Hausler's analysis.

Q. 17: What future corrosion of the drywell shell in the sand bed region would you expect?

A. 17: (BG) Near zero. For the external surface, as I explained in my Direct Testimony: "[t]here can be no future corrosion unless the epoxy coating system fails in some manner . . . . The epoxy coating will prevent water with its dissolved cathodic reactant oxygen from coming into contact with the underlying metal shell." (Part 6, A.11) Even if the epoxy coating system fails, "I still need the ongoing presence of water . . . to have corrosion of the underlying carbon steel drywell shell." (Part 6, A.12) For the internal surface, the presence of concrete adjacent to a wetted drywell shell in the sand bed region limits corrosion to insignificant levels.

V. CONCLUSIONS

Q. 18: Please summarize your conclusions regarding Dr. Hausler's analysis of potential future corrosion in the sand bed region.

A. 18: (All) In summary, Dr. Hausler's testimony on the topic of potential future corrosion is based on inapplicable analyses and incorrect assumptions. Accordingly, Dr. Hausler's testimony should be given little weight. AmerGen has taken into account the actual conditions of the drywell shell in the sand bed region, and the actual potential corrosion mechanisms. Based on this, we conclude that AmerGen has established an appropriate aging management program.

Q. 19: Does this conclude your Rebuttal Testimony regarding the potential for future corrosion of the drywell shell in the sand bed region?

A. 19: (All) Yes.

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

[signature] 8/14/07

Barry Gordon Date

Michael P. Gallagher Date

Peter Tamburro Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

________________________ ________________

Barry Gordon Date

Michael P. Gallagher 08-15-07

Michael P. Gallagher Date

________________________ ________________

Peter Tamburro Date

In accordance with 28 U.S.C. § 1746, I state under penalty of perjury that the foregoing is true and correct:

_______________________________ _______________

Barry Gordon Date

_______________________________ _______________

Michael P. Gallagher Date

Pet Tam 8/16/07

Peter Tamburro Date

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	August 17, 2007
AmerGen Energy Company, LLC	)	
	)	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear Generating Station)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of "AmerGen's Rebuttal Statement of Position," with supporting testimony and exhibits, were served this day upon the persons listed below, by e-mail and first class mail, unless otherwise noted.

Secretary of the Commission*
U.S. Nuclear Regulatory Commission
Attn: Rulemakings and Adjudications Staff
One White Flint North
11555 Rockville Pike
Rockville, Maryland 20852-2738
(E-mail: HEARINGDOCKET@nrc.gov)

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

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

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

John A. Covino
Valerie Anne Gray
Division of Law
Environmental Permitting and Counseling Section
P.O. Box 093
Hughes Justice Complex
Trenton, NJ 08625
(E-mail: john.covino@dol.lps.state.nj.us)
(E-mail: valerie.gray@dol.lps.state.nj.us)

Office of Commission Appellate Adjudication**
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Richard Webster
Rutgers Environmental Law Clinic
123 Washington Street
Newark, NJ 07102-5695
(E-mail: rwebster@kinoy.rutgers.edu)

Suzanne Leta
NJPIRG
11 N. Willow Street
Trenton, NJ 08608
(E-mail: sleta@njpirg.org)

Paul Gunter
Beyond Nuclear
6930 Carroll Avenue
Suite 400
Takoma Park, MD 20912
(E-mail: paul@beyondnuclear.org)

Mitzi A. Young
Mary C. Baty
Office of the General Counsel, 0-15D21
U.S. Nuclear Regulatory Commission
Washington, DC 20555
(E-mail: may@nrc.gov)
(E-mail: mcb1@nrc.gov)

Debra Wolf
Law Clerk
Atomic Safety and Licensing Board
Mail Stop: T-3 F23
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001
(E-mail: daw1@nrc.gov)

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Brian P. Oldham

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of:	)	August 17, 2007
AmerGen Energy Company, LLC	)	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear Generating Station)	)	

AMERGEN'S PRE-FILED REBUTTAL TESTIMONY EXHIBITS

EXHIBITS 25-36

Location ID	1992		1994		1996		2006				1992, 1994, 1996, and 2006
	Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error	2006 lower 95% Confidence	2006 Upper 95% Confidence	Grand Standard Error
	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils
9D	1004	10.0	992	10.4	1008	10.6	993	11.2	965.1	1010	5.1
11A	825	8.2	820	7.7	830	8.7	822	8.0	804.7	838.4	4.0
11C All	909	13.4	894	11.7	951	15.1	898	12.8	872.2	924.3	5.8
11C Bot	860	6.4	850	4.5	883	7.4	855	4.5	847.1	865.0	3.1
11C Top	970	23.8	982	23.4	1042	21.4	958	24.7	NC	NC	12.3
13A	858	9.6	837	7.8	853	8.8	846	8.2	829.3	862.3	4.3
13D All	973	13.3	958.9	12.7	989	11.6	968	12.9	942.3	994.1	6.3
13D Bot	906	9.0	895	8.2	933	9.6	904	8.9	886.0	922.0	4.6
13D Top	1055	14.1	1037	13.6	1059	11.2	1047	13.7	NC	NC	7.4
15D	1058	8.7	1053	9.0	1066	8.5	1053	8.9	1035	1071	4.4

APPLICANT'S EXH. 25

Location ID	1992		1994		1996		2006				1992, 1994, 1996, and 2006
	Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error	2006 lower 95% Confidence	2006 Upper 95% Confidence	Grand Standard Error
	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils
17A All	1022	15.0	1017	15.5	1058	13.0	1015	15	985.3	1045.0	7.4
17A Bot	942	11.8	934	10.7	997	10.7	935	10.5	914.2	956.6	5.9
17A Top	1125	7.2	1129	6.8	1144	11.1	1122	7.2	NC	NC	4.1
17D	817	9.2	810	9.4	848	9.0	819	9.5	798.8	838.6	4.7
17/19 All	983	4.2	970	4.9	980	4.6	969	4.0	961.1	977.0	2.3
17/19 Bot	989	6.3	975	7.8	990	6.2	972	5.9	960.6	984.3	3.4
17/19 Top	976	4.8	963	4.9	967	6.0	964	4.8	NC	NC	2.6
19A	800	8.4	806	9.9	815	9.6	807	8.9	787.8	825.3	4.6
19B	840	8.7	824	7.8	837	9.5	848	8.6	830.2	864.6	4.3
19C	819	11.0	820	10.5	854	11.8	824	11.3	800.1	847.6	5.6
1D	1121	5.0	1101	10.0	1151	13.6	1122	8.4	1100	1144	10.6

Location ID	1992		1994		1996		2006				1992, 1994, 1996, and 2006
	Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error	2006 lower 95% Confidence	2006 Upper 95% Confidence	Grand Standard Error
	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils	Mils
3D	1182	5.2	1184	4.9	1175	7.5	1180	5.7	1166	1193	2.8
5D	1182	7.0	1168	2.6	1173	2.2	1185	2.0	1180	1189	2.2
7D	1137	6.1	1136	4.3	1138	5.9	1133	6.5	1117	1148	2.7
9A	1157	4.1	1157	4.5	1155	4.8	1154	4.2	1144	1164	2.1
13C	1149	1.9	1140	3.8	1154	3.2	1142	3.1	1135	1150	1.8
15A	1133	11.5	1114	16.3	1127	10.8	1121	16.6	1082	1160	6.6

NC- Indicates that the Lower and Upper 95% confidence interval were not accurately computed in C-1302-187-E310-041 Rev. 0

General Thickness at 19 Grid Locations

AmerGen

Location		Pre-1992	May 1992	Sept. 1992		1994		1996		2006		Min. Req'd	Nominal Thick.	Margin
				Thick	Std Error	Thick	Std Error	Thick	Std Error	Thick	Std Error			
1D		1115				1101	±10.0	1151	±13.6	1122	±8.4			365
3D		1178				1184	±4.9	1175	±7.5	1180	±5.7			439
5D		1174				1168	±2.6	1173	±2.2	1185	±2			432
7D		1135				1136	±4.3	1138	±5.9	1133	±6.5			397
9A		1155				1157	±4.5	1155	±4.8	1154	±4.2			418
9D		992	1000	1004	±10.0	992	±10.4	1008	±10.6	993	±11.2			256
11A		833	842	825	±8.2	820	±7.7	830	±8.7	822	±8.0			84
11C	Bot	856	882	859	±6.4	850	±4.5	883	±7.4	855	±4.5			114
	Top	952	1010	970	±23.8	982	±23.4	1042	±21.4	958	±24.7			216
13A		849	865	858	±9.6	837	±7.8	853	±8.8	846	±8.2			101
13D	Bot	900	931	906	±9.0	895	±8.2	933	±9.6	904	±8.9			159
	Top	1048	1088	1055	±14.1	1037	±13.6	1059	±11.2	1047	±13.7	736	1154	301
13C				1149	±1.9	1140	±3.8	1154	±3.2	1142	±3.1			404
15A		1120				1114	±16.3	1127	±10.8	1121	±16.6			378
15D		1042	1065	1058	±8.7	1053	±9.0	1066	±8.5	1053	±8.9			306
17A	Bot	933	948	941	±11.8	934	±10.7	997	±10.7	935	±10.5			197
	Top	999	1125	1125	±7.2	1129	±6.8	1144	±11.1	1122	±7.2			263
17D		822	823	817	±9.2	810	±9.5	848	±8.9	818	±9.5			74
17/19	Top	954	972	976	±4.8	963	±4.9	967	±6.0	964	±4.8			218
Frame	Bot	955	990	989	±6.3	975	±7.8	991	±6.2	972	±5.9			219
19A		803	809	800	±8.4	806	±9.9	815	±9.6	807	±8.9			64
19B		826	847	840	±8.7	824	±7.8	837	±9.5	848	±8.6			88
19C		822	832	819	±11.0	820	±10.5	854	±11.8	824	±11.3			83

Note: Shaded cells indicate thickness value used to conservatively calculate the margin

APPLICANT'S EXH. 26

APPLICANT'S EXH. 27

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DRF 143164

GPU Nuclear
Technical Data Report

TDR No. 1108	Revision No. 0
Budget Activity No. 402950	Page 1 of 45
Project: Oyster Creek Drywell Vessel Corrosion Mitigation	Department/Section 5500/5550
	Revision Date

Document Title:
Summary Report of Corrective Action Taken from Operating Cycle 12 through 14R

Originator Signature	Date	Approval(s) Signature	Date
John C. Flynn	4/23/93	J. J. Colitz	4/29/93
Mark Yekta	4/28/93	[signature]	4/28/93
S K Saha	4/29/93	[signature]	4/28/93
		Approval for External Distribution	Date

Does this TDR include recommendation(s)? ☐ Yes ☒ No If yes, TFWR/TR# ______

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Abstract:

This report summarizes the activities performed by GPUN to mitigate the corrosion mechanism attacking the Oyster Creek Drywell vessel. The report provides a "road map" of the documents created to implement corrective actions taken during the 14R refueling outage.

A bay-by-bay discussion of the condition of the vessel, results of UT inspections and structural evaluation, with respect to code requirements, is included.

It is concluded that, by completing 14R activities, future corrosion has been stopped in the sand bed region, but that the pending pressure reduction submittal to NRC must be approved to provide a corrosion allowance for upper elevations.

*Abstract Only

N 0030 (02-88)

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The potential for corrosion of the drywell vessel was first recognized when water was noticed coming from the sand bed drains in 1980. It was confirmed by ultrasonic thickness (UT) measurements taken in 1986 during 11R. Since that time a great deal of evaluation, inspection, analysis, planning and corrective action has been directed toward mitigating the problem. The first extensive corrective action, i.e. installation of a cathodic protection system, proved to be ineffective.

In 1990 an intensified effort was initiated. As a result of laboratory experiments the corrosion mechanism in the sand bed was determined to be galvanic. The upper regions of the vessel, above the sand bed, were handled separate from the sand bed region because of the significant difference in corrosion rate and physical difference in design. Corrective action for the upper vessel involved providing a corrosion allowance by demonstrating, through analysis, that the design pressure was conservative. A Technical Specification change request was submitted to the NRC in July of 1991 to reduce the design pressure from 62 psig to 44 psig. The new design pressure, when approved, coupled with effective measures to prevent water intrusion into the gap between the vessel and the concrete will allow the upper portion of the vessel to meet ASME code for the projected life of the plant.

The high rate of corrosion in the sand bed region required prompt corrective action of a physical nature. Corrective action was defined as; (1) removal of sand to break up the galvanic cell, (2) removal of the corrosion product from the vessel and (3) application of a protective coating. Keeping the vessel dry was also identified as a requirement even though it would be less of a concern in this region once the coating was applied. The work was initiated during 12R by removing sheet metal from around the vent headers to provide access to the sand bed from the Torus Room. During operating cycle 13 some sand was removed and access holes were cut into the sand bed region through the shield wall. The work was finished during 14R.

After sand removal, the concrete floor was found to be unfinished with improper provisions for water drainage. Corrective actions taken in this region during the 14R outage included; (1) cleaning of loose rust from the drywell shell, followed by application of epoxy coating and (2) removing the loose debris from the concrete floor followed by rebuilding and reshaping the floor with epoxy to allow drainage of any water that may leak into the region.

During the 14R outage UT measurements of the drywell vessel were taken from the sand bed region. In general these measurements verified projections that had been made based on measurements taken from inside the drywell. There were however, several areas thinner than projected. In all cases these areas were found to meet ASME code requirements after structural analysis. The details of this analytical work are presented in Section 6 of this report.

The cleaning, reshaping and coating effort that was completed in 14R should mitigate corrosion in the sand bed area. Since this was accomplished while the vessel thickness was sufficient to satisfy ASME code requirements, the drywell vessel in the sand bed region is no longer a limiting factor in plant operation. Inspections will be conducted in future refueling outages to ensure that the coating remains effective. In addition, UT measurements will also be taken. The frequency and extent of these measurements will be evaluated after 15R.

DRYWELL CORROSION MITIGATION PROJECT

BA 402950

1.0 INTRODUCTION

1.1 Background

Leakage was observed from the drains in the sand bed, which surround the lower exterior surface of the carbon steel drywell vessel, during the 1980, 1983 and 1986 refueling outages. Inspections performed during the 1986 refueling outage 11R confirmed that corrosion was occurring in the sand bed region (elevation 8 feet, 11¼ inches to 12 feet, 3 inches). Later investigations confirmed that corrosion was also taking place at elevations above the sand bed. A program of repetitive ultrasonic thickness (UT) measurements was established to monitor the corrosion in the vessel. During 12R (1988) a cathodic protection system was installed in the sand bed region to minimize corrosion in this area where the rate of corrosion was greatest. The monitoring program was also expanded during 12R.

By the Spring of 1990 it was evident from the UT monitoring program that the cathodic protection system installed during 12R was not sufficient to abate the high corrosion rate in the sand bed. A multi discipline project team was formed and charged with identifying the corrosion mechanism and developing a corrective action plan. The team had determined by the fall of 1991 that the corrosion was galvanic in nature. Circumstances that helped to promote this phenomenon were the fact that water had leaked into the sand bed region and that the drain system failed. The water contained impurities that were leached out of the insulation material in the upper elevations. Corrective action for the sand bed region required that water leaking into the cavity be stopped and that the galvanic cell be broken.

It was determined that the original design pressure for the vessel was unrealistically high. A Technical Specification change request was developed and submitted to the NRC on July 7, 1991. The change involved a reduction in the design pressure for the vessel from 62 psig to 44 psig. When approved this will provide a corrosion margin, for the upper elevation, sufficient to insure ASME code compliance through the life of the plant.

1.2 Sand Bed Repair

To disrupt the galvanic cell, the water leak must be stopped and the sand in the sand bed region would have to be moved away from the vessel. Since the sand performed a structural function in the original design concept, removal of the sand had to be supported by analysis. GE Nuclear Energy Division of San Jose, California performed the above analysis. The results confirmed that if the sand was removed, the structure would still meet ASME code requirements. (See references 2.1 -2.3). Based on the results of this analysis a plan was developed to: (a) remove the sand, (b) clean the vessel of the corrosion product, (c) measure wall thickness from the exterior of the drywell, (d) weld repair of localized thin areas if necessary and (e) apply a protective coating.

2.0 REFERENCES

2.1 GE Nuclear Energy, DRF # 00664, Index No. 9-3, Revision 0 "An ASME Section VIII Evaluation of Oyster Creek Drywell for Without Sand Case - Part 1 Stress Analysis",

2.2 GE Nuclear Energy, DRF # 00664, Index No.9-4, Re 2 "An ASME Section VIII Evaluation of Oyster Creek Drywell thout Sand Case - Part 2 Stability Analysis"

2.3 Teledyne Engineering Services, "Justification for U ion III, Subsection NE, Guidance in Evaluating the Oyste: ywell", Technical Report TR-7377-1

2.4 OC-MM-402950-004, "Removal of Sand from Sand Bed"

2.5 OC-MM-402950-006, "Reactor Building Torus Wire Lif. pports"

2.6 ABB Impell Report No. 370194-01, "Structural Evalua of the Reactor Building with Manways in the Drywell Shield Wall t Oyster Creek Nuclear Station"

2.7 OC-MM-402950-009, "Setup for Boring Holes in Drywell Shield Wall"

2.8 OC-MM-402950-007, "Boring of Holes in Drywell Shield Wall"

2.9 MPR Associates, MPR-TR-83156-001, "Test Plan for Concrete Cutting Tests for Manway Holes in Shield Wall"

2.10 MNCR-93-0062, Reactor Building Shield Wall Concrete Formation, 1/25/93

2.11 FCN 088664, Cut Rebar Location

2.12 OC-MM-402950-010, "Cleaning and Coating the Drywell Exterior in the Sand Bed Area"

2.13 GPUN Memo, 5383-93-008, S.M. French to S.C. Tumminelli, "Oyster Creek Drywell Scale", dated 1/20/93

2.14 GPUN Laboratory Report 5383-92-1204, Rev.0, "Oyster Creek Drywell Scale Evaluation", dated 12/15/92

2.15 GPUN Calculation, #C-1302-243-5340-067, Rev.0, "Calculation for Drywell Wall Loss"

2.16 GPUN Memo, 5320-92-029, T. H. Chang to J. C. Flynn, "Assessment for F Frame Rebar Location at the Sand Bed Region", dated 2/5/93

2.17 MNCR-92-0188, Sand Bed Concrete Floor Condition, 12/28/92

2.18 GPUN Memo 5511-92-073, Baig to Distribution, dated 9/8/92.

2.19 GPUN TDR - 948, "Statistical Analysis of Drywell Thickness Data"

2.20 OC-IS-402950-008, "Drywell Vessel Thickness Examinations from Sand Bed"

2.21 GE Letter Report, "Sandbed Local Thinning and Raising the Fixity Height Analysis (Line Items 1 and 2 In Contract # PC-0391407)", dated December 11, 1992

2.22 GPUN Memo 5320-93-020, K. Whitmore to J.C.Flynn, "Inspection of Drywell Sand Bed Region and Access Holes", dated January 28, 1993.

2.23 GPUN Calculation # C-1302-187-5320-024, Rev. 0, Oyster Creek Drywell External UT Evaluation in Sandbed," dated 4/16/93.

2.24 Isotope Survey of Sand Removed from Oyster Creek Sand Bed.

2.25 GPUN System Chemistry Laboratory Analysis Report, dated 1/15/93, See DRF 133903.

3.0 CYCLE 13 WORK

3.1 Sheet Metal Removal

During the 13R outage (1991) sheet metal was removed from around the ten vent headers in the Torus room to provide access into the top of the sand bed region. Due to schedule constraints some of this work was deferred to the operating cycle.

3.2 Sand Removal

The high rate of drywell corrosion in the sand bed required that the sand be removed as soon as possible. To accomplish this, a scheme was devised to remove the sand through the vent header gaps and the holes put in the shield wall for cathodic protection installation by using a high volume vacuum machine (Vacuum Engineering Corporation VecLoader HEPA VAC). (See reference 2.4). The work was started in November of 1991 and stopped in April of 1992. Some sand was removed from all bays. Approximately sixty percent of the sand calculated to be in the sand bed (77 - 55 gallon drums of sand) was removed. Before work could be done from the top of the torus, the Safety department required that the existing safety line be replaced. (See reference 2.5).

3.3 Access Holes

Completion of the sand bed repair required access to the sand bed region. Access paths from both inside the drywell and from the Torus room were considered. With the aid of the Kepner Tregoe (KT) decision analysis technique, the Torus room option was finally chosen. A structural analysis of the Reactor building and the concrete shield wall was conducted by ABB Impell Corporation to determine if cutting access holes in the shield wall was acceptable structurally. The analysis was done for ten twenty inch diameter holes, one in the vicinity of each vent header. The results verified that this approach was acceptable. (See reference 2.6).

To expedite the work, since the results of the structural analysis were not available, the job was split into two work packages. One covered equipment setup (reference 2.7) and the other the actual cutting of the holes (reference 2.8).

A full scale mockup of one half a bay was constructed at the Forked River site adjacent to Building 2 to debug the core boring setup that would be used to cut the access holes in the drywell shield wall. MPR Associates developed a test plan for this purpose (reference 2.9). The mockup proved to be very useful. Several changes were made to the work packages as a result of the mockup tests. In addition, the mockup proved to be a valuable asset for training and orientating workers for the unique work environment associated with this project. A specialty contractor, Urban H.A.R.T, Inc., was retained to train Emergency Medical Technicians in rescue techniques, provide space training and acclimate workers to the sand bed environment.

Work platforms were built in four bays. The other six bays had platforms which were installed during the cathodic protection project. Temporary shielding was also installed next to the vent header to reduce worker radiation exposure.

The cutting process was initiated on 9/8/92 and completed on 11/19/92. The process included cutting ten holes completely through to the sand bed region and removing the concrete core for a distance of six feet (see Figure 1). The total length of the holes was approximately eight feet. Video cameras installed in the sand bed region through the vent header gap provided a clear picture of the drill bit as it broke through into the region. A concrete core approximately two feet thick was left in the hole to serve as a radiation shield during plant operation. The larger pieces of core material (rubble) were bagged and carried up to the 23 foot elevation. Small pieces were vacuumed up using an electric vacuum machine staged in the northeast corner room at the minus 19 foot elevation. In general, this phase of the work went very well. Much more steel was encountered in the shield wall than anticipated and this affected the overall productivity. In bays 15 and 9 voids were encountered that affected the drill rig water cooling system. Water leaked out of the core hole and seeped through the shield wall. Catch basins and "wet vacs" were used to capture the water. Reference 2.10 documents the condition of the shield wall concrete as witnessed from access holes. Reference 2.11 documents the shield wall reinforcement that was cut in the process of cutting the access holes.

4.0 14R WORK

4.1 General

Reference 2.12 documents this phase of work which is referred to as the cleaning/coating phase.

Training and qualification of the workers was completed prior to plant shutdown thus allowing work to start on 11/28/92, the first day of the 14R outage. The schedule called for two ten hour shifts working seven days a week. After mobilization of equipment and supplies, the first activity was to remove the two foot concrete plug in each of the holes. Once the plug was out, a team of safety and radcon inspectors surveyed the bays before workers were allowed to enter the holes.

4.2 Sand Removal

There were thick crusts of corrosion product laying on top of the sand. (See Fig. 2). It was necessary to remove this material before the task of removing sand could begin. In most bays, very little corrosion product was left on the vessel. (See Fig. 3). The oxide crusts may have spalled off the vessel as the plant went to cold shutdown in preparation for the 14R outage. The last video views taken during the operating cycle 13 sand removal effort showed that some material had fallen off the vessel, but not to the extent found. The corrosion product pieces were removed and bagged. The sand was then removed using an electric VecLoader vacuum. Appendix A contains

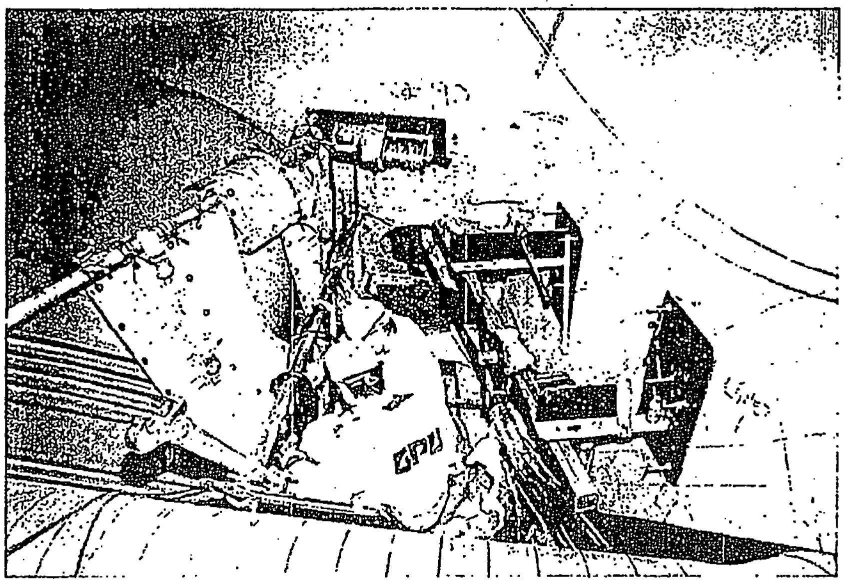

Figure 1

Access hole drilling set up view from the top of the Torus.

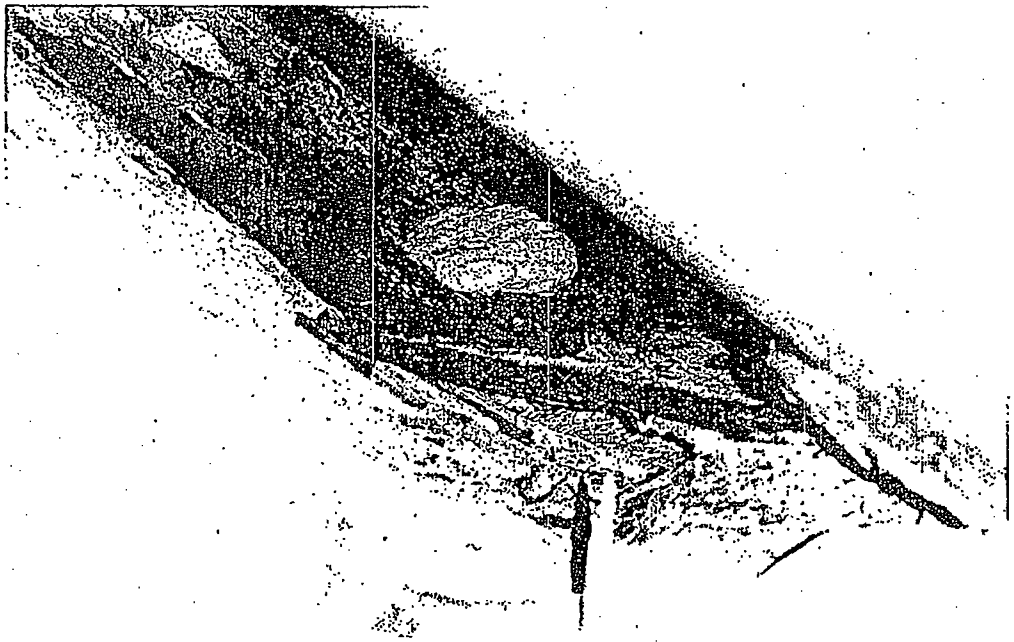

Figure 2

Sand Bed Region - Typical condition found on initial entry.

Figure 3

Corrosion product on drywell vessel.

a list of the waste materials created during this work. The thickness of some of the corrosion product raised a concern regarding how much base metal was left on the vessel. One 12 x 12 inch (approximate) piece of oxide crust with a thickness varying in the range of 1.25 to 1.50 inches was sent to the GPUN Materials Laboratory for analysis (see reference 2.13, 2.14 and 2.15). The result of the analysis essentially validated projections based on UT readings from inside the drywell and later readings taken from the sand bed region. In general, two bays were worked at one time. Initially, the bays judged to be in the worst shape, i.e. the most corroded, were worked first. However, due to reactor cavity water leaking into bays 11, 13 and 15 during the third week of the outage, work in these bays was postponed until after the completion of refueling and the refueling cavity was drained.

4.3 Surface Preparation

As part of the qualification process for surface preparation and coating that preceded the outage, workers were trained in the use of tools. The tools had been evaluated to ensure that the surface preparation effort removed corrosion product and loose rust without removing metal from the vessel. Pneumatic wire brush and needle gun tools were the primary means of preparing the vessel surface for the coating system. Devoe Devprep 88 cleaner was used to clean grease, oil, salts and loose rust off the surface prior to applying the coating. The Devprep was washed off by high pressure hydrolasing.

4.4 As Found Conditions

Inspection of the sand bed region after the sand was removed brought to light some conditions that deviated from the construction drawings. The shield wall reinforcement that the construction drawings showed as passing through the sand bed is one example. Only one row of bars was visible, and only about half that row in most bays. The condition of the sleeves that cover the bars was good, i.e. no evidence of deep corrosion. This resulted in an additional space of about nine inches and this extra space between the vessel and the reinforcement made working in this area easier than had been anticipated. Engineering Mechanics personnel inspected this condition and found evidence that the second row of reinforcement was buried in the shield wall. (See reference 2.16).

A more serious finding was the condition of the floor in the sand bed. The concrete was not finished, there were holes and craters along side the vessel, there was no evidence of a drainage ditch as shown on the drawings and in most cases the drain pipes were higher than the floor. (See Figs. 4 and 5). This was a general condition in all bays, however some were worse than others. Apparently the finish pour of concrete was not installed. This condition had a significant effect on the project's schedule and cost. To make the drain system effective the holes and craters needed to be filled, and the floor leveled using a suitable material compatible with both concrete and the steel shell. (See Figs. 6 and 7). The Devoe epoxy product 184 was used to refurbish the floor. This was done after evaluation of the suitability of the material in the sand bed environment. This condition was documented using a MNCR (see reference 2.17). As a part of the floor refurbishment, a wedge of Devoe 140S caulking material was placed at the intersection of the vessel shell and the floor. The caulking material will keep water away from the vessel in the event a volume of water greater than the drains capacity is introduced into the area. (See Figs. 8 and 9).

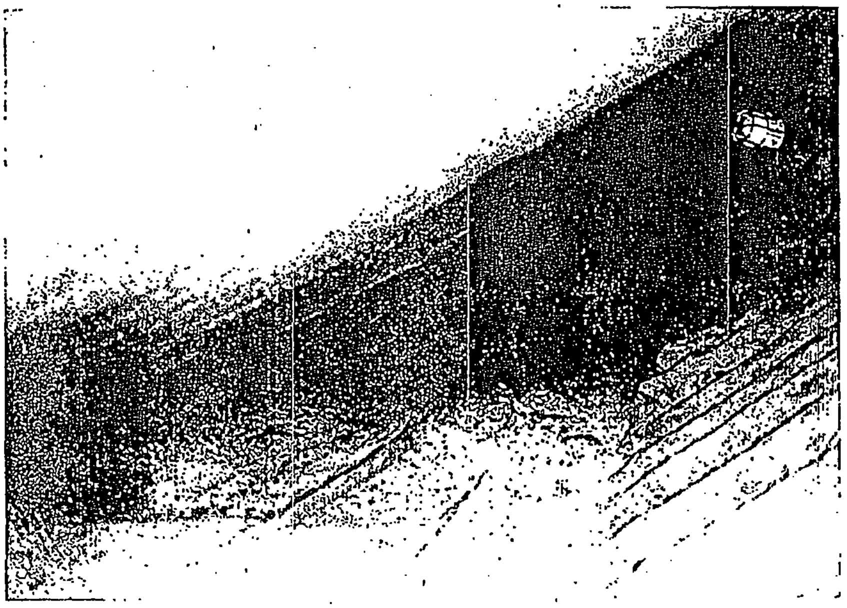

Figure 4

As found condition of floor bed.

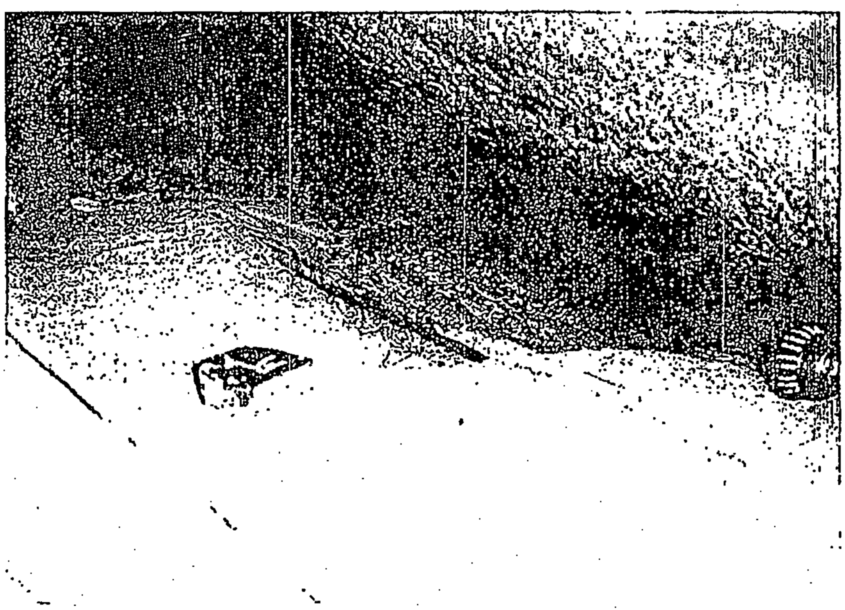

Figure 5

Deep depression in floor adjacent to drywell vessel.

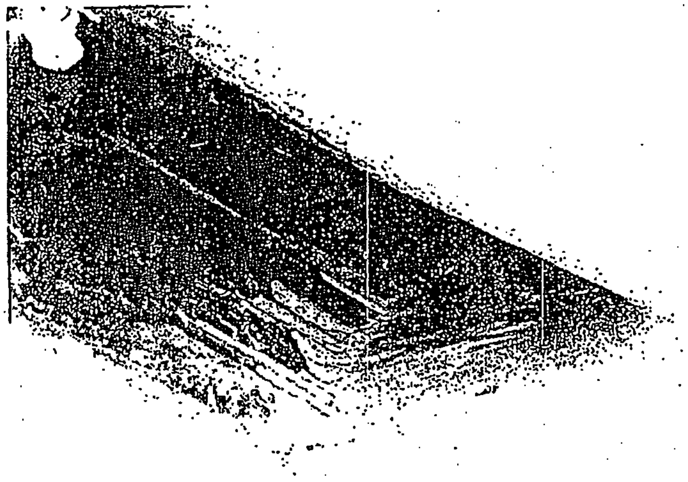

Figure 6

Finished floor & vessel.

Figure 7

Drain after floor has been refurbished.

Figure 8

Close up of caulking.

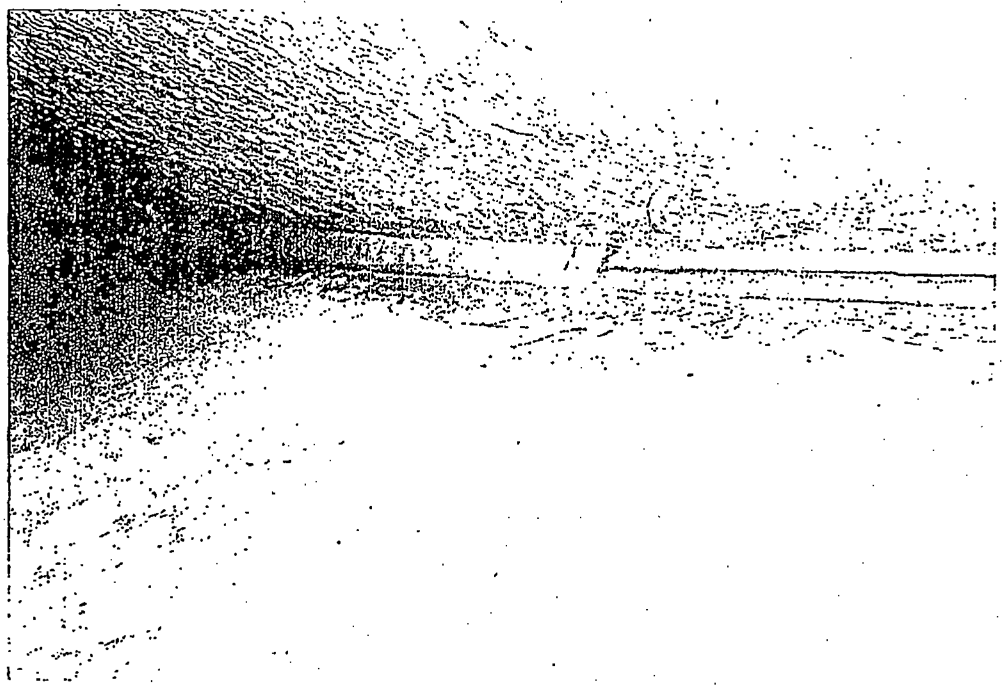

Figure 9

Finished floor, vessel with two top coats - caulking material applied.

4.5 Coating of the Drywell Shell

The coating system consists of a prime coat of Devoe Pre-prime 167 rust penetrating sealer and two top coats of Devoe 184 epoxy coating. The first top coat was tinted light gray and the second one a darker gray. This helped to insure complete coverage of the surface and avoid the potential for a localized galvanic cell to develop. All coating work was done using brushes and 3/4 inch nap rollers.

4.6 Access Hole Closure

The access holes provide direct access to an area that is a high radiation area during operation. Therefore a barrier is required to restrict access. This was accomplished by placing sand bags in the entire length of the hole. The bags weigh about twenty five pounds each and can be removed during future outages to conduct inspections and repairs of the coating if necessary. One row of small plastic bags (3 x 5 inches) was filled with granular boron carbide to help shield any neutron radiation that might stream from the 20 inch access holes.

4.7 Repair Contingency

As a precautionary measure, a repair approach designed to address local, as opposed to global, drywell repair requirements was identified and partially funded. Representatives from CBI, MPR and GPUN met in August 1992 to discuss repair strategies (see reference 2.18). The outcome of the meeting was that the most appropriate repair scheme for relatively small areas would be weld overlay. Competitive bids were solicited from three sources to provide weld procedures and to test the feasibility of doing the repair in the sand bed by using the mockup. CBI was the successful bidder. The mockup demonstration was very successful. It demonstrated that the weld overlay repair process was not only feasible, but relatively straight forward in spite of limited working space. However, the mockup demonstration raised a technical concern regarding the effect of residual stresses introduced into the vessel during the welding process. CBI submitted a quote for analysis to resolve this concern. However, no further action was taken when it became obvious that weld repair of the vessel was not necessary.

5.0 UT READINGS

5.1 General

The UT readings taken from the inside of the drywell do not cover the entire surface of the sand bed area because most of the area is below the internal drywell floor and therefore not accessible from inside the drywell. The access provided during 14R from the Torus room provided an opportunity to investigate the entire area. A number of UT readings in each bay were taken to evaluate the condition of the vessel. See reference 2.19 for a description of UT readings from inside the drywell.

5.2 Initial Approach for UT Inspections from the Sand Bed

It was recognized in the pre-14R planning process that UT readings from the sand bed should be taken once access was achieved. To this end a specification was prepared and issued (reference 2.20). However, it was not clear, during the planning stage, how the detail requirements of the specification would be carried out. It was known that the surface was irregular, but the degree of irregularity was pure speculation. During a meeting held on 8/21/92 it was decided to assign a GPUN materials engineer (S. Saha) the responsibility for deciding the extent of UT coverage and selection of the locations to be UT'd. This was done to ensure consistency. NDE would have the final word as to whether or not the areas were prepared properly for UT readings. At this point in time it was planned to identify the two thinnest locations in three bays and prepare a six inch by six inch grid similar to the grids used to monitor from the inside of the drywell. The bays selected would be the three in the worst condition as determined from UT readings taken previously from inside the drywell and visual observations during the sand removal effort. These bays were 19, 17 and 11. If during the process of getting a bay ready for coating, additional suspect areas were identified, readings would also be taken in those areas.

How to identify the thinnest areas to locate the inspection grids presented a dilemma that was also discussed at the 8/21/92 meeting. Several schemes were discussed. The most promising being one using a UT probe to survey the bays for relative thickness through rust and pits. The NDE representative accepted an action item to pursue this approach. Two major challenges were involved with this assignment. One, to replicate the physical condition of the drywell surface so that inspection techniques could be evaluated and two, to anticipate the physical space limitations associated with conducting inspections in the sand bed. The second one was not a problem as it turned out. There is adequate space in the sand bed region to conduct inspections. However, all attempts to replicate the physical condition of the drywell surface failed. This drove us to experimenting with a UT probe suspended in a film of water to compensate for surface irregularities. Since we were only looking for relative thickness this appeared to be a solution. Once the thinnest location was selected we planned to prepare the surface so that reliable UT readings could be obtained.

5.3 Modified Approach

As is documented below, once access to the sand bed region of bays 17 and 19 was obtained it was soon apparent that meaningful UT information could not be obtained without preparing the surface by grinding on the drywell shell where heavy corrosion had taken place. Several probes were tried. None provided useful information including the experimental immersion probe. The corroded vessel shell resembled a cratered golf ball surface. The areas where the heaviest corrosion had taken place appeared obvious from a visual inspection since the inside shell wall was relatively uniform. The GPUN metallurgist (S. Saha) identified on a sketch, areas to be prepared for UT readings. At a later time he reviewed the surface preparation and thickness data and identified additional locations to ensure that the thinnest areas were surveyed. He has documented his observations in Section 6 of this TDR. Because of a high level of confidence in the visual inspection and the fact that the surface preparation for adequate UT inspection required removal of some metal not corroded, the idea of preparing six inch by six inch grids was abandoned. That approach no longer seemed necessary or prudent.

Sam Saha visually surveyed each bay and identified locations for UT readings that provided an adequate profile of the areas judged to be the thinnest in the bay. The acceptance criteria was that a bay would be deemed to be acceptable if the general area thickness is determined by UT readings to be equal to or greater than 0.736 inches. The 0.736 inch limit is based on an analysis which shows that the drywell meets ASME code requirements (references 2.1 and 2.2). Thickness readings less than 0.736 inches were referred to the GPUN Engineering Mechanics group for evaluation. Each evaluation is documented in Section 6 of this report.

5.4 **Selection of Locations for UT Surveys**

As detailed in paragraph 5.3, the selection of locations for ultrasonic thickness measurements rested on the visual examination of the vessel shell in each bay. The vessel shell, from the sand bed side, looked like a typical golf ball, i.e. a rough surface full of dimples except that the dimples varied in size. It was reasoned that since the inside surface of the vessel shell is smooth and not corroded, any thin area on the outer surface should represent the minimum thickness in that region. It was further reasoned that if six to twelve scattered spots, located in the area of worst corrosion, are ground smooth and the thickness of each spot is measured by UT method we will have a high level of confidence that we have identified the thinnest shell thickness for a bay. This approach is conservative since, (a) we are forcing a statistical bias in choosing only the thinnest areas and (b) grinding of the selected spots to obtain a flat surface for reliable UT readings will remove additional good metal. This conservative approach for selection of UT spots was finally adopted after assuring that the interior vessel wall is indeed smooth. This was proven in bays 17 and 19 by obtaining a uniform backwall reflection of the sound waves with UT equipment. GPUN metallurgist (S. Saha) located, mapped and identified the worst corroded areas in each bay for thickness measurements. The selected spots and the measured thickness are discussed in Section 6 of this TDR.

5.5 **Structural Acceptance Criteria**

Acceptance Criteria - General Wall

The acceptance criteria used to evaluate the measured drywell thickness is based upon GE reports 9-3 and 9-4 (Ref. 2.1 & 2.2) as well as other GE studies (Ref. 2.21) plus visual observations of the drywell surface (Ref. 2.22). The GE reports used an assumed uniform thickness of 0.736 inches in the sand bed area. This area is defined to be from the bottom to top of the sand bed, i.e., El. 8 feet, 11½ inches to El. 12 feet, 3 inches and extending circumferentially one full bay. Therefore, if all the UT measurements for thickness in one bay are greater than 0.736 inches the bay is evaluated to be acceptable. In bays where a reading or measurements are below 0.736 inches, more detailed evaluation is required.

This detailed evaluation is based, in part, on visual observations of the shell surface plus a knowledge of the inspection process. The first part of this evaluation is to arrive at a meaningful value for shell thickness for use in the structural assessment. This meaningful value is referred to as the thickness for evaluation. It is computed by accounting for the depth of the spot where the thickness measurement were made and the roughness of the shell surface. The surface of the shell has been characterized as being "dimpled" as in the surface of a golf ball where the dimples are about one half inch in diameter. Also, the surface contains some depressions 12 to 18 inches in diameter not closer than 12 inches apart, edge to edge (Ref. 2.22). The depth of surface roughness using the drywell shell impressions taken in the roughest bay was calculated. Two locations in bay #13 were selected since bay 13 is the roughest bay. Approximately 40 locations within the two impressions were measured for depth and the average plus one standard deviation was calculated to be at 0.186 inches. A value of 0.200 inches was used in this calculation as a conservative depth of uniform dimples for the entire outside surface of the drywell in the sand bed region.

The inspection focused on the thinnest portion of the drywell, even if it was very local, i.e., the inspection did not attempt to define a shell thickness suitable for structural evaluation. Observations indicate that some inspected spots are very deep. They are much deeper than the normal dimples found, and very local, not more than 1 to 2 inches in diameter. (Typically these observations were made after the spot was surface prepped for UT measurement. This results in a wide dimple to accommodate the meter and slightly deeper than originally found by 0.030 to 0.100 inches). The depth of these areas was measured and averaged with respect to the top of local areas. These depths are referred to herein as the AVG micrometer measurements. The thickness for evaluation is then computed from the above information as:

T (evaluation) = UT (measurement) + AVG (micrometer) - 0.200 inches

where:

T (evaluation) = thickness for evaluation

UT (measurement) = thickness measurement at the area (location)

AVG (micrometer) = average depth of the area relative to its immediate surroundings

0.200 inch = a conservative value of depth of typical dimple on the shell surface.

After this calculation, if the thickness for analysis is greater than 0.736 inches; the area is evaluated to be acceptable.

<u>Acceptance Criteria - Local Wall:</u>

If the thickness for evaluation is less than 0.736 inches, then the use of specific GE studies is employed (Ref. 2.21). These studies contain analyses of the drywell using the pie slice finite element model, reducing the thickness by 0.200 inches in an area 12 x 12 inches in the sand bed region, tapering to original thickness over an additional 12 inches, located to result in the largest reduction possible. This location is selected at the point of maximum deflection of the eigenvector shape associated with the lowest buckling load. The theoretical buckling load was reduced by 9.5% from 6.41 to 5.56. Also, the surrounding areas of thickness greater than 0.736 inches is used to adjust the actual buckling values appropriately. Details are provided in the body of the calculation.

Acceptance Criteria - Very Local Wall (2½ Inch Diameter):

All UT measurements below 0.736 inches have been determined to be in isolated locations less than 2½ inches in diameter. The acceptance criteria for these measurements confined to an area less than 2½ inches in diameter is based on the ASME Section III Subsection NE Class MC Components paragraph NE 3332.1 and NE 3335.1 titled "OPENING NOT REQUIRING REINFORCEMENT AND REINFORCEMENT OF MULTIPLE OPENINGS." These Code provisions allow holes up to 2½ inches in diameter in Class MC vessels without requiring reinforcement. Therefore, thinned areas less than 2½ inches in diameter need not be provided with reinforcement and are considered local. Per NE 3213.10 the stresses in these regions are classified as local primary membrane stresses which are limited to an allowable value of 1.5 Sm. Local areas not exceeding 2½ inches in diameter have no impact on the buckling margins. Using the 1.5 Sm criteria given above, the required minimum thickness in these areas is:

$$T\ (\ required\ ) = (\ 2/3\ ) * (\ 0.736\ ) = 0.490\ \text{inches}$$

Where 2/3 is Sm/1.5Sm and is the ratio of the allowable stresses.

Acceptance Criteria - Very Local Wall (2½ Inch Diameter):

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$$T\ (\text{ required }) = (2/3) * (0.736) = 0.490 \text{ inches}$$

Where 2/3 is Sm/1.5Sm and is the ratio of the allowable stresses.

6.0 RESULTS

6.1 General

The locations and thickness measurements for each bay are sketched and tabulated in paragraphs 6.2 through 6.11.

The Engineering Mechanics section reviewed all of the UT readings and documented their conclusions in a calculation. (See reference 2.23). Following is a summary for each bay.

All "location" measurements in the graphics contained in Sections 6.2 through Section 6.11 are measured from the intersection of the drywell shell and vent pipe/reinforcement plate welds for vertical measurements and from the drywell shell butt weld for horizontal measurements.

Average micrometer measurements listed in the tables are the average of four readings taken at 0/45°/90°/135° azimuth within a 1 inch band surrounding spots that were ground for UT measurements. These were only taken in areas where remaining wall thickness was below 0.736 inches.

6.2 Bay #1 Data

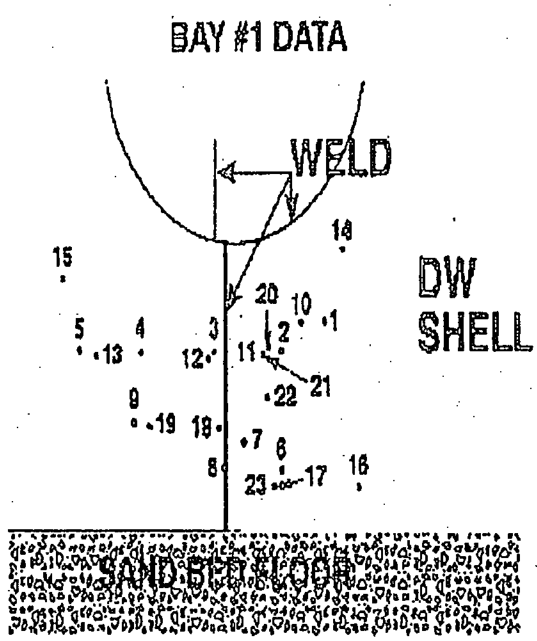


Figure 10

Bay 1 Data - Table 1

Location	UT Measurements (inches)	Avg Micrometer (inches)
1	0.720	0.218
2	0.716	0.143
3	0.705	0.347
4	0.760	---
5	0.710	0.313
6	0.760	---
7	0.700	0.266
8	0.805	---
9	0.805	---
10	0.839	---
11	0.714	0.212
12	0.724	0.301
13	0.792	---
14	1.147	---
15	1.156	---
16	0.796	---
17	0.860	---
18	0.917	---
19	0.890	---
20	0.965	---
21	0.726	0.211
22	0.852	---
23	0.850	---

A. Overview of Bay's Physical Condition

The shell in bay 1 is characterized by a rough surface full of dimples of varying sizes up to ½ inch in diameter. The most remarkable feature is the presence of a band 8 inches to 18 inches wide which is 4 to 6 inches below the vent pipe reinforcement plate weld and about 30 inches in length. This *bathtub ring contains the worst corrosion. Spots* #1, 2, 3, 4, 5, 11, and 12 are located in this bathtub ring. Below the band the corrosion is much less. Above the band no corrosion was seen (spot #14 and #15) and the original red lead coating was still visible.

B. Summary of Structural Evaluation

The inspection focused on the thinnest areas of the drywell, even if it was very local, i.e., the inspection did not attempt to define a shell thickness suitable for structural evaluation. The shell appears to be relatively uniform in thickness except for a band of corrosion which looks like a "bathtub" ring (see Fig. 10). Beyond the bathtub ring on both sides, the shell appears to be uniform in thickness at a conservative value of 0.800 inches. Measurements 14 and 15 confirm that the thickness above the bathtub ring is at 1.154 inches starting at elevation 11 feet, 00 inches. Below the bathtub ring the shell is uniform in thickness where no abrupt changes in thicknesses are present. Thickness measurements below the bathtub ring are all above 0.800 inches except location 7 which is very local area.

Therefore, a conservative mean thickness of 0.800 inches is estimated to represent the evaluation thickness for this bay. Given a uniform thickness of 0.800 inches, the buckling margin for the refueling load condition is recalculated based on the GE report 9-4 (Ref. 2.2). The theoretical buckling strength from report 9-4 (ANSYS Load Factor) is a square function of plate thicknesses. Therefore, a new buckling capacity for the controlling refueling load combination is calculated to be at 13% above the ASME factor of safety of 2.

Locations 1, 2, 3, 4, 5, 10, 11, 12, 13, 20, and 21 are confined to the bathtub ring as shown in Figure 10. An average value of these measurements is an evaluation thickness for this band as follows;

Location	Evaluation Thickness
1	0.738"
2	0.659"
3	0.852"
4	0.760"
5	0.823"
10	0.839"
11	0.726"
12	0.825"
13	0.792"
20	0.965"
21	0.737"

Average = 0.792"

An average evaluation thickness of 0.792 inches for the bathtub ring may raise concern given that the bathtub ring is noticeable and that the difference between its average evaluation thickness (0.792 inches) and the average thickness taken for the entire region (0.800 inches) is only 0.008 inches. This results from the fact that average micrometer readings were generally not taken for the remainder of the shell since each reading was greater than 0.736 inches. In reality, the remainder of the shell is much thicker than 0.800 inches. The appropriate evaluation thickness can not be quantified since no micrometer readings were taken.

The individual measured thicknesses must also be evaluated for structural compliance. Table 1 identifies 23 locations of UT measurements that were selected to represent the thinnest areas, except locations 14 and 15, based on visual examination. These locations are a deliberate attempt to produce a minimum measurement. Locations 14 and 15 were selected to confirm that no corrosion had taken place in the area above the bathtub ring.

Eight locations shown in Table 1 (1, 2, 3, 5, 7, 11, 12, and 21) have measurements below 0.736 inches. Observations indicate that these locations were very deep and not more than 1 to 2 inches in diameter. The depth of each of these areas relative to its immediate surroundings was measured at 8 locations around the spot and the average is shown in Table 1. Using the general wall thickness acceptance criteria described earlier, the evaluation thickness for all measurements below 0.736 inches were found to be above 0.736 inches except for two locations, 2 and 11, as shown in Table 2. Locations 2 and 11 are in the bathtub ring and are about 4 inches apart. This area is characterized as a local area 4 x 4 inches located at about 15 to 20 inches below the vent pipe reinforcement plate with an average thickness of 0.692 inches. This thickness of 0.692 inches is a full 0.108 inch reduction from the conservative estimate of a 0.800 inch evaluation thickness for the entire bay. In order to quantify the effect of this local region and to address structural compliance, the GE study on local effects is used (Ref. 2.21).

This study contains an analysis of the drywell shell using the pie slice finite element model, reducing the thickness by 0.200 inches (from 0.736 to 0.536 inches) in an area 12 x 12 inches in the sand bed region located to result in the largest reduction possible. This location is selected at the point of maximum deflection of the eigenvector shape associated with the lowest buckling load. The theoretical buckling load was reduced by 9.5%. The 4 x 4 inch local region is not at the point of maximum deflection. The area of 4 x 4 inches is only 11% of the 12 x 12 inch area used in the analysis. Therefore, this small 4 x 4 inch area has a negligible effect on the buckling capacity of the structure.

In summary, using a conservative estimate of 0.800 inches for evaluation thickness for the entire bay and the presence of a bathtub ring with a evaluation thickness of 0.792 inches plus the acceptance of a local area of 4 x 4 inches based on the GE study, it is concluded that the bay is acceptable.

SUMMARY OF Measurements BELOW 0.736 Inches

Table 2

Location	UT Measurement (1)	Avg Micrometer (2)	Mean Depth/Valley (3)	T (Evaluation) (4)=(1)+(2)-(3)	Remarks
1	0.720"	0.218"	0.200"	0.738"	Acceptable
2	0.716"	0.143"	0.200"	0.659"	Acceptable
3	0.705"	0.347"	0.200"	0.852"	Acceptable
5	0.710"	0.313"	0.200"	0.823"	Acceptable
7	0.700"	0.266"	0.200"	0.766"	Acceptable
11	0.714"	0.212"	0.200"	0.726"	Acceptable
12	0.724"	0.301"	0.200"	0.825"	Acceptable
21	0.726"	0.211"	0.200"	0.737"	Acceptable

6.3 Bay #3 Data

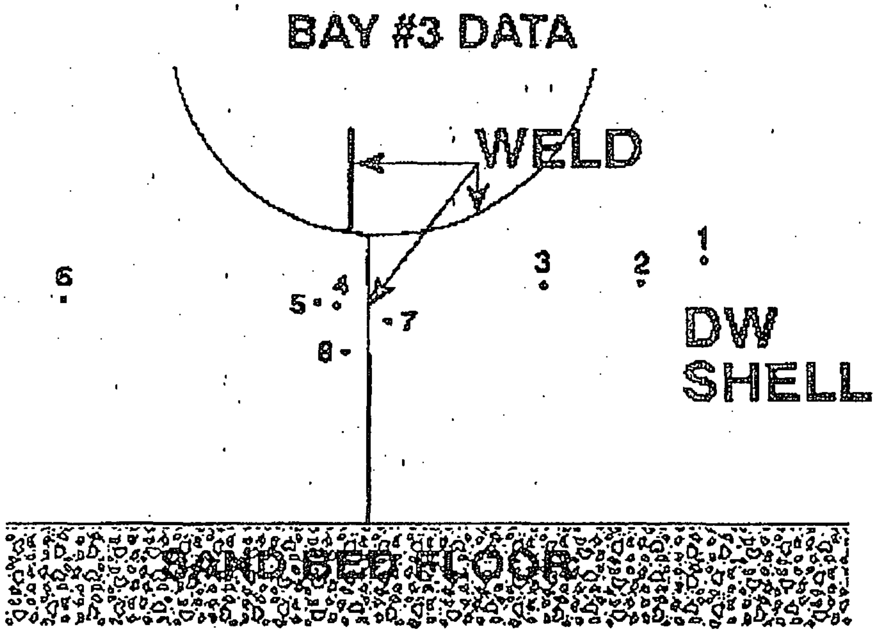


Figure 11

Bay 3 Data - Table 3

Location	UT Readings (inches)	Avg Micrometer (inches)
1	0.795	—
2	1.000	—
3	0.857	—
4	0.898	—
5	0.823	—
6	0.968	—
7	0.826	—
8	0.780	—

A. Overview of Bay's Physical Condition

Except for a "band" approximately 6 inches below the vent header weld and 8 - 10 inches wide, the corrosion observed was uniform and characterized by a uniformly dimpled surface. The upper portion of the shell beyond the "bathtub ring" and the vent pipe was not corroded. The original "red lead" primer coating is still visible. The reinforcement bar sleeves, on the concrete side, were corroded uniformly. No perforation was seen in any of these sleeves. The concrete floor was in poor shape. It had a huge crater about half the length of the bay running along the drywell shell. It was about 18 inches deep at the worst location. No drainage channel was found on the floor. From the visual appearance, it was evident that the concrete floor was never constructed to the original design.

B. Summary of Structural Evaluation

The outside surface of this bay is rough, similar to bay one, full of dimples comparable to the outside surface of a golf ball. This observation is made by the inspector who located the thinnest areas for the UT examination. Eight locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 11). These locations are a deliberate attempt to produce a minimum measurement. Table 3 shows measurements taken to measure the thicknesses of the drywell shell using a D-meter. The results indicate that all of the areas have thickness greater than the 0.736 inches.

Given the UT measurements, a conservative mean evaluation thickness of 0.850 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

6.4 Bay #5 Data

NOTE: In this bay the drywell shell (butt) weld is about 8 inches to the right of center line of the vent pipe. Therefore, all measurements were taken from a line drawn on shell which approx. coincide with the vent pipe center line.

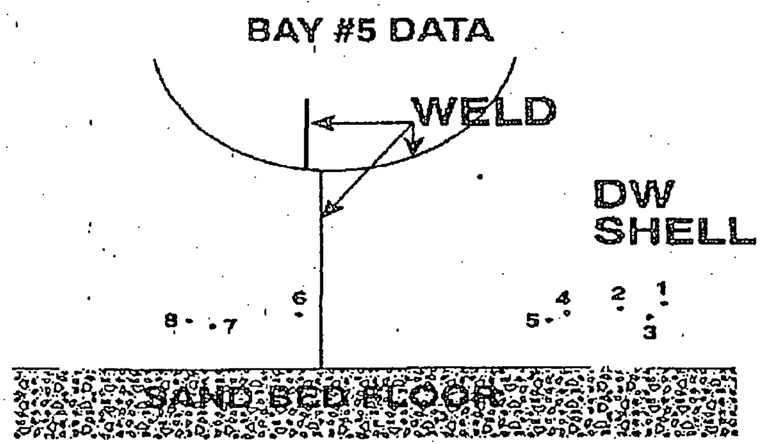


Figure 12

Bay 5 Data - Table 4

Location	UT Readings (inches)	Avg Micrometer (inches)
1	0.970	—
2	1.040	—
3	1.020	—
4	0.910	—
5	0.890	—
6	1.060	—
7	0.990	—
8	1.010	—

A. Overview of Bay's Physical Condition

This bay was very similar to bay 3 in physical condition except that, (1) the floor crater was 12 inches deep at the worst location and (2) the localized low spots from corrosion were clustered at the junction of bays 3 and 5, 30 - 32 inches above the floor.

B. Summary of Structural Evaluation

Eight locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 12). These locations are a deliberate attempt to produce a minimum measurement. Table 4 shows readings taken to measure the thicknesses of the drywell shell using a D-meter. The results indicate that all of the areas have thickness greater than the 0.736 inches.

Given the UT measurements, a conservative mean evaluation thickness of 0.950 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

6.5 Bay #7 Data

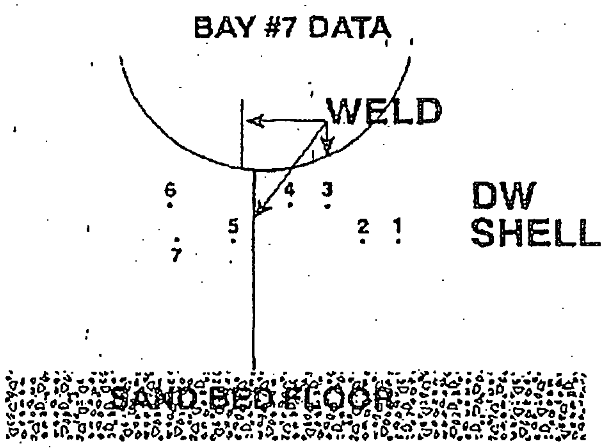


Figure 13

Bay 7 Data - Table 5

Location	UT Readings (inches)	Avg Micrometer (inches)
1	0.920	—
2	1.016	—
3	0.954	—
4	1.040	—
5	1.030	—
6	1.045	—
7	1.000	—

A. Overview of Bay's Physical Condition

The drywell surface showed uniform dimples in the corroded area, but it was shallow in depth. The bathtub ring, seen below the vent header in other bays, was not very prominent in this bay. The sleeves for the reinforcement bars showed no perforations and were uniformly corroded. The concrete floor had no drainage channel, was unfinished and had a few small craters.

B. Summary of Structural Evaluation

Seven locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 13). These locations are a deliberate attempt to produce a minimum measurement. Table 5 shows readings taken to measure the thicknesses of the drywell shell using a D-meter. The results indicate that all of the areas have thickness greater than the 0.736 inches.

Given the UT measurements, a conservative mean evaluation thickness of 1 inch is estimated for this bay and therefore, it is concluded that the bay is acceptable.

6.6 Bay #9 Data

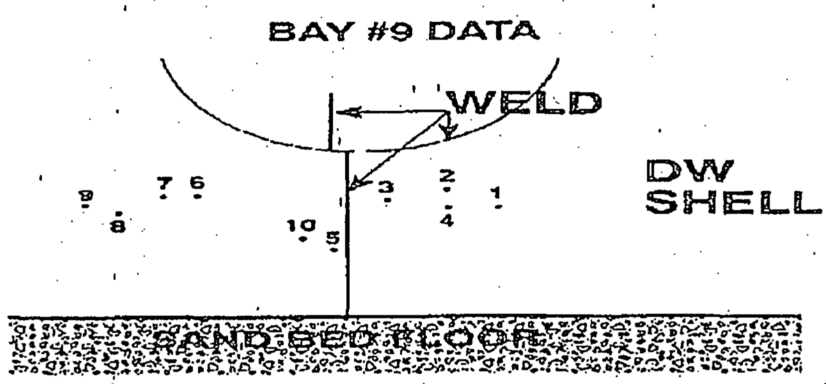


Figure 14

Bay 9 Data - Table 6

Location	UT Readings (inches)	Avg Micrometer (inches)
1	0.960	—
2	0.940	—
3	0.994	—
4	1.020	—
5	0.985	—
6	0.820	—
7	0.825	—
8	0.791	—
9	0.832	—
10	0.980	—

A. Overview of Bay's Physical Condition

This bay was similar to bay 7 in physical condition except that the bathtub ring that is 6 to 9 inches wide and 6 to 8 inches below the vent pipe reinforcement plate contained some localized corrosion. Above this band no corrosion had occurred.

B. Summary of Structural Evaluation

Ten locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 14). These locations are a deliberate attempt to produce a minimum measurement. Table 6 shows readings taken to measure the thicknesses of the drywell shell using a D-meter. The results indicate that all of the areas have thickness greater than the 0.736 inches.

Given the UT measurements, a conservative mean evaluation thickness of 0.900 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

6.7 Bay #11 Data

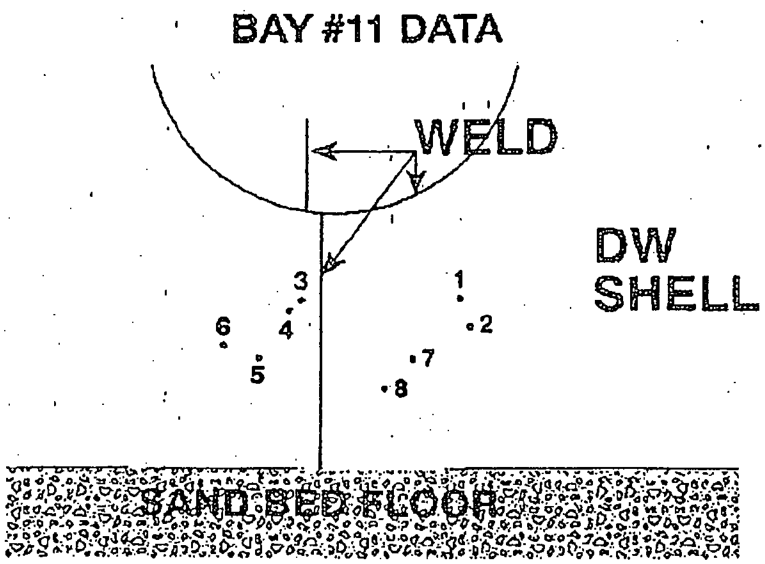


Figure 15

Bay 11 Data - Table 7

Location	UT Readings (inches)	Avg Micrometer (inches)
1	0.705	0.246
2	0.770	—
3	0.832	—
4	0.755	—
5	0.831	—
6	0.800	—
7	0.831	—
8	0.815	—

A. Overview of Bay's Physical Condition

This bay was wet, during the initial inspection, from the water leaking out of the reactor cavity. The water was seen trickling/dripping down the concrete wall on the inside of the sand bed. No water stream/trickle was seen on the drywell shell. Most of the localized corroded spots were on the upper right hand side (i.e. toward bay 9) 10 to 12 inches below the vent pipe reinforcement plate. The shell on the left hand side (i.e. toward bay 13) showed an uniformly corroded (dimpled) surface. The concrete reinforcement bar sleeves were corroded but not perforated. The concrete floor was unfinished and no drainage channel was seen.

B. Summary of Structural Evaluation

Eight locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 15). These locations are a deliberate attempt to produce a minimum measurement. Table 7 shows readings taken to measure the thicknesses of the drywell shell using a D-meter. The results indicate that all of the areas have thickness greater than the 0.736 inches, except one location. Location 1 as shown in Table 8, has a reading below 0.736 inches. Observations indicate that this location was very deep and not more than 1 to 2 inches in diameter. The depth of area relative to its immediate surrounding was measured at 8 locations around the spot and the average is shown in Table 8. Using the general wall thickness acceptance criteria described earlier, the evaluation thickness for location 1 was found to be above 0.736 inches as shown in Table 8.

Given the UT measurements, a conservative mean evaluation thickness of 0.790 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

<u>Summary of Readings Below 0.736 Inches</u>

<u>Table 8</u>

Location	UT Measurement (1)	Avg Micrometer (2)	Mean Depth/Valley (3)	T (Evaluation) (4)=(1)+(2)-(3)	Remarks
1	0.705"	0.246"	0.200"	0.751"	Acceptable

6.8 Bay #13 Data

NOTE: Spots with suffix (e.g. 1A or 2A) were located close to the spots in question and were ground carefully to remove minimum amount of metal but adequate enough for UT.

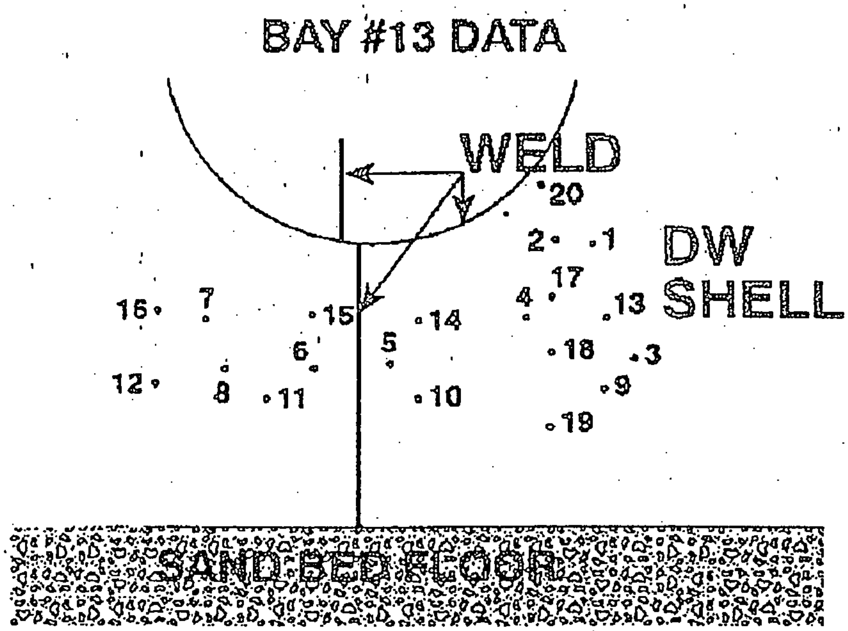


Figure 16

Bay 13 Data - Table 9

Location	UT Reading (inches)	Avg Micrometer (inches)
1/1A	0.672/0.890	0.351
2/2A	0.722/0.943	0.360
3	0.941	---
4	0.915	---
5/5A	0.718/0.851	0.217
6/6A	0.655/0.976	0.301
7/7A	0.618/0.752	0.257
8/8A	0.718/0.900	0.278
9	0.924	---
10/10A	0.728/0.810	0.211
11/11A	0.685/0.854	0.256
12	0.885	---
13	0.932	---
14	0.868	---
15/15A	0.683/0.859	0.273
16	0.829	---
17	0.807	---
18	0.825	---
19	0.912	---
20	1.170	---

A. Overview of Bay's Physical Condition

The drywell shell in this bay appeared uniformly dimpled except around a plug in the upper right hand corner (towards bay 11). The plug was located in the worst corroded area of the shell, but it was not corroded. The bathtub ring below the vent pipe reinforcement plate was less prominent than was seen in other bays. The concrete floor in this bay was in better shape as compared to other bays, but it was still uneven and craters were present. There was no drainage channel. The reinforcement bar sleeves were uniformly corroded, but no perforations of the sleeves were seen.

B. Summary of Structural Evaluation

The variation in shell thickness is greater in this bay than in the other bays. The bathtub ring below the vent pipe reinforcement plate was less prominent than was seen in other bays. The corroded areas are about 12 to 18 inches in diameter and are at 12 inches apart, located in the middle of the sand bed. Beyond the corroded areas on both sides, the shell appears to be uniform in thickness at a conservative value of 0.800 inches. Near the vent pipe and reinforcement plate the shell exhibits no corrosion since the original lead primer on the vent pipe/reinforcement plate is intact. Measurement 20 confirms that the thickness above the bathtub ring is at 1.154 inches. Below the bathtub ring the shell appears to be fairly uniform in thickness where no abrupt changes in thicknesses are present. Thickness measurements below the bathtub ring are all 0.800 inches or better.

Therefore, a conservative mean thickness of 0.800 inches is estimated to represent the evaluation thickness for this bay. Given a uniform thickness of 0.800 inches, the buckling margin for the refueling load condition is recalculated based on the GE report 9-4 (Ref. 2.2). The theoretical buckling strength from report 9-4 (ANSYS Load Factor) is a square function of plate thicknesses. Therefore, a new buckling capacity for the controlling refueling load combination is calculated to be at 13% above the ASME factor of safety of 2.

Locations 5, 6, 7, 8, 10, 11, 14, and 15 are confined to the bathtub ring as shown in Figure 16. An average value of these measurements is an evaluation thickness for this band as follows:

Location	Evaluation Thickness
5	0.735"
6	0.756"
7	0.675"
8	0.796"
10	0.739"
11	0.741"
12	0.885"
14	0.868"
15	0.756"
16	0.829"

Average = 0.778"

The inspector suspected that some of the above locations in the bathtub ring were over ground. Subsequent locations with suffix A, e.g. 5A, 6A, were located close to the spots in question and were ground carefully to remove the minimum amount of metal but adequate enough for UT examination as shown in Figure 16. The results indicate that all subsequent measurements were above 0.736 inches. The average micrometer readings taken for these locations confirm the depth of measurements at these locations. In spite of the fact that the original readings were taken at heavily ground locations, they are the one used in the evaluation.

The individual measurements must also be evaluated for structural compliance. Table 9 identifies 20 locations of UT measurements that were selected to represent the thinnest areas, except location 20, based on visual examination. These locations are a deliberate attempt to produce a minimum measurement. Location 20 was selected to confirm that no corrosion had taken place in the area above the bathtub ring.

Nine locations shown in Table 9 (1, 2, 5, 6, 7, 8, 10, 11, and 15) have measurements below 0.736 inches. Observations indicate that these locations were very deep, overly ground, and not more than 1 to 2 inches in diameter. The depth of each of these areas relative to its immediate surroundings was measured at 8 locations around the spot and the average is shown in Table 9. Using the general wall thickness acceptance criteria described earlier, the evaluation thickness for all measurements below 0.736 inches were found to be above 0.736 inches except for two locations, 5 and 7, as shown in Table 10. In addition, subsequent measurements close to the locations identified above, were taken and they were all above 0.736 inches. Locations 5 and 7 are in the bathtub ring and are about 30 inches apart. These locations are characterized as local areas located at about 15 to 20 inches below the vent pipe reinforcement plate with an evaluation thicknesses of 0.735 inches and 0.677 inches. The location 5 is near to location 14 for an average value of 0.801 inches and therefore acceptable. Location 7 could conservatively exist over an area of 6 x 6 inches for a thickness of 0.677 inches. This thickness of 0.677 inches is a full 0.123 inches reduction from the conservative estimate of a 0.800 inch evaluation thickness for the entire bay. In order to quantify the effect of this local region and to address structural compliance, the GE study on local effects is used (Ref. 2.21).

This study contains an analysis of the drywell shell using the pie slice finite element model, reducing the thickness by 0.200 inches (from 0.736 to 0.536 inches) in an area 12 x 12 inches in the sand bed region located to result in the largest reduction possible. This location is selected at the point of maximum deflection of the eigenvector shape associated with the lowest buckling load. The theoretical buckling load was reduced by 9.5%. The 6 x 6 inch local region is not at the point of maximum deflection. The area of 6 x 6 inches is only 25% of the 12 x 12 inch area used in the analysis. Therefore, this small 6 x 6 inch area has a negligible effect on the buckling capacity of the structure.

In summary, using a conservative estimate of 0.800 inches for evaluation thickness for the entire bay and the presence of a bathtub ring with a evaluation thickness of 0.778 inches plus the acceptance of a local area of 6 x 6 inches based on the GE study, it is concluded that the bay is acceptable.

Summary of Measurements Below 0.736 Inches

Table 10

Location	UT Measurement (1)	Avg Micrometer (2)	Mean Depth/Valley (3)	T (Evaluation) (4)=(1)+(2)-(3)	Remarks
1	0.672"	0.351"	0.200"	0.823"	Acceptable
2	0.722"	0.360"	0.200"	0.882"	Acceptable
5	0.718"	0.217"	0.200"	0.735"	Acceptable
6	0.655"	0.301"	0.200"	0.756"	Acceptable
7	0.618"	0.257"	0.200"	0.675"	Acceptable
8	0.718"	0.278"	0.200"	0.796"	Acceptable
10	0.728"	0.211"	0.200"	0.739"	Acceptable
11	0.685"	0.256"	0.200"	0.741"	Acceptable
15	0.683"	0.273"	0.200"	0.756"	Acceptable

6.9 Bay #15 Data

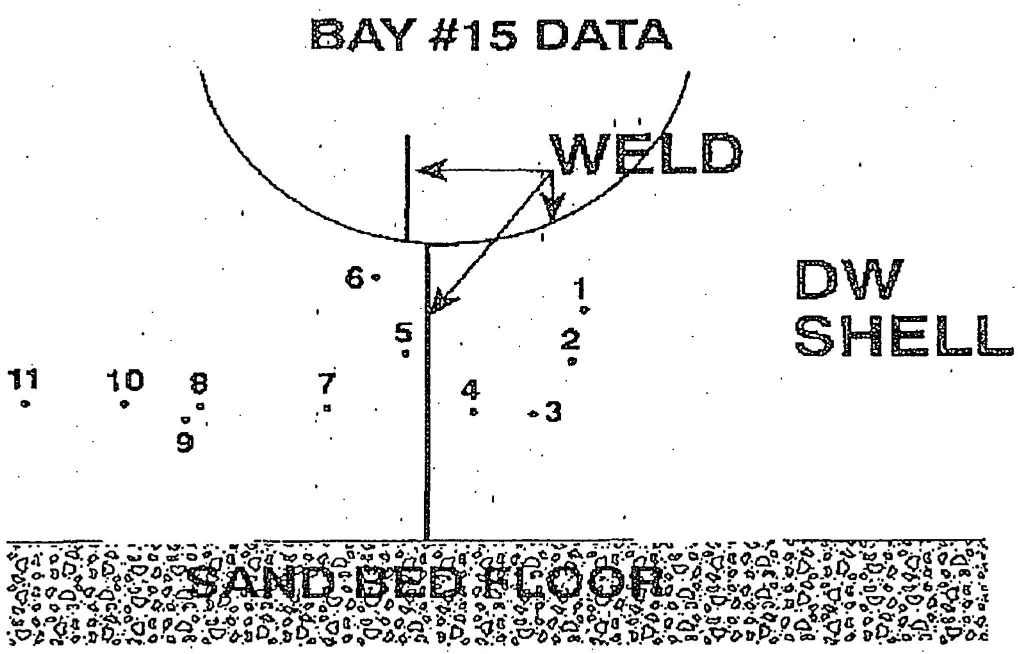


Figure 17

Bay 15 Data - Table 11

Location	UT Readings (inches)	Avg Micrometer (inches)
1	0.786	—
2	0.829	—
3	0.932	—
4	0.795	—
5	0.850	—
6	0.794	—
7	0.808	—
8	0.770	—
9	0.722	0.337
10	0.860	—
11	0.825	—

A. Overview of Bay's Physical Condition

The drywell shell in this bay was uniformly dimpled and the upper part of the shell (i.e. near the vent pipe/reinforcement blade and up) was not corroded. The original "red lead" primer was still visible in this region. The bathtub ring was less prominent than other bays. The reinforcement bar sleeves were corroded, but not perforated. The concrete floor had no drainage channel and there were craters in the floor.

B. Summary of Structural Evaluation

Eleven locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 17). These locations are a deliberate attempt to produce a minimum measurement. Table 11 shows readings taken to measure the thicknesses of the drywell shell using a D-meter. The results indicate that all of the areas have thickness greater than the 0.736 inches, except one location. Location 9 as shown in Table 11, has a reading below 0.736 inches. Observations indicate that this location was very deep and not more than 1 to 2 inches in diameter. The depth of area relative to its immediate surrounding was measured at 8 locations around the spot and the average is shown in Table 11. Using the general wall thickness acceptance criteria described earlier, the evaluation thickness for location 9 was found to be above 0.736 inches as shown in Table 12.

Given the UT measurements, a conservative mean evaluation thickness of 0.800 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

<u>Summary of Measurements Below 0.736 Inches</u>

<u>Table 12</u>

Location	UT Measurement (1)	Avg Micrometer (2)	Mean Depth/Valley (3)	T (Evaluation) (4)=(1)+(2)-(3)	Remarks
9	0.722"	0.337"	0.200"	0.859"	Acceptable

6.10 Bay #17 Data

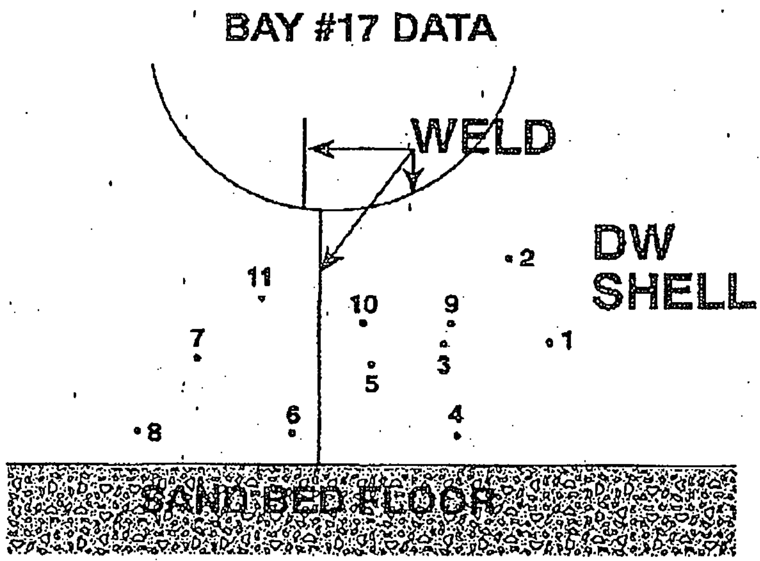


Figure 18

Bay 17 Data - Table 13

Location	UT Readings (inches)	Avg Micrometer (inches)
1	0.916	—
2	1.150	—
3	0.898	—
4	0.951	—
5	0.913	—
6	0.992	—
7	0.970	—
8	0.990	—
9	0.720	0.351
10	0.830	—
11	0.770	—

A. Overview of Bay's Physical Condition

This bay (along with bay 19) provided the first glimpse of the conditions of the drywell shell. The most remarkable feature of this bay was the presence of the bathtub ring 8 to 10 inches wide that was located 8 to 10 inches below the vent tube reinforcement plate. UT spots # 1,3,5 and 7 are located in this band which is the most corroded area in this bay. Spots # 1 through 8 were ground carefully to minimize loss of good metal. Spots # 9,10 and 11 were ground flat and most likely removed good metal. The reinforcement bar sleeves were corroded, but not perforated. The concrete floor was unfinished with no sign of a drainage channel.

B. Summary of Structural Evaluation

Eleven locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 18). These locations are a deliberate attempt to produce a minimum measurement. Table 13 shows readings taken to measure the thicknesses of the drywell shell using a D-meter. The results indicate that all of the areas have thickness greater than the 0.736 inches, except one location. Location 9 as shown in Table 13, has a reading below 0.736 inches. Observations indicate that this location was very deep and not more than 1 to 2 inches in diameter. The depth of area relative to its immediate surrounding was measured at 8 locations around the spot and the average is shown in Table 13. Using the general wall thickness acceptance criteria described earlier, the evaluation thickness for location 9 was found to be above 0.736 inches as shown in Table 14.

Given the UT measurements, a conservative mean evaluation thickness of 0.900 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

<u>Summary of Measurements Below 0.736 Inches</u>

<u>Table 14</u>

Location	UT Measurement (1)	Avg Micrometer (2)	Mean Depth/Valley (3)	T (Evaluation) (4)=(1)+(2)-(3)	Remarks
9	0.720"	0.351"	0.200"	0.871"	Acceptable

6.11 Bay #19 Data

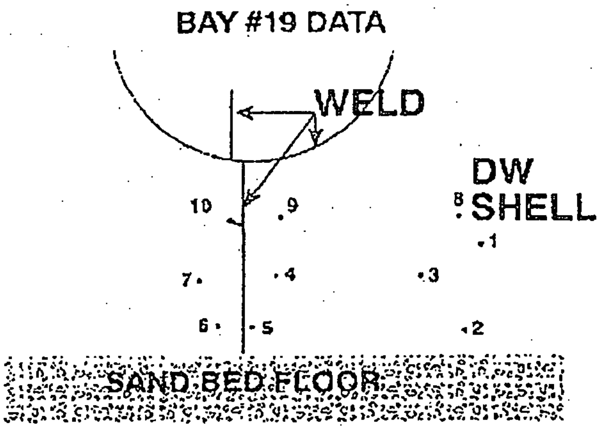


Figure 19

Bay 19 Data - Table 15

Location	UT Readings (inches)	Avg Micrometer (inches)
1	0.932	—
2	0.924	—
3	0.955	—
4	0.940	—
5	0.950	—
6	0.860	—
7	0.969	—
8	0.753	—
9	0.776	—
10	0.790	—

A. Overview of Bay's Physical Condition

The physical condition of this bay was similar to bay 17 except that UT spots 1 through 7 were ground carefully to minimize loss of good metal, whereas spots 8, 9 and 10 were ground flat.

B. Summary of Structural Evaluation

Ten locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 19). These locations are a deliberate attempt to produce a minimum measurement. Table 15 shows readings taken to measure the thicknesses of the drywell shell using a D-meter. The results indicate that all of the areas have thickness greater than the 0.736 inches.

Given the UT measurements, a conservative mean evaluation thickness of 0.850 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

7.0 CONCLUSION

The cleaning and coating effort that was completed in 14R will stop corrosion in the sand bed area. Since this was accomplished while the vessel thickness was sufficient to satisfy ASME code requirements the drywell vessel in the sand bed region is no longer a limiting factor in plant operation. Inspections will be conducted in future refueling outages to insure that the coating remains effective. In addition, UT investigations from inside the drywell will also be taken. The frequency and extent of these investigations will be evaluated after 15R.

APPENDIX A

WASTE DISPOSAL

This Appendix describes the disposition of waste generated during the implementation of the project. The various wastes generated are given below:

1.	Sand	172 barrels (55 gallon/barrel)
2.	Concrete	59 barrels
3.	Corrosion scale	7 barrels
4.	Concrete slurry	16 barrels
5.	Coating products,	(Approximately 1000 cans, application tools etc. buckets, brushes, rollers,etc.)

The sand removed from the sand bed was slightly contaminated. Reference 2.24 provides the activity levels found in various barrels of sand.

The threshold of activity below which a bulk waste is considered clean is as follows:

> cesium 137 $\leq 1.1 \times 10^{-7}$ micro curies/gm.
>
> All other isotopes = no detectable activity with a γ scan machine with a range of 1×10^{-8} uc/gm - mirco curies/gm.

About 15 barrels of sand were bagged and used as shielding in the ten twenty inch diameter access manways. The remaining sand will be stored in building #9 at the Forked River site until the sand activity reduces below the threshold activity.

Approximately 59 barrels of concrete were removed while cutting the access manways. Thirty two barrels of concrete came in large pieces and was disposed of as clean waste after frisking. Twenty seven barrels of bulk concrete are being surveyed by the plant chemistry department using gamma scan, and depending on the outcome, will be disposed of as clean waste , if the criteria for the threshold limits can be met. If very low activity levels are found as in the case of sand, it will be stored in building #9. If activity levels are higher, the concrete will be disposed of as regular low level radwaste.

Approximately seven barrels of corrosion scale were removed. The material was frisked and released as non radioactive waste. Chemical analysis was performed by GPUN Materials Lab in Reading for the presence of hazardous metals. Reference 2.25 provides the lab test results. The corrosion scale was released as clean non radioactive waste as no hazardous metals were found.

Approximately 16 barrels of concrete slurry were removed during the access manway core boring operation. The slurry was allowed to settle, the water was checked for ph and then processed through radwaste (ph was below the limit). Concrete was disposed of as regular low level radwaste.

Paint cans, paint barrels, brushes, rollers and similar items that were used during the Devoe coating application processes, were kept on-site until the coating got hardened and then were frisked and released as clean waste. Paint cans generally had to be coated on the exterior with the epoxy coating to eliminate the sticky condition prior to frisking for radioactivity.

AmerGen

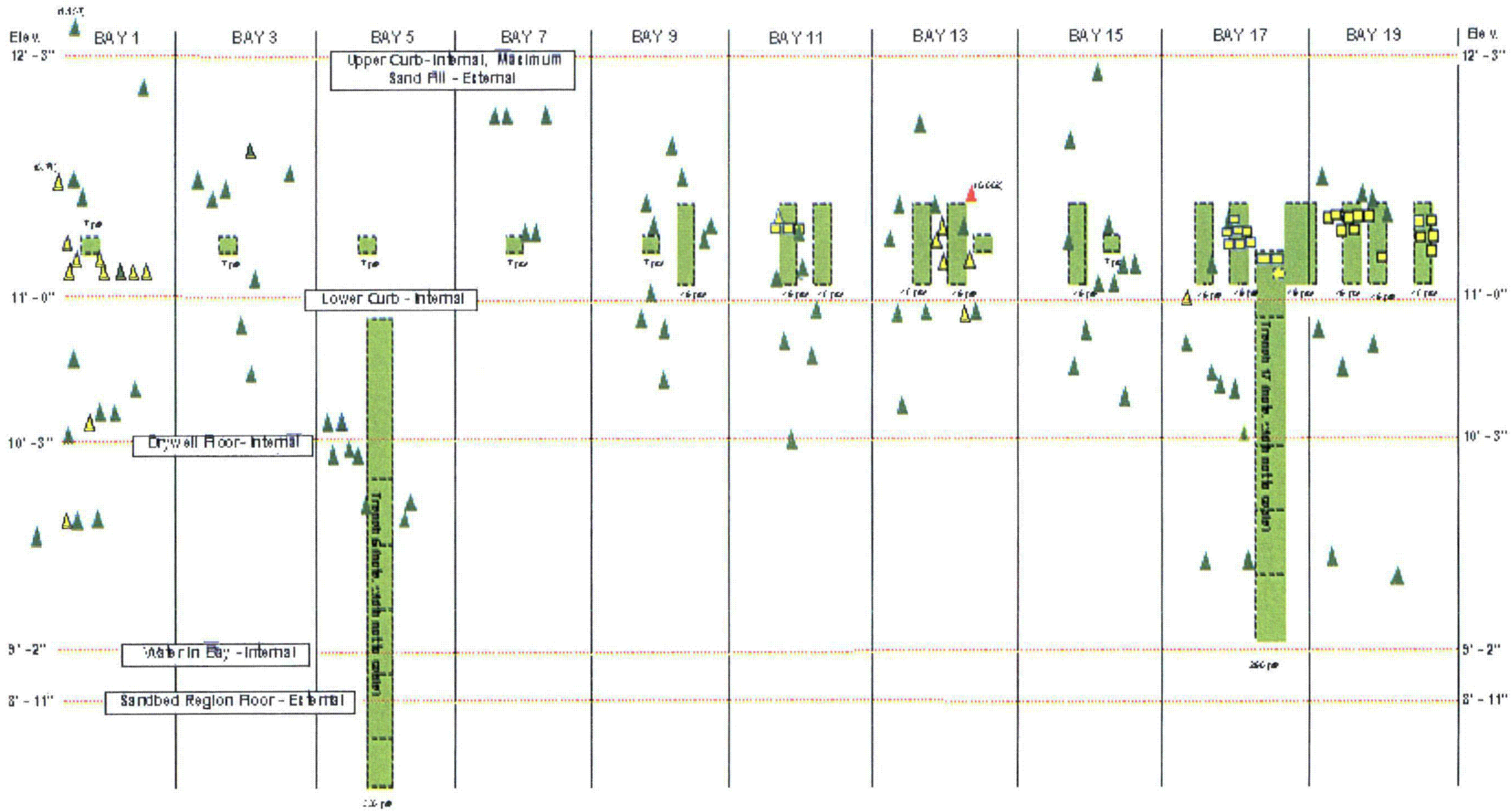
2006 Measurement Locations in the Sandbed Region

Color Code for thickness:

Green = UT Measurements > 736 Mils
Yellow = UT Measurements Between 636 and 736 Mils
Red = UT Measurements Between 536 and 636 Mils

Location / Type of UT Measurement

△ External Point UT Measurements
⬚ Internal Grid UT Measurements
□ Internal Point UT Measurements



Bay Location (Bay Number)

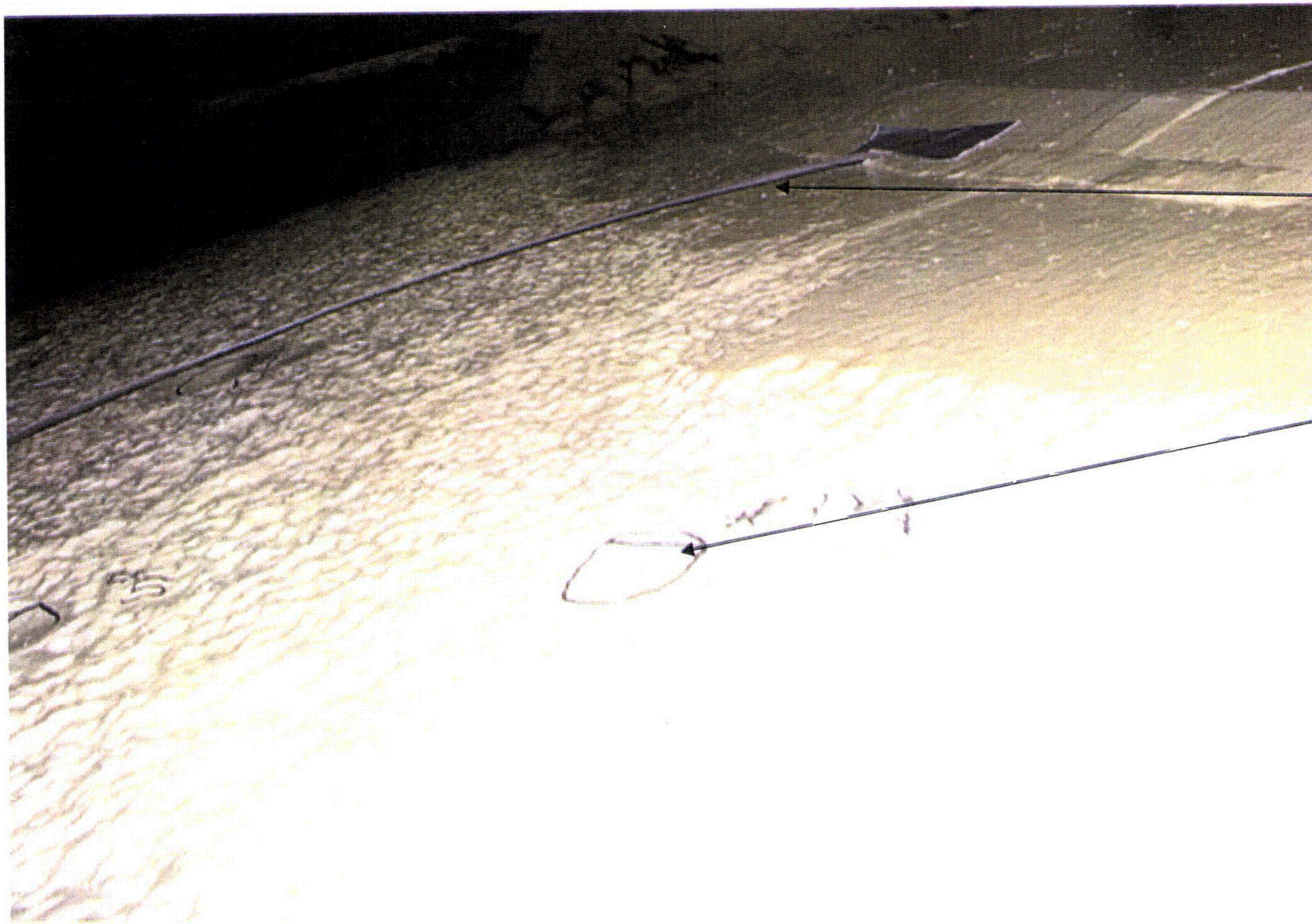
(Handout P1)

For illustration of measurement locations in each bay. Vertical dimensions to scale showing approximate measurement locations. Horizontal dimensions not to scale for the individual bays.

APPLICANT'S EXH. 28

Sand Bed Region 2006

AmerGen
An Exelon Company



Reference for locating inspection points

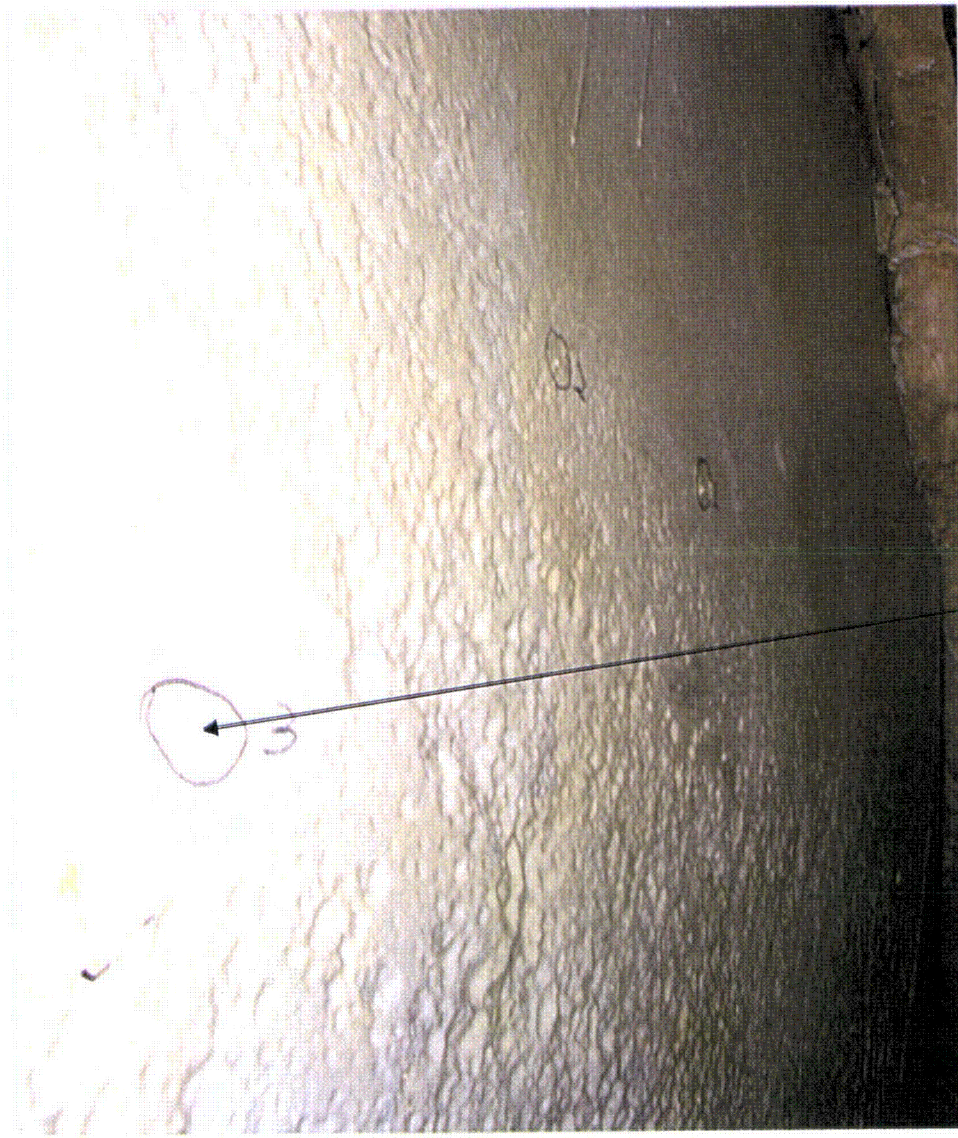
External UT Inspection location

Bay 13 Drywell shell

APPLICANT'S EXH. 29

Sand Bed Region 2006

AmerGen
An Exelon Company



Bay 7 – External UT inspection location

APPLICANT'S EXH. 30

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards Plant License Renewal Subcommittee

Docket Number: (not applicable)

Location: Rockville, Maryland

Date: Tuesday, October 3, 2006

Work Order No.: NRC-1271 Pages 1-232

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

MEETING OF PLANT LICENSE RENEWAL SUBCOMMITTEE

+ + + + +

TUESDAY,

OCTOBER 3, 2006

+ + + + +

The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 1:30 p.m., Dr. Otto Maynard, Chairman, presiding.

MEMBERS PRESENT:

OTTO MAYNARD	Chair
GRAHAM B. WALLIS	Member
WILLIAM J. SHACK	Member
SAID ABDEL-KHALIK	Member
J. SAM ARMIJO	Member
MARIO BONACA	Member
OTTO L. MAYNARD	Member
JOHN D. SIEBER	Member

ACRS STAFF PRESENT:

LOUISE LUND

FRANK GILLESPIE

HANS ASHER

RICK SKELSKEY

DONNIE ASHLEY

MICHAEL MODES

JIM DAVIS

KEN CHANG

MIKE HESSLER

ALSO PRESENT:

MIKE GALLAGHER

PETE TAMBURNO

AHMED OUAOU

TERRY SCHUSTER

FRED POLASKI

PAUL GUNTER

RICHARD WEBSTER

C-O-N-T-E-N-T-S

Ahmed, the filter?

MEMBER WALLACE: That's what plugged?

MR. GALLAGHER: The filter.

MR. OUAOU: As Mike mentioned previously, the drain itself was full of sand as part of the design to avoid --

MEMBER WALLACE: It was filled with sand.

MR. OUAOU: It was filled with sand to avoid draining the sand from the sandbed region but as a result of water intrusion in the area, you have fines that mixed with the sand. You don't have the drainage and that was why it was plugged.

MR. GALLAGHER: Okay, so to get to your question on the next slide, which is Slide 12, excuse me, Slide 11, this is the reactor cavity seal area. And this -- this shows a cross section of that. This slide is useful to show the water leakage path. And basically as we indicated, the water leakage was through defects in the reactor cavity liner and worked its way into the trough area. Again, this projector is light but I think your slides are a little better.

The water worked its way -- or leaked into this trough area and some of this trough area there was low spots originally in the trough area and so the water which leaked through here, leaked down and spilled over into the air gap.

MEMBER BONACA: Now, two questions. One, how sure are you that that's the source of water since this is being contested? You've tested this water?

MR. GALLAGHER: We're very sure that that's the source of the water. Other --

MEMBER BONACA: That's an issue.

MR. GALLAGHER: Other -- during the corrective action, early on, there was other sources that were pursued such as the refueling seal and things like that and it was determined that the majority was through this other --

MEMBER BONACA: And then the question I had was, the seal is supposed to be preventing water penetration but if you have cracks in the liner you are defeating the design objective. And the question I'm raising is because whatever you do to control corrosion, to do whatever you can do to monitor, you still are defeating the design objective and fitting water through that gap. I mean, is that an initiative to try to fix those cracks or replace the liner?

MR. GALLAGHER: Absolutely, what we --

MEMBER BONACA: Otherwise the root cause of all this is not going to go away. And I mean, the goal objective of inspecting those bellows and seals is defeated by definition. Simply you have cracks and they're allowing water to come down.

MR. GALLAGHER: When we go into our program and talk about what we've done in the past and what we're committing to do for the future, we put strippable coating on the reactor cavity liner before we fill it with water during refilling outages. And that's been very, very effective to eliminate the water from this air gap.

MEMBER BONACA: You still have been getting water in these containers.

MR. GALLAGHER: Okay, we can talk about the containers now, if that's --

MEMBER BONACA: No, that's okay, you're going to talk about it later.

MEMBER SHACK: Well, let me go over this strippable coating now. You have put this -- I mean, every time you fill this with water, that's -- part of your procedure is to apply the strippable coating first?

MR. GALLAGHER: We have made a commitment that going forward, every time we fill the reactor cavity, we will put strippable coating.

MEMBER SHACK: You haven't done that every time since the problem started?

MR. GALLAGHER: We've done it, I think, every time except two outages. And --

MEMBER SIEBER: The answer is, no, they haven't done it every time.

MEMBER BONACA: That's right.

MEMBER ARMIJO: Was that just oversight or error or was it a --

MEMBER SHACK: A procedural failure?

MR. GALLAGHER: Pete, can you answer that question?

MR. TAMBURNO: This is Pete Tamburno, Senior Mechanical Engineer. There were two outages during the time frame that GPU owned the plant that the strippable coating was not put on and I believe it was during a time when the plant was announced to be decommissioned.

MR. GALLAGHER: But, you know, for clarity, we have made a commitment and we put that in our license renewal application that we will put the strippable coating on.

MEMBER SHACK: Now, when you --

MEMBER BONACA: Yeah, go ahead.

MEMBER SHACK: When you have the strippable coating in place and you're -- I trust you're still monitoring for leakage, do you get any leakage with the strippable coating in place? You're still getting leakage?

MEMBER BONACA: Yes, they do.

MR. GALLAGHER: We have had -- when we went through our commitments on this -- the current commitments, current licensing basis commitments, we couldn't find any current documentation on the monitoring of the water leakage. We've talked with people that have been in the sandbed and they have said that, you know, there is no water in the sandbed when they go in there to do the visual inspections on the coating. So we believe that our corrective actions have been effective, which I'll go in to tell you what we've done comprehensively to insure that the water is going down the trough drain and not into the air gap.

CHAIRMAN MAYNARD: I'd like for us to let the licensee go ahead, I think trying to give a history and --

MR. GALLAGHER: Yeah, we have a pretty good presentation.

CHAIRMAN MAYNARD: We can come back to these -- anything that is not answered, we can come back to but I want to leave time for us to do that.

MR. GALLAGHER: And I think we'll hit on

previous the sand could stay damp and that's what happened. That's how you got the corrosion without necessarily draining at all.

MEMBER SIEBER: That's right.

MR. ASHER: I will address your question about the operation of water. We've heard about this a long time back even during the Dresden containments and we asked the same questions that you are asking to the applicants. Okay. And the general answer was that it will operate and it won't corrode anything. I said no. I'm not ready to believe that. So what we resulted that did, the earlier one, and I saw a separate case too that we asked them to do the UT measurements from upper areas through which the water is continuing to the sand bed area. Okay. And a number of applicants said unless they see no activity of water at all during the entire life, then we will say that is not necessary. But that we have seen any water leakage from their refueling cavity or any other areas collected in the sand bed area, then the whole spherical area and cylindrical area are suspect. In this case also, at Oyster Creek also, they are required to do the UT in the upper area of the shaft.

MEMBER WALLIS: So the UT is the real check rather than looking in the buckets.

APPLICANT'S EXH. 31

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Advisory Committee on Reactor Safeguards Subcommittee on Plant License Renewal
Docket Number:	(not applicable)
Location:	Rockville, Maryland
Date:	Thursday, January 18, 2007
Work Order No.:	NRC-1398

Pages 1-371

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

SUBCOMMITTEE ON PLANT LICENSE RENEWAL

OYSTER CREEK GENERATING STATION

\+ + + + +

THURSDAY,

JANUARY 18, 2007

\+ + + + +

The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., DR. OTTO L. MAYNARD, Chairman, presiding.

MEMBERS PRESENT:

OTTO L. MAYNARD

, Chairman

GRAHAM B. WALLIS, Vice-Chairman

WILLIAM J. SHACK, ACRS Member

MARIO V. BONACA, ACRS Member

DANA A. POWERS, ACRS Member

JOHN D. SIEBER, ACRS Member

SAID ABDEL-KHALIK, ACRS Member

J. SAM ARMIJO, ACRS Member

NRC STAFF PRESENT:

LOUISE LUND
DONNIE ASHLEY
MICHAEL JUNGE
BARRY GORDON
RICH CONTE
MICHAEL MODES
JIM DAVIS
NOEL DUDLEY
P. T. KUO
SUJIT SAMMADAR

ALSO PRESENT:

MIKE GALLAGHER
PETE TAMBURRO
FRED POLASKI
AHMED OUAOU
HARDIYAL MEHTA
HOWIE RAY
TOM QUINTENZE
JOHN O'ROURKE
TIM O'HARA
JON CAVALLO
MARTY McALLISTER
JASON PETTI

<u>ALSO PRESENT</u> (Continued):

MIKE HESSHEIMER

PAUL GUNTER

RICHARD WEBSTER

I-N-D-E-X

I-N-D-E-X (Continued)

also high puree and will not lead to any degradation of the carbon steel.

MR. ARMIJO: Where did this water come from?

MR. GORDON: This is apparent during a maintenance.

MR. ARMIJO: It was a spill.

MR. GORDON: Yes, spills and things like that.

MR. GALLAGHER: As we mentioned in the beginning, it's equipment leakage. So the design of the drywell and the equipment leakage collection system, and so any leakage would come down, go in the sub pile room, go in a trough, and then goes into the sump. So it's designed that way to collect any leakage. That's where this leakage came from.

MR. ARMIJO: But did this water migrate through the concrete or did it just kind of flow over the top of something and just pour into this hole?

MR. POLASKI: It could have come from two sources. The investigation showed that the trough that we pointed out earlier in the sub pile room that all of the leakage is supposed to flow into and then drain to the sump did have some leakage in it. It was not in the condition it should have been, and that some of that water did migrate through the concrete and showed up in these troughs.

The other thing is John mentioned earlier that we have now installed caulking at the edge of the curve, you know, against the scale of the drywell. Most other BWRs have that caulked. Oyster Creek did not. Oyster Creek is unique. It has a curve there, but if there was any leakage that got on the shell of the drywell and ran down, it could have gotten directly below the concrete. Either of those ways could have accounted for this.

MR. GORDON: And, again, this slide shows the water, and you can see the carbon steel there, the bare carbon steel. This has some superficial corrosion on it.

What happens to the steel that's not protected by the water, basically the side pH water.

MR. SHACK: Did you make inspections or, okay, there is inspections later.

PARTICIPANTS: Yes.

MR. GORDON: What happens to the steel that isn't protected by this high pH, high purity water? When the drywell is inerted, the cathodic reactant for the Trojan (phonetic) reaction oxygen is depleted and corrosion would basically stop at that point.

Any possible subsequent steel corrosion would occur only during the brief outages, which are just a few, you know, ten days per year on average, and you wouldn't expect to see much atmospheric corrosion.

Finally, the transport of any oxygenated water that may come in from equipment manipulation would be affected by the high pH core water and also it would have to displace the oxygen depleted water before you'd see any corrosion.

So basically imbedded steel in concrete is not a concern on either the interior or the exterior of the drywell.

CHAIRMAN MAYNARD: Are you going to provide more justification for the superficial corrosion that you saw there or cover that in the inspection? I mean, you made a statement that there's some superficial rust there. I'd like to have a little bit more to go on than just that. How do you know it's superficial?

MR. GALLAGHER: Yes, Howie, answer that.

MR. RAY: Yes, so that's going to actually lead into the infraction to be performed.

CHAIRMAN MAYNARD: As long as it gets

covered there

MR. POLASKI: We will cover it in a couple of slides.

MR. GALLAGHER: And, Dr. Maynard, basically the bottom line is on the interior when we did UTs in the trench, and so you could easily wipe off the corrosion, and then we UTed the whole trench area and we have that data in here.

MR. POLASKI: So any other questions on --

DR. ABDEL-KHALIK: How much farther do you think beyond the trench that you dug in does the water extend or is the concrete in intimate contact with the steel along this entire bottom surface?

MR. POLASKI: The concrete that's on the inside --

DR. ABDEL-KHALIK: Right.

MR. POLASKI: -- as we said before, the concrete or the drywell shell was welded together and then the concrete was poured on the outside and then on the inside. So it is in intimate contact.

DR. ABDEL-KHALIK: So if it is in intimate contact, why is there water in the top part that you dug out?

MR. POLASKI: Well, even though it's in intimate contact, you can still get water into that.

There isn't really a gap there, but water can get in between, you know, soaked into the concrete along the steel.

MR. GALLAGHER: Yes, the concrete pour water throughout the concrete slab, and you know, so there's water there.

MR. RAY: Yes, the concrete is poured in different sections. So there's actually a pass where the water can get into the concrete or could migrate through the different paths and seek its elevation, to answer your question.

DR. ABDEL-KHALIK: Can you speak up a little bit louder?

MR. RAY: Yes. The concrete was poured in several different layers. So there are --

DR. ABDEL-KHALIK: Horizontal halves?

MR. RAY: Horizontal, yes.

DR. ABDEL-KHALIK: So, I mean, if I look at this picture, how much water is there and how much water don't I see?

MR. POLASKI: We believe based on what we found, when we found this water there was about five inches in the bottom of Trench 5. It was pumped out and then it filled back in again. So it was coming from, you know, underneath the concrete and other areas.

We believe that the whole inside of the drywell below the floor has water in there.

MR. ARMIJO: So you think there's water in this lower part of the sphere --

MR. POLASKI: Yes.

MR. ARMIJO: -- between the concrete and the shell.

MR. POLASKI: Yes, that's correct.

MR. ARMIJO: And the source is the sump.

MR. POLASKI: Well, the source is equipment leakage. It wasn't from the sump itself, but from the troughs that then lead into the sump indicated there was leakage out of that trough. However, there would have been water in the past if there was a leakage in the drywell, and again, there was some small amount of leakage in the drywell; if it got on the drywell shelf, could have run down and gotten directly below. It could have been there for years.

MR. GALLAGHER: Let's be clear. The trough that we're talking about is this trough that goes 360 degrees on the interior of the sub pile room. That's designed to collect the water and then move it to the sump.

There were some defects in this trough so that some water could have got into the concrete. We don't know how far, you know, water is down there. We're assuming it's down there and that we've taken action to have an aging management program, assuming it's there to check, and that's what we've done.

MR. ARMIJO: Well, the water level, you know, if it's in direct contact, if it refills, the water level is coming from somewhere. That's at least that elevation or higher.

MR. GALLAGHER: Yes, and this elevation here is the highest at that point. It's higher than the bottom of the trench was. We've corrected this trough. So we wouldn't expect anymore water to get in there, but we added it to our aging management program to verify that, to verify if there's any ongoing effect.

But this trough elevation, see, right here, if you look at the side, that's the bottom of the trough, and then the bottom of the trench we're talking about is at the bottom of the sand bed floor.

So any water you have coming down here going into the trough, if the trough was not finished correctly, would have gone into the concrete. So we fixed that.

MR. ARMIJO: But it's feasible the whole bottom of that shell could have water in it.

MR. GALLAGHER: And that's what we're presuming. We haven't verified it, you know, because we only excavated down here.

MR. POLASKI: We're assuming there's water there, but Mr. Gordon's presentation is just addressing what would the conditions be, and once that water gets in there --

MR. GALLAGHER: It should be benign.

MR. POLASKI: -- it should be benign. A passive layer was there when the concrete was initially poured.

MR. SHACK: It would be better if it wasn't there.

MR. GALLAGHER: That's correct.

MR. GORDON: But you know, concrete, even if it's very well cured and very old, it still has this moisture in it. It's like a very hard sponge with this concrete pour with a high pH pure water. So it really is basically a hard sponge, and it works very successfully with steel.

DR. ABDEL-KHALIK: But that would not be the source of the water you're seeing. I mean, you pumped it out and the thing filled up again.

MR. RAY: The source of the water was coming through the trough. We paired a void there, and we won't have that source of water.

DR. ABDEL-KHALIK: Okay. If you went and looked at it today, it would be full of water again?

MR. RAY: We would not expect it. It still had a little moisture in the bottom Trench 5 when we started back up. With the operating cycle, we would expect that to evaporate off.

MR. SIEBER: Did you find cracks in the concrete?

MR. RAY: No, we've done structural monitoring, logged into the concrete, and had no significant cracks. The only void we found was in that trough, and we did verify there was leakage through there with a leak test.

MR. POLASKI: Any other questions? Okay.

MR. SHACK: It just seems like 40 years of operation to find a trough has a hole in it.

MR. POLASKI: Yes.

MR. ARMIJO: When the trough was first excavated, was there any data that showed that there was water in the trough when it was first built?

MR. GALLAGHER: The trench?

MR. ARMIJO: The trench, I mean, yeah, the trench. When that was opened up the first time, did people find that full of water?

MR. GALLAGHER: When it was opened up the first time, I don't think there was any water in there, but we did find we did have some information that there was water there at one point, and in subsequent checks it wasn't there. So that's why we thought there was not a water environment in the lower elevation of the drywell, and that's why we hadn't included that as an environment in our LRA.

One thing we did though. We said, well, let's look at these trenches again, and that's when we identify this and put it in our corrective action system to update our LRA.

MR. ARMIJO: Have you ever experienced recirc water pump seal leak?

MR. GALLAGHER: Plant -- Tom Quintenze.

MR. QUINTENZE: I'm Tom Quintenze, AmerGen.

The question, I believe, was have you ever experienced recirc pump seal leaks.

MR. ARMIJO: Yes.

MR. QUINTENZE: And the answer to that is yes.

MR. ARMIJO: Would that be the source of

this water?

MR. QUINTENZE: It could be the source of water. In earlier years we did have some significant leak, but current history indicates that we've maintained our unidentified leak rate, which would be leakage from a recirc pump seal at a very low level, on the order of .1 to .2 gallons per minute.

MR. GALLAGHER: We know that we do have equipment leakage, like control rod drives. There's some leakage from them typically. They're right above the sub pile room, you know, right above this room here, and water drips down in all BWRs, and that's the case.

As Tom mentioned, there is an unidentified leakage criteria, no more than five gallons a minute unidentified leakage in your primary containment, and you know, we meet the technical specification limits by far. But this is designed to collect that leakage, any leakage like that and then take it away to the sump and then pump it out of containment.

MR. ARMIJO: Thank you.

MR. SIEBER: Given enough time though, that's a lot of water.

MR. GALLAGHER: Yes.

MR. POLASKI: All right. We've now heard

area would not cause significant corrosion inside the drywell.

MR. GALLAGHER: And part of the basis is, when we get to the next slide, when we interrogated the six inches below the concrete floor, the corrosion rate -- Howie, why don't you go into that and you can show him that -- the corrosion rate which is really over the entire period of time since that shell was imbedded in concrete.

MR. ARMIJO: Before you go, did you find water to the same extent in Trench 17 as you did in Trench 5?

MR. RAY: No, we did not. The Trench 17 is about six inches shallower than the trench in Bay 5.

MR. GALLAGHER: So it's a higher elevation. There was a little moisture in there, but --

MR. ARMIJO: If there had been water there, it would have drained to a lower level?

MR. GALLAGHER: Yes.

MR. RAY: It was seeking its elevation. It was voiced in Bay 17, but there's no standing water.

DR. ABDEL-KHALIK: The statement that was

We then took that corrosion byproduct and sent it to our labs for further analysis.

DR. WALLIS: So you didn't do an integrated measurement of how many truckloads of rust you took away.

MR. TAMBURRO: No, sir.

DR. WALLIS: No. Okay.

CHAIRMAN MAYNARD: But you know it has got to be a lot.

DR. WALLIS: Yeah.

DR. ABDEL-KHALIK: I have a follow-up question. Is the status of the sump pump or the sump level monitored in the control room?

MR. POLASKI: Yes, it is. There's surveillance tests the operators perform when it's pumped out, and they put it out to measure the leakage and how much water is going into the sump.

CHAIRMAN MAYNARD: Isn't that one of the input to your leak rate calculations?

MR. POLASKI: Well, that is the primary for unidentified leakages, is the pump-out.

DR. ABDEL-KHALIK: Okay. Thank you.

MR. POLASKI: If there are no other questions, we'll now go on to the final part of our presentation on the upper drywell shell. We have

THE HEADINGS AND NUMBERING USED BELOW ARE CONSISTENT WITH THE PM REQUEST CRITERIA FORM, ATTACH. 2 OF MA-MA-716-009.

1. COMPONENT ID(S): Drywell and Torus (PM18704M)

2. UNIT / SYSTEM #: 1/187

3. Revise

4. COMPONENT NAME: Drywell and Torus

5. PROPOSED CHANGE TO PM DATABASE:
This eval is being submitted under AR A2133631 for the purpose of planning these activities for the 1R21 Outage.

Remove the existing planned work order activities 01,02,03 and 04, in PM18704M, since these activities are implemented in PM18703M.

A/R Number: A2014243, Evaluation NBR 80, IR #34845 was previously issued to create this PM. In addition, A2127016, Eval 01 was issued against the Library AR for this PM to provide further direction on the content of this PM. The purpose of this eval is to supplement the previous requests with those requirements required to be annotated and completed for License Renewal commitments, and to plan this PM under a 1R21 AR and corresponding work order(s).

In addition, this eval provides guidance to document the references for commitments made prior to license renewal for leakage monitoring to support the Drywell Corrosion Monitoring Program.

A. Incorporate the following into the PM:

1. ON THE FIRST PAGE OF THE NEW RECURRING TASK WORK ORDER, IN ONE OF THE FIELDS LABELED "PM CLASS / BASIS CODES", ENTER AN "L" (TO INDICATE THE W/O IS ASSOCIATED WITH A LICENSE RENEWAL COMMITMENT).

2. ON SCREEN 2 OF THE NEW WORK ORDER, IN THE COMMENTS SECTION, ENTER THE FOLLOWING:
THE OYSTER CREEK LICENSE RENEWAL APPLICATION INCLUDES A COMMITMENT TO DEVELOP AND IMPLEMENT AN ASME Section XI, Subsection IWE PROGRAM. THE COMMITMENT FOR THIS AGING MANAGEMENT PROGRAM (AMP) IS DOCUMENTED IN PASSPORT AR 00330592, ASSIGNMENT 27, Sub assignment 07. THE OYSTER CREEK IWE PROGRAM PROVIDES, AGING MANAGEMENT OF THE PRIMARY CONTAINMENT THE COMMITMENT MADE UNDER AMP B.1.27, ASME Section XI, Subsection IWE TAKES CREDIT FOR THE INSPECTION ADDRESSED BY THIS WORK ORDER TO ENSURE THAT CORROSION IS NOT AFFECTING THE FUNCTIONS OF THE PRIMARY CONTAINMENT. THESE LICENSE RENEWAL COMMITMENTS ARE ANNOTATED WITH THE **(CM-1)** ANNOTATION. IN ADDITION, LEAKAGE MONITORING IS ALSO A COMMITMENT FOR THE DRYWELL CORROSION MONITORING

PROGRAM, WHICH PREDATED THE LICENSE RENEWAL COMMITMENTS. THESE COMMITMENTS ARE TRACKED BY REGULATORY ASSURANCE AS COMMITTED IN THE FOLLOWING REFERENCES AND ARE DESIGNATED BY **(CM-2)**:FEBRUARY 15, 1996 LETTER NRC TO GPU NUCLEAR(TAC NO. M92688). IN THE INSPECTION ACTIVITIES UNDER THIS WORK ORDER, ENTRIES THAT ARE FOLLOWED WITH A "**(CM-1)**" or "**(CM-2)**" DESIGNATION ARE COMMITMENTS, AND MAY NOT BE DELETED OR REVISED UNLESS THE REQUIREMENTS OF LS-AA-110 ARE FULFILLED.

.

.

B.In the Purpose Section of the work order activities enter the following:

.

The purpose of this activity is to complete commitments made for License Renewal and as part of our Drywell Corrosion Monitoring Program. These commitments are documented in the comments section of the work order. The license renewal commitments are annotated with the **(CM-1)** annotation. In addition, leakage Monitoring is also a commitment for the Drywell Corrosion Monitoring Program, which predated the License Renewal Commitments. These commitments are designated by **(CM-2)**:

C.Include the steps below to satisfy license renewal commitments.

1.Perform an inspection of the 5 sand bed region drains, in the torus room, for leakage every day during each outage while the reactor cavity contains water. **(CM-1)(CM-2, no frequency committed)**

.

a.Verify the poly bottles, which collect water leakage from the drains, are empty.

.

b.Visually inspect the tubing, which connect the drainpipes to the poly bottles for current flow of water or water drops.

.

c.Visually inspect the floor areas around and under the Torus for presence of water. If leakage is found, determine the source of leakage, and if not from the sandbed drains report the leakage in IR.

.

d.Notify engineering immediately if water is found in the poly bottles or if water leakage is observed coming from the sandbed drain lines.

.

e.If leakage is detected in any of the Sandbed Drains issue an IR with the following required actions per our commitments**(CM-1)**:

.

1)Determine the source of leakage and investigate and address the impact of leakage on the drywell shell, including:

.

a)Verification of the condition of the drywell shell coating and moisture barrier (seal) in the sand bed region and

b) Performance of UT examinations of the shell in the upper regions.

2) UTs will also be performed on any areas in the sand bed region where visual inspection indicates the coating is damaged and corrosion has occurred.

3) UT results will be evaluated per the existing program.

4) Any degraded coating or moisture barrier will be repaired.

5) These actions will be completed prior to exiting the associated outage.

2. Perform an inspection of the reactor cavity concrete trough drain for leakage every day during each outage while the reactor cavity contains water. **(CM-1)(CM-2, no frequency committed)**

a. The affected drain is 2-inch diameter NN-6, valve V-18-131 shown on P&ID GE-237E756 Sheet 1 & JC-147434 Sheet 2. Leakage from the drain can be observed by inspecting the Steel collection trough at elev. 75'.

b. Notify engineering immediately if evidence of water leakage is observed.

c. Issue an IR documenting the leakage, with the required action for engineering to evaluate the amount of leakage and any further actions. Evaluation of the leakage should consider the previous understanding of what acceptable leakage may be as agreed by the NRC and documented in the references for **(CM-2)**.

6. REASON FOR REQUEST: LICENSE RENEWAL COMMITMENT DEFINED IN PASSPORT COMMITMENT TRACKING AR 00330592.27 07.

7. PCM TEMPLATE REVIEWED; TITLE: NA

8. FREQUENCY: Daily during Refueling Outages

REQUIRED IN MODES: 4,5

9. INITIAL DUE DATE: 1R21

10. INITIAL SCHEDULE CODE / WINDOW: 1R21

11. FOR SCOPE INCREASES, CONCURRENCE OBTAINED FROM APPLICABLE WORK GROUP MANAGER:
WORK GROUP MANAGER SIGNATURE: Not applicable these are regulatory commitments.

12. COMMENTS (SIGNIFICANT ISSUES / 'YES' (ATTACHMENT 1)/

. BASIS / MODIFYING RCM CRITICAL TASK:
. LICENSE RENEWAL COMMITMENT DEFINED IN PASSPORT
. COMMITMENT TRACKING AR 00330592.27.07. and Drywell Corrosion Monitoring Program commitments.

.

13. SUBMITTED BY SYSTEM MANAGER / PROGRAM ENGINEER / OR
. COMPONENT SPECIALIST: REVIEWED BY: Bob Barbieri

.

14. APPROVED BY PLANT ENGINEERING MANAGER /
. PROGRAMS MANAGER OR CMO SUPERVISOR: Not Required

.

PREPARED BY: Ahmed M. Ouaou and revised by Tom Quintenz
DATE: 07/12/06

APPLICANT'S EXH. 33

*** ACTION REQUEST *** PAGE: 01

A/R TYPE	: AT AITL	A/R NUMBER	: A2014243
REQUEST ORG	: OWPM	A/R STATUS	: ASIGND
REQUEST DATE	: 14SEP01	STATUS DATE	: 14SEP01
REQUESTED BY	: MULHOLLAND,G	LAST UPDATE	: 25JAN06
		PRINT DATE	: 25JAN06

EVALUATION NBR:	81	ORIG DATE ASSIGNED:	
EVALUATING ORG:	OMM	EVAL DUE DATE:	01APR06
EVAL ASIGND TO:	CHERNESKY, DAVE	DATE ASSIGNED:	28OCT05
EVAL REQUEST ORG:	OEPE		
EVAL REQUESTOR:	BARBIERI,R	EVAL STATUS	: ACCEPT
EVAL RETURNED BY:			

IMPORTANCE CODE:___ OEAP:___ SCHEDULE CODE:_______ DATE FIXED:___

EVAL DESC: CREATE NEW PM

THIS IS IN RESPONSE TO AR 00348545. THE DUE DATE IS BASED	RB03	25OCT05
ON ASSIGNMENT #4. PLEASE CREATE A NEW PM TO PERFORM A	RB03	25OCT05
CAMERA INSPECTION OF THE REACTOR CAVITY DRAIN LINE BOTH	RB03	25OCT05
BEFORE AND DURING EACH REFUELING OUTAGE. THIS DRAIN LINE	RB03	25OCT05
IS A MAJOR FACTOR IN MINIMIZING LEAKAGE, WHICH AFFECTS	RB03	25OCT05
THE DRYWELL CORROSION RATE. THIS INSPECTION IS A COMMIT-	RB03	25OCT05
MENT AND MUST BE PERFORMED.	RB03	25OCT05
THIS DRAIN LINE IS LOCATED NEAR THE FUEL POOL COOLING	RB03	25OCT05
HEAT EXCHANGERS AND IS SHOWN ON DRAWING GE 237E756.	RB03	25OCT05
.	RB03	25OCT05
* ATTACHMENT 2 *	RB03	25OCT05
.	RB03	25OCT05
1. COMPONENT ID: SYSTEM 187, DRYWELL AND TORUS	RB03	25OCT05
.	RB03	25OCT05
2. SYSTEM #: 187	RB03	25OCT05
.	RB03	25OCT05
3. ADD / CHANGE / DEACTIVATE: ADD	RB03	25OCT05
.	RB03	25OCT05
4. COMPONENT NAME: DRYWELL AND TORUS	RB03	25OCT05
.	RB03	25OCT05
5. PROPOSED CHANGE TO PM DATABASE: ADD NEW PM TO	RB03	25OCT05
PERFORM CAMERA INSPECTION OF REACTOR CAVITY DRAIN LINE	RB03	25OCT05
PRIOR TO AND DURING EVERY REFUELING OUTAGE. THE PM	RB03	25OCT05
SHALL INCLUDE INSTRUCTIONS TO CLEAR A BLOCKAGE, IF ONE	RB03	25OCT05
IS FOUND. THE DRAIN LINE IS LOCATED NEAR THE FUEL POOL	RB03	25OCT05
COOLING HEAT EXCHANGERS.	RB03	25OCT05
.	RB03	25OCT05
6. REASON FOR REQUEST: THIS INSPECTION WAS A COMMITMENT	RB03	25OCT05
TO THE NRC, TO MINIMIZE REACTOR CAVITY LEAKAGE AND	RB03	25OCT05
THEREBY PREVENT FURTHER CORROSION OF THE DRYWELL SHELL.	RB03	25OCT05
IR 348545 WAS ISSUED TO DOCUMENT THE FACT THAT THE	RB03	25OCT05
INSPECTION WAS MISSED LAST OUTAGE, AND RECOMMENDED	RB03	25OCT05
ADDING THIS AS A PM.	RB03	25OCT05
.	RB03	25OCT05
7. PCM TEMPLATE REVIEWED; TITLE: NA	RB03	25OCT05
.	RB03	25OCT05
8. FREQUENCY: REFUELING OUTAGES REQUIRED IN MODES:	RB03	25OCT05
REFUEL	RB03	25OCT05
.	RB03	25OCT05
9. INITIAL DUE DATE: 1R21 - 10/1/2006	RB03	25OCT05
.	RB03	25OCT05
10. INITIAL SCHEDULE CODE / WINDOW: 1R21	RB03	25OCT05

*** ACTION REQUEST ***

A/R TYPE : AT AITL	A/R NUMBER : A2014243
REQUEST ORG : OWPM	A/R STATUS : ASIGND
REQUEST DATE: 14SEP01	STATUS DATE: 14SEP01
REQUESTED BY: MULHOLLAND,G	LAST UPDATE: 25JAN06
	PRINT DATE : 25JAN06

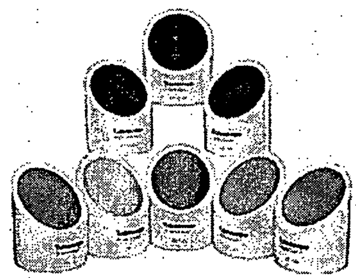
.	RB03	25OCT05
11. FOR SCOPE INCREASES, CONCURRENCE OBTAINED FROM	RB03	25OCT05
APPLICABLE WORK GROUP MANAGER:	RB03	25OCT05
WORK GROUP MANAGER SIGNATURE: NA	RB03	25OCT05
.	RB03	25OCT05
12. COMMENTS/BASIS/MODIFYING RCM CRITICAL TASK: THIS	RB03	25OCT05
ADDITION IS A REGULATORY ISSUE.	RB03	25OCT05
.	RB03	25OCT05
13. SUBMITTED BY: R. BARBIERI	RB03	25OCT05
.	RB03	25OCT05
14. APPROVED BY (MANAGER): HUTCHINS, SP	SPH1	25OCT05
.	RXB5	28OCT05
EVAL ASSIGNED TO PLANNING TO DEVELOP PM 18703M	RXB5	28OCT05

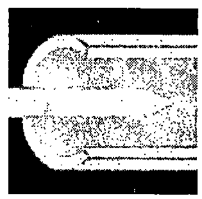
========================END OF ACTION REQUEST==============================

TK-7

TK-7

TK®-7 is a thin film, modified phenolic coating specifically formulated for use in high temperature and high pressure gas production environments containing CO_2 and H_2S. By design, TK-7 provides controlled diffusion of gases through the coating film. This characteristic prevents depressurization blistering that can occur in standard phenolic coating systems, while still providing superior corrosion protection. Standard coating systems are subject to blistering as gases and vapors attempt to escape from the coating during depressurization of the well. TK-7 has been utilized successfully in high CO_2 and H_2S gas production along the U.S. Gulf Coast for as long as twelve years as 325°F (163°C). Consult your Tuboscope representative for the latest performance results using TK-7.





Technical Specifications:

Type

Modified phenolic (liquid)

Color

Tan

Temperature

To 400°F (204°C)

Pressure

To yield strength of pipe

Applied Thickness

5-8 mils (127-203 μm)

Primary Applications

Production tubing, wellhead, flowlines and downhole equipment

Primary Services

Oil, natural gas, and CO_2 up to 400°F (204°C) and sour gas to 300°F (149°C) and above depending on concentration.

Limited Service

Wells with high water cuts (also see TK-2 or TK-69).

STIMULATION FLUIDS:

When stimulation fluids are charged through coated tubing, there is generally little effect if the fluids are flushed completely through the tubular. However, some organic acids, caustic and solvents may have a detrimental effect on certain organic coating systems and should be evaluated prior to use. If stimulation fluids are left in the tubing, they can reach formation temperature and cause accelerated attack on the coating. A Tuboscope representative should be consulted when stimulation is contemplated.

SAMPLE OF TESTING CAPABILITIES:

Thermal Analysis - Differential Scanning Calorimeter, Thermogravimetric Analyzer

Spectroscopy - Fourier Transform Infrared Spectrophotometer, UV-VIS Spectrophotometer

Chromatography - Gel Permeation Chromatograph (SEC), High Performance Liquid Chromatograph, Gas Chromatograph

Additional Physical/Chemical Testing - Microscope Analysis, Autoclave, Immersion Testing, Flow Loop Analysis

Product Development - Lab Compounding Capabilities

Coatings should be recommended by a Tuboscope representative in order to provide the best product for the specific environment at hand.

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Cures To A Tough, Water Resistant Coating

100% Volume Solids

- Very low viscosity
- Low film thickness required
- No shrinkage

RECOMMENDED USES

The extraordinary penetrating properties of Pre-Prime 167 Sealer provide a means of reinforcing rusty steel substrates—this in turn insures the adhesion of subsequent coatings.

- Recommended in areas where, due to restrictions or economics, blasting or thorough hand cleaning is not feasible.
- Very effective sealer and/or reinforcement for masonry surfaces.
- Excellent sealer for aged "white rusted" zinc surfaces.

SPECIFICATION DATA

Coating Type	100% Solids epoxy
Color Clear	**Catalog Number** 167-K-0000
Packaging	4 Gallon and 1 Gallon two-component kits
Component Ratio	3 to 1 by volume
Gloss	Medium sheen
Flash Point	100°F (38°C) Setaflash
Thinner	Do not thin
Pot Life	4 hours at 77°F (25°C)
Shelf Life	More than 1 year

Density	8.5 Lbs/Gal (1.02 kg/l)
VOC	0
Temperature Resistance	250°F (121°C) dry
Volume Solids	100%
Theoretical Spreading Rate	1604 Sq. Ft/Gal at 1 mil 39.3 Sq. m/l at 25 microns
Recommended Film Thickness 1.5 wet mils to obtain 1.5 dry mils	
Application Methods	Air spray, brush or roller
Dry Time To recoat	At 77°F (25°C), 50% RH Overnight

Application Guide

Surface Preparation

Pre-Prime 167 Sealer is designed for less than ideal surface preparation. However, performance will be improved as surface preparation improves. All oil/grease contaminants, loose rust, loose scale and unsecured old paint must be removed.

Best performance will be obtained by treating all surfaces with Devprep® 88 Cleaner, followed by a high pressure water wash before applying Pre-Prime 167 Sealer.

Mixing and Thinning

Pre-Prime 167 Sealer is a two component product supplied in 4 Gallon and 1 Gallon kits which contain the proper ratio of ingredients. The entire contents of each container must be mixed together.

Add the convertor portion to the base portion slowly with continued agitation. After the convertor add is complete, continue to mix slowly until homogeneous. Do not thin this material.

The pot life of the mixed material is 4 hours at 77°F (25°C). Higher temperatures will reduce working life of the coating; lower temperatures will increase it.

Application

Provide good, thorough ventilation.

Apply Pre-Prime 167 Sealer by conventional air spray, brush or roller. Airless spray is not recommended. To minimize overspray, use low air pressure and pot pressure—5 to 10 PSI.

Pre-Prime 167 Sealer is low in viscosity. It should be applied in one thin, wet coat sufficient to completely cover and penetrate to the steel surface. Do not apply heavy coats. Clean up application equipment with Devoe T-10 Thinner.

Apply one coat of Pre-Prime 167 Sealer at 1-1/2 mils—allow overnight cure. An additional coat of Pre-Prime 167 Sealer may be required for very porous surfaces. After overnight cure, Pre-Prime 167 Sealer may be overcoated if still tacky.

Pre-Prime 167 Sealer is normally topcoated with Bar-Rust™ 235 or Bar-Rust 236 Coating. Consult your Devoe Coatings Representative for alternatives.

Precautions

See the material safety data sheet and product label for complete safety and precaution requirements.

167/July, 1988

REGIONAL HEADQUARTERS

DEVOE COATINGS COMPANY
Division of GROW GROUP, INC.

KENTUCKY
P.O. Box 7600
Louisville 40207
(502) 897-9861

NEW JERSEY
[illegible] Ferndale Pl.
Rahway 07065
(201) 388-5100

CANADA
Devoe Coatings Canada
Div of Grow Group Canada, Ltd
55 MacDonald Ave
Dartmouth, Nova Scotia
Canada B3B [illegible]
(902) 469-[illegible]

THE NETHERLANDS
Devoe Coatings B.V.
Rotterdamseweg 144A
2629 AP DELFT Holland
(15) 5692[illegible]

SINGAPORE
Devoe Coatings Singapore
20 Penjuru Lane
Singapore 2260
(65) 2641772

TEXAS
515 North Belt
Suite 250
Houston 77060
(713) 999-4188

CALIFORNIA
2625 Durahart St.
Riverside 92507
(714) 686-6930

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Since 1754

DEVOE COATINGS

Marine·Industrial·Offshore

Devran® 184

100% Solids Epoxy Tank Coating

(Formerly Chemfast® 100)

Catalog Number 184-K-XXXX

FEATURES

100% Solids two-component coating

Can be applied with standard heavy-duty airless spray equipment

Devran 184 Coating has a 2 hour pot life

Excellent chemical, solvent and water immersion resistance

Aromatic solvents including xylene, cumene and aromatic naphthas

All gasolines including the super unleaded grades*

Methyl tertiary butyl ether

Caustic solutions

Can be applied up to 1/2 inch thick on horizontal surfaces

Approvals

EPA—Potable water tank lining

*Super unleaded gasoline containing methanol or ethanol are not suitable.

RECOMMENDED USES

- Repair of tank bottoms, including water tanks, fuel tanks, selected chemical tanks and ballast tanks.
- Complete tank linings
- Repair of pitted steel surfaces
- Potable water tank lining—no odor or taste problems
- Chemical resistant self-leveling coating for concrete floors and waste troughs
- Sewage and waste treatment plants
- Containment areas

SPECIFICATION DATA

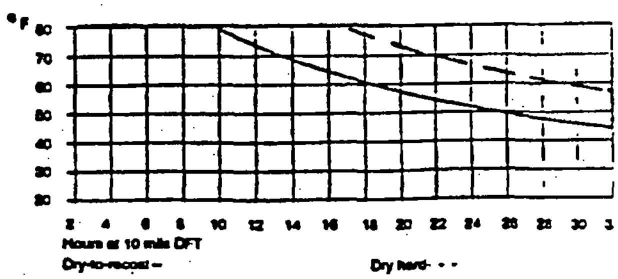
Coating Type	Advanced technology epoxy
Colors	**Catalog Number**
Aluminum Gray	184-K-2000
Oxide Red	184-K-7821
Packaging	4 Gallon two-component kits
Component Ratio	3 to 1 by volume
Gloss	High gloss
Flash Point	200°F (93°C) Setaflash
Thinner	Thinning not recommended
Clean up with Devoe T-10 Thinner	
Pot Life	2 hours at 77°F (25°C)
Shelf Life	More than 1 year
Density	14.8 Lbs/Gal (1.77 kg/l)
VOC	0
Temperature Resistance	250°F (121°C) dry
Volume Solids	100%

Theoretical Spreading Rate
1604 Sq. Ft/Gal at 1 mil
39.3 Sq. m/l at 25 microns

Recommended Film Thickness
8—10 wet mils to obtain 8—10 dry mils
Two coats for tank coatings, plus two stripe coats
Thicker coatings can be applied to horizontal surfaces.

Application Airless spray

Time—Temperature Drying Curve



The above curve is intended only as a general guideline. Ventilation, film thickness, humidity, thinning and other factors can influence the rate of dry (ASTM D1640).

Application Guide

Surface Preparation

All surfaces must be free of oil, grease salt and moisture before abrasive blasting to near white metal equivalent to Steel Structures Painting Council SP10 or Swedish Standard Sa 2-1/2. The minimum steel profile after blasting should be 2 mils (50 microns) in depth and be of a jagged nature as opposed to a peen pattern. Surfaces must be free of grit dust.

The first coat of the system should be applied to cleaned surfaces as soon as possible to prevent rerusting or contamination.

Ventilation

Although Devran 184 Coating is solventless, good ventilation with dry air is required for the protection of the applicator, to prevent condensation and to obtain proper coating performance. Ventilation should be maintained throughout the cure period. Be sure the air in the lowest areas is constantly replaced with fresh, dry air.

Mixing and Thinning

Devran 184 Coating is a two component product supplied in 4 Gallon kits which contain the proper ratio of ingredients. The entire contents of each container must be mixed together.

Mix the base portion slowly for several minutes. After mixing the base portion, add the convertor slowly with continued agitation. After the convertor add is complete, continue to mix slowly until the system is homogeneous.

Thinning is not normally required. At lower temperatures, efforts should be made to bring the coating to 77°F.

The pot life of the mixed material is 2 hours at 77°F (25°C). Higher temperatures will reduce working life of the coating; lower temperatures will increase it.

Application

Airless spray is recommended. Where airless equipment is used, a 45 to 1 pump and .023" to .029" tip size will provide a good spray pattern. Ideally, fluid hoses should *not* be less than 3/8" ID and not longer than 50 feet to obtain optimum results.

Devran 184 Coating can also be applied to floors or decks with a spreader or squeegee.

A minimum of four days cure with ventilation at temperatures above 77°F (25°C) should be allowed before tank linings are put into cargo service. Longer curing times with ventilation are required if temperatures are lower than 77°F.

Do not allow coating to remain in the application equipment longer than 2 hours. Flush out all application equipment whenever there is a delay in application.

Precautions

See the material safety data sheet and product label for complete safety and precaution requirements.

184/April, 1990

DEVOE COATINGS COMPANY
Division of GROW GROUP, INC.

REGIONAL HEADQUARTERS

KENTUCKY
P.O. Box 7600
Louisville 40207
(502) 897-9861

TEXAS
515 North Belt
Suite 250
Houston 77060
(713) 999-4186

NEW JERSEY
800 Ferndale Pl.
Rahway 07065
(201) 388-5100

CALIFORNIA
2625 Durahart St
Riverside 92507
(714) 686-6930

CANADA
Devoe Coatings Canada
Div of Grow Group Canada, Ltd
55 MacDonald Ave
Dartmouth, Nova Scotia
Canada B3B 1T9
(902) 469-7831

THE NETHERLANDS
Devoe Coatings B.V
Rotterdamseweg 144A
2628 AP DELFT Holland
(15) 569212

SINGAPORE
Devoe Coatings Singapore
20 Penjuru Lane
Singapore 2260
(65) 2641772

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Dr. Mehta Biography

Dr. Mehta received his B.S. in Mechanical Engineering from Jodhpur University (India), M.S. and Ph.D. from University of California, Berkeley. He was elected an ASME Fellow in 1999 and is a Registered Professional Engineer in the State of California.

Dr. Mehta has been with GE Nuclear Division (now called GE-Hitachi Nuclear Energy) since 1978 and currently holds the position of Chief Consulting Engineer, Mechanics. He has over 30 years of experience in the areas of stress analysis, linear-elastic and elastic-plastic fracture mechanics, residual stress evaluation, and ASME Code related analyses pertaining to BWR components. He has also participated as principal investigator or project-manager for several BWRVIP, BWROG and EPRI sponsored programs at GE, including the Large Diameter Piping Crack Assessment, IHSI, Carbon Steel Environmental Fatigue Rules, RPV Upper Shelf Margin Assessment and Shroud Integrity Assessment. He is the author/coauthor of over 35 ASME Journal/Volume papers. Prior to joining GE, he was with Impell Corporation where he directed various piping and structural analyses.

For more than 20 years, Dr. Mehta has been an active member of the ASME Boiler & pressure Vessel Code, Section XI Subgroup on Evaluation Standards and associated working and task groups. He also has been active for many years in ASME's PVP Division as a member of the Material & Fabrication Committee and as conference volume editor and session developer. His professional participation also included several committees of the PVRC, specially the Steering Committee on Cyclic Life and Environmental Effects in Nuclear Applications. He had a key role in the development of environmental fatigue initiation rules that are currently under consideration for adoption by various ASME Code Groups.

DR. HARDAYAL S. MEHTA
ACADEMIC QUALIFICATION

B.E. (Mechanical)	1964	University of Jodhpur (India)
M.S. (Mechanical)	1968	University of California, Berkeley
Ph.D. (Mechanical)	1971	University of California, Berkeley

LIST OF PUBLISHED TECHNICAL PAPERS AUTHORED/COAUTHORED BY H.S. MEHTA

1. E.R. Lambert, H.S. Mehta and S. Kobayashi, "A New Upper-Bound Method for Analysis of Some Steady-State Plastic Deformation Processes," Journal of Engineering for Industry, Trans. of ASME, Vol. 91, Series B, No.3, August 1969.

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3. H.S. Mehta and S. Kobayashi, "Finite Element Analysis and Experimental Investigation of Sheet Metal Stretching," Journal of Engineering for Industry, Trans. of ASME, 1972.

4. H.S. Mehta and S. Ranganath, "Environmental Fatigue Crack Growth Analysis Based on Elastic-Plastic Fracture Mechanics," ASME Paper No. 82-PVP-23, 1982.

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8. Mehta, H.S., "An Assessment of the Probability of Double-Ended Guillotine Break in a BWR Recirculation Piping," Proceedings of International Conference on Nuclear Power Plant Aging , Availability Factor and Reliability Analysis; San Diego, CA, 1985, pp. 467-472.

Mehta, H.S., "J-Integral Analysis of Ductile Fracture Margin in Piping Weld Overlays," Transactions of the 9th SMiRT Conference, 1987, Volume G, pp. 469-474.

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PARTICIPATION BY H.S. MEHTA IN ASME CODE, PVRC AND PVP DIVISION ACTIVITIES

1. Member of the following ASME Section XI Code Groups:

   Working Group on Pipe Flaw Evaluation
   Working Group on Flaw Evaluation
   Working Group on Operating Plant Criteria
   Subgroup on Evaluation Standards

2. Member of ASME Pressure Vessel & Piping (PVP) Division committees on Materials & Fabrication and Codes & Standards.

3. Continued participation as Session Developer, Session Chairman at PVP Division Conferences. Edited three PVP conference volumes (Coeditor: PVP-Vol. 241: Fatigue, Fracture & Risk - 1992; Principal Editor: PVP Vol. 260: Fracture Mechanics -Applications and New Materials, Principal Editor: PVP Volume 287: Fracture Mechanics Applications - 1994).

5. Member of PVRC Steering Committee on Cyclic Life and Environmental Effects in Nuclear Application (2001-2004). This Steering Committee was considering the revision of ASME Code fatigue curves for low alloy, carbon and stainless steels to include environmental effects. Recommendations of this committee had significant impact on BWR Fatigue evaluations. As a part of this Committee, I served as Chairman of Task Group on Total Damage Evaluation. I was also member of the several PVRC Working Groups/Task Groups which report to this Committee: W/G on S/N Analysis Data, T/G on Margins of Safety in Fatigue, T/G on Evaluation Factors on Fatigue and W/G on da/dN Data Analysis.

6. Member, International Association of Structural Mechanics in Reactor Technology.

7. Member, ASTM (Committee E.08 - Fracture and Fatigue).