UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
OFFICE OF THE SECRETARY

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of	)	
	)	Docket No. 50-0219-LR
AMERGEN ENERGY COMPANY, LLC	)	
	)	ASLB No. 06-844-01-LR
(License Renewal for the Oyster Creek	)	
Nuclear Generating Station)	)	June 23, 2006
	)	

MOTION FOR LEAVE TO SUPPLEMENT THE PETITION

Nuclear Information and Resource Service, Jersey Shore Nuclear Watch, Inc., Grandmothers, Mothers and More for Energy Safety, New Jersey Public Interest Research Group, New Jersey Sierra Club, and New Jersey Environmental Federation (collectively "Citizens" or "Petitioners") submit this Motion because AmerGen provided additional commitments and information as part of the license renewal process on June 20, 2006.

The Atomic Safety and Licensing Board (the "Board") in its Order of June 6, 2006 invited Citizens to petition to add a new contention and directed Citizens to limit their argument to AmerGen's docketed commitment of April 4, 2006. LBP-06-16 at 9 (Jun. 6, 2006) (unpublished). Petitioners were given until June 26, 2006 to do so. Id. However, on June 20, 2006, AmerGen provided NRC with supplemental information concerning their aging management program for the Oyster Creek drywell shell during the license

renewal period as well as additional commitments. Letter from Gallagher to NRC, dated June 20, 2006.

Citizens request leave to submit a supplement to their Petition to address AmerGen's new commitments and the new information provided in the June 20, 2006 letter. In addition, Citizens request the Board to order AmerGen and NRC Staff to respond to both the Petition and the supplement together ten days after the supplement is filed. This would allow the Board to evaluate the most current status of the dispute between AmerGen and Citizens, and would avoid needless duplicative rounds of filings.

For the foregoing reasons, the Board should grant leave for Petitioners to supplement the current pleading and order AmerGen and NRC to respond to the Petition and the supplement at the same time.

Respectfully submitted

Richard Webster, Esq
RUTGERS ENVIRONMENTAL
LAW CLINIC
Attorneys for Petitioners

Dated: June 23, 2006

DOCKETED
USNRC

June 23, 2006 (3:55pm)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
OFFICE OF THE SECRETARY

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of	)	
	)	Docket No. 50-0219-LR
AMERGEN ENERGY COMPANY, LLC	)	
	)	ASLB No. 06-844-01-LR
(License Renewal for the Oyster Creek Nuclear Generating Station)	)	June 23, 2006
	)	

PETITION TO ADD A NEW CONTENTION

PRELIMINARY STATEMENT

Nuclear Information and Resource Service, Jersey Shore Nuclear Watch, Inc., Grandmothers, Mothers and More for Energy Safety, New Jersey Public Interest Research Group, New Jersey Sierra Club, and New Jersey Environmental Federation (collectively "Citizens" or "Petitioners") submit this Petition at the invitation of the Atomic Safety and Licensing Board ("ASLB") in its decision of June 6, 2006 in this proceeding. In accordance with that decision, Citizens now seek to add a new contention alleging that AmerGen Energy Co. LLC ("AmerGen") must set forth a monitoring program for the sand bed region of the drywell shell that ensures that adequate safety margins are maintained throughout the licensing period, and that it has so far failed to do so. Citizens request a hearing on this issue in accordance with 10 C.F.R. § 2.309.

BACKGROUND

This proceeding concerns the aging of the steel containment vessel of the Oyster Creek Nuclear Generating Station that is termed the drywell shell. The shell provides containment in the

event of an accident. The lower portion of the shell is spherical with an inside diameter of 70 feet. Ex. NC 8 at 47. It is free standing from an elevation of 8 feet 11.75 inches from the bottom. Id. at 40. For around 3 feet 4 inches above that level to elevation 12 feet 3 inches, the exterior of steel liner used to have sand supporting it, but the sand was removed 1992. Id. at 47-48. This exterior portion of the drywell shell is termed the sand bed region. An interior floor is at elevation 10 feet 3 inches, id. at 47, and concrete curbs around the edge of the floor go up to the 11 foot elevation. Ex. NC 10. In the sand bed region, the design thickness of the vessel was 1.154 inches. Ex. NC 8 at 40.

Citizens initially contended that the testing of the extent of corrosion at all levels of the drywell shell proposed in AmerGen's license renewal application was inadequate to assure the continued integrity of this safety-critical structure for the period of the license extension. Petition at 3. To support this contention, Petitioners showed that the drywell shell is a safety-critical structure that acts both as a pressure boundary and as a structural support. Id. at 4. Petitioners then showed that water leakage onto the exterior of the drywell shell has caused significant corrosion, particularly in the sand bed region, where the N.R.C. regarded the corrosion as a "threat to drywell integrity." Id. at 4-6. Petitioners showed further that N.R.C. in 1986 regarded ultra-sonic testing of the sand bed region and other accessible areas of the drywell liner as "essential . . . for the life of the plant." Id. at 7.

Petitioners asserted that the potential for ongoing corrosion means that ongoing comprehensive testing is required to ensure the remaining razor-thin safety margins are met throughout any extended life of the plant. Indeed, Petitioners' Exhibit 5 at pages 8 and 12 showed that while AmerGen reported the "current thinnest" area to be 0.8 inches in December 1992, the actual thinnest areas are less than 0.736 inches, which was the original basis for evaluation. Multiple measurements in bays 1 and 13 and isolated measurements in bays 11, 15, and 17 were below 0.736 inches. Id. at 12.

The ASLB admitted a narrowed version of the initial contention pertaining to the need for ultrasonic ("UT") testing of the drywell in the sand bed region. LBP-06-07, 63 NRC 188 (2006). In that decision, the Board decided that Citizens had adequately demonstrated representational standing. LBP-06-07 at 3-6. Because this issue is res judicata, this Petition does not address this issue further, but relies upon Citizens' previous accepted demonstration of standing. The ASLB recently found that a new commitment made by AmerGen on April 4, 2006 to use UT testing to verify the thickness of drywell shell in the sand bed region every ten years had rendered the initial contention moot. LBP-06-16 (June 6, 2006). The ASLB also invited Citizens to submit a new contention concerning the adequacy of AmerGen's newly proposed UT testing regime for the sand bed region. Id. at 9.

Information that has become available since Citizens since filed the initial contention has now clarified many issues. For example, AmerGen has recently reported that over 20 areas in the sand bed region are now thinner than 0.736 inches and these areas have an average thickness of 0.703 inches. Ex. NC 2 at 13. In addition, the thinnest single measurement to date is 0.603 inches. Ex. NC 1 at 7. Citizens have also been able to discover the various acceptance criteria that are proposed, more details about the spatial scope of the monitoring, and how the results would be analyzed. To avoid repetition, this Petition presents the details of the support for the new contention in the Section on basis.

ARGUMENT

The proposed new contention satisfies the regulatory requirements by providing a specific statement of the contention, an explanation of basis, a demonstration that it is within the scope of the proceedings, and a demonstration of material issues that are in dispute. In addition, the proposed new contention is timely, because it is based on highly significant new information, including AmerGen's newly proposed testing regime.

A. Specific Statement of the Contention

In order to bring a contention before the Commissioners, Citizens must "[p]rovide a specific statement of the issue of law or fact to be raised or controverted." 10 C.F.R. § 2.309(f)(1)(i). The contention is:

> AmerGen must provide an aging management plan for the sand bed region of the drywell shell that ensures that safety margins are maintained throughout the term of any extended license, but the proposed plan fails to do so because the acceptance criteria are inadequate, the monitoring frequency is too low and is not adaptive to possible future narrowing of the safety margins, the scope of the monitoring is insufficient to systematically identify and sufficiently test all the degraded areas of the shell in the sand bed region, the quality assurance for the measurements is inadequate, and the methods proposed to analyze the results are flawed.

B. Explanation of Basis

1. Legal Requirements

At this preliminary stage, Citizens do not have to submit admissible evidence to support their contention, rather they have to "[p]rovide a brief explanation of the basis for the contention," 10 C.F.R. § 2.309(f)(1)(ii), and "a concise statement of the alleged facts or expert opinions which support the ... petitioner's position." 10 C.F.R. § 2.309(f)(1)(v).

This rule ensures that "full adjudicatory hearings are triggered only by those able to proffer ... minimal factual and legal foundation in support of their contentions." In the Matter of Duke Energy Corp. (Oconee Nuclear Station, Units 1, 2, and 3), CLI-99-11, 49 N.R.C. 328, 334 (1999) (emphasis added). The Commission has clarified that, "an intervener need not . . . prove its case at the contention stage . The factual support necessary to show a genuine dispute exists need not be in affidavit or formal evidentiary form, or be of the quality necessary to withstand a summary disposition motion." In the Matter of Georgia Institute of Technology, CLI-95-12, 42 N.R.C. 111, 118 (1995). Thus, the Commission has indicated that where petitioners make technically

meritorious contentions based upon diligent research and supported by valid information and expert opinion, the requirement for an adequate basis is more than satisfied.

2. Factual Issues Already Addressed By The ASLB

Citizens already demonstrated a basis for their initial contention about the lack of adequate UT testing. The initial petition and documents supporting that contention are incorporated into this pleading by reference. As recognized by the ASLB in its decision admitting the initial contention, Citizens had ample basis for the following points:

i) the drywell shell is a safety structure, LBP-06-07 at 26;

ii) water intruded into the sand bed region causing severe corrosion; id. at 33.

iii) water either is intruding, or could intrude in the future, leading to corrosive conditions on the outside of the drywell shell, id. at 36;

iv) the epoxy coating that was applied to protect the sand bed is now beyond its rated life and may be deteriorating, id. at 31, 36;

v) corrosion could occur even if the epoxy coating had not visibly deteriorated, id. at 36-37;

3. Proposed Monitoring For The Sand Bed Region Of The Drywell Shell

AmerGen has recently committed to perform visual inspections of the epoxy coating once before the end of the licensing period, and every ten years thereafter. Letter from Michael P. Gallagher, AmerGen, to NRC (Apr. 4, 2006). In addition, AmerGen has committed to performing UT measurements in the sand bed region at the same locations where UT measurements were conducted in 1996 prior to any license extension and at ten year intervals thereafter. Id.

Statistically significant deviations from the 1992, 1994, and 1996 UT results will result in:

i) performing additional confirmatory UT testing;

ii) notifying the NRC within 48 hours of the identified condition;

iii) conducting visual inspection of the external surfaces where corrosion may be occurring;

iv) performing an engineering evaluation to assess the extent of corrosion and whether additional inspections are required to assure drywell integrity;

v) performing an operability determination and justification for operation until the next inspection.

4. Deficiencies In the Proposed Monitoring Regime

As outlined in the contention and discussed in more detail below, Citizens have identified many deficiencies in the proposed monitoring regime. The NRC Staff also recently raised some similar issues regarding the accuracy of the previous results and the time between inspections. AmerGen's response to Staff's concerns was filed on June 20, 2006. However, as instructed in the ASLB's June 6, 2006 decision dismissing the initial contention, Citizens have based this new contention on the April 4th commitment made by AmerGen. LBP-06-16 at 9. Because the June 20, 2006 AmerGen response amends AmerGen's commitments, Citizens are filing an accompanying motion to supplement this Petition in response to the new commitments.

Turning to the substance, the proposed monitoring regime does not ensure that safety margins will be maintained throughout any renewed licensing period because the acceptance criteria are inadequate, the monitoring frequency is too low and is not adaptive to how close the shell thickness is to the acceptance criteria, degraded areas of the shell would not be systematically identified and sufficiently tested, the quality assurance for the measurements is inadequate, and the statistical techniques used in data analysis are flawed. This Section discusses these issues in detail.

These identified deficiencies are safety-critical, because the sand bed region of the shell is severely corroded making margins of safety much thinner than when the plant was first built. To maintain safety, the monitoring regime must be able to predict how fast the metal could corrode to safety-critical levels, and must ensure that testing of areas that are closest to the margins occurs before there is any possibility that the metal has corroded too much. For example, in parts, over 0.5 inches of metal has corroded away from the steel drywell shell, leaving a metal thickness of just

over 0.6 inches. According to AmerGen, no part of the drywell shell in the sand bed region should be thinner than 0.49 inches. Thus, the monitoring regime must ensure that a thinning of around 0.1 inches would be detected to ensure that the corrosion could not threaten the structural integrity of the shell. Monitoring once every ten years is inadequate for this purpose because corrosion rates of more than 0.03 inches per year have been observed under corrosive conditions.

a) The Acceptance Criteria Are Inadequate

To first establish the thickness acceptance criteria, AmerGen used modeling of a 36 degree slice of the drywell shell (called a bay) that assumed the sand bed region had uniform thickness. Ex. NC 1 at 7-8. That model showed that if the shell at the sand bed had a uniform thickness of 0.736 inches, it would be able to support itself. Id. at 8. In addition, further modeling showed that one contiguous area of one square foot in each bay could be thinner than 0.736 inches, provided it was thicker than 0.536 inches. Ex. NC 3 at 9. Furthermore, analysis showed that areas 2.5 inches in diameter could be as thin as 0.49 inches. Ex. NC 1 at 9.

To analyze the UT results, AmerGen initially analyzes whether the average wall thickness in each 6 inch by 6 inch monitored area is below 0.736 inches and whether each measurement is greater than 0.49 inches. Ex. NC 2 at 5. To evaluate areas where localized thickness is less than 0.736 inches AmerGen uses additional local wall acceptance criteria. Ex. NC 1 at 8. For small areas of less than 1 square foot, the mean thickness must be greater than 0.536 inches. Id. In addition, contiguous areas below 0.736 inches in average thickness should not exceed one square foot. Id. at 10.[1]

The latter acceptance criterion did not fully reflect the limitations in the modeling that was used to derive the results. For instance, the modeling assumed only one area thinner than 0.736

1 The wording of AmerGen's response is slightly ambiguous in this regard. However, reference to the original calculation C-1302-187-5320-024, attached as Citizens' Exhibit NC 3, at Sheet 9 confirms that the modeling on which this criterion was based showed adequate strength if a 1 foot by 1 foot square area in each bay was 0.536 inches thick, and the rest of the bay was uniformly 0.736 inches in thick.

inches in each bay, but in bay 13 alone there are a total of at least nine areas that are below 0.736 inches. Ex. NC 3 at 26. In fact, AmerGen has recently reported that over 20 areas in total are now thinner than 0.736 inches and these areas have an average thickness of 0.703 inches. Ex. NC 2 at 13. AmerGen has also recently recognized that the minimum required linear distances between thin areas has not been calculated, but it has asserted that safety will be maintained if the total area under 0.736 inches in the sand bed region is less than one square foot. Id. at 11. Applying this criterion, AmerGen recently estimated that 0.68 square feet of the sand bed area are thinner than 0.736 inches. Id. at 13. However, it is unclear how AmerGen derived this estimate and it is notable that no estimate of uncertainty was given. As discussed below, the area thinner than 0.736 inches is very sensitive to reductions in the thickness of the shell. Thus, it the uncertainty of this estimate must be high.

Even this revised one square foot acceptance criterion is a misinterpretation of the modeling results. The model did not look at whether other geometries, such as a long thin gash, would lead to failure even if the thin area is less than one square foot. It also did not look at a situation which approximates the real condition, where the exterior of the drywell is more like a golf-ball with alternating thinner and thicker regions. Thus, AmerGen should either use the model to find the smallest area that could allow buckling to occur and compare that to the worst case total thin areas, or it should input comprehensive measurements into the model to show that the worst case that could occur before the next scheduled measurements could not allow buckling. In both cases, AmerGen should take full account of the uncertainty in the current thin area and the potential for future corrosion to rapidly expand that area.

b) Monitoring Frequency Is Too Long And Monitoring Periods Must Adapt To Safety Margins

AmerGen has stated that it derived the proposed one in ten year testing frequency from the standard in-service interval. Ex. NC 4 at 63. This is totally inadequate. As discussed in the

memorandum of Dr. Hausler, dated June 23, 2006 and attached to this Petition, the proposed visual inspections of the coating cannot substitute for UT testing, because they are too infrequent and corrosion could occur behind the coating without being noted visualy. Memorandum of Dr. R. Hausler, dated June 23, 2006 at 6. Furthermore, the current safety margins are, at best, razor thin. For instance, the thickness of small areas are now within around 0.083 inches of the safety margin, based on a measured thinnest point of 0.603 inches, a 0.03 inch allowance for uncertainty, and the acceptance criterion for such points of 0.49 inches. Id. The means of the six inch by six areas that are proposed to be measured again were within 0.07 inches of the safety margin in September 1994. Ex. NC 8 at 56. In addition, the acceptance criterion requiring the area per bay that is less than 0.736 inches thick to be less than one square foot in area would be violated if less than around 0.026 inches of corrosion occurs. Memorandum of Dr. Hausler, dated June 23, 2006 at 7.

A reasonable estimate of the worst case potential corrosion rate that may occur could be obtained by analyzing the pre-1992 data. Id. at 6, 13. Observed corrosion rates to 1990 ranged up to 0.035 inches per year and were very uncertain. Ex. NC 9 at 7. As an illustration, even if the worst case corrosion rate were 0.02 inches per year and no corrosion has occurred since 1992, the drywell shell could exceed AmerGen's acceptance criterion for area below 0.736 inches in about one year. Memorandum of Dr. Hausler, dated June 23, 2006 at 7. Other criteria could be exceeded in around 4 years. The uncertainty in the worst case corrosion rate means that the measurements must be made at considerably shorter intervals than those calculated here to ensure that a measurement is taken before any of the acceptance criteria are violated.

Thus, if a corrosive environment is present on the outside of the shell, UT measurements must be taken at least once every year, based on the current acceptance criteria. Id. Finally, the frequency of the measurements must be related to the time in which the shell could corrode beyond

the safety margin. Thus, if the next round of measurements shows any deterioration, the monitoring frequency would have to be increased. Id.

c) The Proposed Scope Of The Monitoring Is Too Narrow

The spatial scope of the monitoring must be sufficient to allow meaningful comparison with the acceptance criteria that are to be applied to the results. In addition, the monitoring must look for all anticipated aging effects. Looking first at the spatial scope of the monitoring, at present the proposed monitoring only covers twelve 6 inch by 6 inch areas and seven 6 inch by 1 inch areas. Ex. NC 2 at 5. Thus, of the around 300 square feet in the sand bed region, 3 square feet, or around 1% is proposed to be monitored. Memorandum of Dr. Hausler, dated June 23, 2006 at 15. Furthermore, because the monitoring points were initially selected by measuring from the inside and around two thirds of the sand bed region is not accessible from the inside, the proposed monitoring regime misses out known areas of the shell that are below 0.736 inches in thickness. Id. at 8.

In addition, because there was no attempt to expand the spatial scope of the measurements when points below 0.736 inches were observed at the edge of the grids, the monitoring protocol only incompletely tracks the thin areas that it does monitor. Id. at 9. The proposed monitoring regime makes also fails to systematically survey the shell for new thin areas. Id. at 8-9. Because the area of each bay below 0.736 inches is an important acceptance criterion and is particularly sensitive to corrosion, it is critical that the monitoring regime systematically identify and track the thickness of all areas that are below 0.736 inches. Id. It is likely that this will require monitoring from the outside of the drywell. Id. at 9.

In addition to expanding the area of monitoring, another type of UT testing must also be added, because the shell is vulnerable to fatigue cracking in pitted areas. Id. at 5. This could go undetected under the currently proposed testing regime.

d) The Quality Assurance For The Measurements Is Inadequate

Recently, the NRC concluded that the 1996 UT testing results are anomalous because they show that the drywell shell got dramatically thicker between 1994 and 1996. Transcript of Meeting on June 1, 2006, attached as Citizens' Exhibit NC 4 at 28, 31. Despite this, AmerGen has continued to use these data to predict the thickness of the drywell shell during any license renewal period. See e.g. Citizens' Exhibit NC 1 at 19-30. This is wholly unjustifiable. To eliminate this possibility in the future, AmerGen must revise its quality assurance plans to identify flawed data soon after it is taken and must undertake to carry out replacement measurements if it finds that the original measurements are questionable. Memorandum of Dr. Hausler, dated June 23, 2006 at 9-10.

e) Statistical Analysis Of Results Is Flawed

As the NRC has recognized, uncertainty is the key issue when analyzing the UT results. Ex. NC 4 at 63-64. In fact, there are a number of uncertainties, all of which need to be taken into account in the design of the monitoring regime. The first is that the UT results themselves are subject to uncertainty. This uncertainty means that the thickness at the time the measurement is taken is uncertain and it also means that the rate of corrosion is uncertain. Adding to the uncertainty in the corrosion rate is that conditions may change over time. For example, coatings may deteriorate, or the volume and composition of the water reaching the corroded area may change.

As Dr. Hausler discusses in detail in his memorandum, the current statistical techniques employed are inadequate to find either the worst case baseline from which corrosion could occur, or the worst case corrosion rate. Memorandum of Dr. Hausler, dated June 23, 2006 at 10-15. The key flaws identified by Dr. Hausler are:

i) AmerGen has failed to use extreme value statistics to estimate the minimum current thickness of the drywell shell, id. at 5, 11, 14-15;

ii) corrosion is assumed to be linear, whereas in reality the corrosion rate can increase rapidly in a non-linear fashion, id. at 3, 12;

iii) analyzing corrosion rates using the average of the individual measurements taken in each grid is an invalid approach that leads to artificially low estimates of uncertainty, id. at 12;

iv) the thinnest points measured in the grids have sometimes been omitted from the means, leading to artificially high estimates of the current mean thickness, id. at 12-13;

v) an estimate of corrosion rate to 95% confidence is not sufficiently conservative for safety-critical issues, because one in twenty times the corrosion would be worse than the estimated rate, id.; and

vi) AmerGen has ignored previous analysis showing that at least four valid measurements are required to make a valid estimate of the corrosion rate and the confidence limits. Id.

Thus, AmerGen must make comprehensive measurements of the current wall thickness as soon as possible. Id. at 15. It must also revise its statistical techniques to calculate worst case estimates for all the parameters that are to be compared to the acceptance criteria, and must also calculate a worst case corrosion rate, which can be used to determine the appropriate time before the next monitoring.

C. The Scope of License Renewal Includes Corrosion Of The Drywell Liner

Petitioners are required to demonstrate that the issues raised in their contentions are within the scope of the proceeding, 10 C.F.R. § 2.309(f)(1)(iii). After extensive briefing of this issue, the ASLB concluded that corrosion of the drywell shell is within the scope of license renewal proceedings. In the Matter of AmerGen Energy Company (License Renewal for Oyster Creek Nuclear Generating Station), LBP-06-07 (slip op. at 39-40) (February, 26, 2006). That finding directly applies to the current contention, because it concerns the very same issue. Thus, the issue of scope is currently res judicata in this proceeding and is not subject to further dispute. However, the decision to admit the initial contention is currently on appeal to the Commission. Therefore, should the Commission amend the ASLB's finding regarding scope in its review of the AmerGen's

appeal, Citizens request an opportunity to file a supplemental briefing addressing the Commission's findings.

D. Showing of Materiality

The regulations require Petitioners to "[d]emonstrate that the issue raised in the contention is material to the findings the N.R.C. must make to support the action that is involved in the proceeding." 10 C.F.R. § 2.309(f)(1)(iv). A showing of materiality is not an onerous requirement, because all that is needed is a "minimal showing that material facts are in dispute, indicating that a further inquiry is appropriate." Georgia Institute of Technology, CLI-95-12, 42 N.R.C. 111, 118 (1995); Final Rule, Rules of Practice for Domestic Licensing Proceedings – Procedural Changes in the Hearing Process, 54 Fed. Reg. 33,171 (Aug. 11, 1989). Similarly, in Gulf States Utilities Co. (River Bend Station, Unit 1), CLI-94-10, 40 NRC 43 (1994), the Commission stated that, at the contention filing stage, "the factual support necessary to show that a genuine dispute exists need not be in formal evidentiary form, nor be as strong as that necessary to withstand a summary disposition motion." 40 NRC at 51. Rather, the petitioner need simply make "a minimal showing that the material facts are in dispute, thereby demonstrating that an inquiry in depth is appropriate." Id. (internal quotation marks omitted).

In admitting the initial Petition, the ASLB found that a genuine and material dispute existed about whether the then proposed aging management program, which did not include periodic UT measurements, would enable AmerGen to maintain safety margins during the term of any extended license. LBP-06-07 at 38-39. This new contention concerning AmerGen's April 4, 2006 commitment continues this material dispute, taking AmerGen's additional commitment into account.

Furthermore, in this Petition, Citizens have shown by reference to exhibits and expert opinion that the proposed monitoring by AmerGen is too limited in scope and too infrequent to

allow the current razor-thin safety margins to be maintained. In addition, Citzens have demonstrated that AmerGen has proposed to use flawed acceptance criteria and statistical methods to determine whether the results are significant and to project how quickly corrosion to safety critical levels could occur in the future. Thus, Citizens contend that the proposed program would fail to ensure that safety margins would continue to be met during any license renewal period.

In contrast, AmerGen has stated that the committed monitoring regime will ensure that it can maintain safety margins throughout any extended license term. AmerGen Motion to Dismiss The Admitted Contention at 8. It has also stated that it made the additional commitments to "provide assurance that the drywell shell will remain capable of performing its design functions throughout the license renewal period." Letter from Michael P. Gallagher, AmerGen, to NRC (Apr. 4, 2006). Thus, at a high level the dispute is about the adequacy of the commitments to ensure that safety margins are maintained.

At the more detailed level, Citizens have identified a myriad of flaws in AmerGen's approach, such as the failure to consider deterioration of the epoxy coating, the assumption that corrosion will be linear, and the failure to measure all the identified degraded areas. Thus, many more detailed material issues are also in dispute. Finally, because safety of the reactor hinges on the outcome of this dispute, it must be resolved before the NRC can issue any extended license.

E. This Request Is Timely

Petitioners may add new contentions after filing their initial petition, so long as they act in accordance with 10 C.F.R. § 2.309(f)(2). Entergy Nuclear Vermont Yankee, L.L.C. (Vermont Yankee Nuclear Power Station), LBP-05-32, 62 NRC 813 (2005). The Commission's regulations allow for a "new contention" to be filed upon a showing that:

> (i) The information upon which the amended or new contention is based was not previously available;

> (ii) The information upon which the amended or new contention is based is materially different than information previously available; and
>
> (iii) The amended or new contention has been submitted in a timely fashion based on the availability of the subsequent information.

10 C.F.R. § 2.309(f)(2)(i)-(iii).

In Vermont Yankee, the Board first admitted a contention of omission challenging an applicant's failure to perform structural and seismic analyses. The applicant subsequently performed structural and seismic analyses, after which it filed a motion to dismiss the contention as moot, which the Board granted. See Vermont Yankee, LBP-05-32, 62 NRC 813, 820. The Board gave the petitioner 20 days to file a new contention. Id. In response, the petitioner filed a contention challenging the sufficiency of the structural and seismic analyses. Id. In admitting the new contention, the Board held that the analyses were clearly information that was "not previously available" because it filled a prior omission, and that they were "materially different than information previously available" because something is obviously different than nothing. Vermont Yankee, LBP-05-32, 62 NRC 813, 820; 10 C.F.R. § 2.309(f)(2)(i)-(ii).

The facts of the present case directly parallel the facts of Vermont Yankee. First, the Board admitted a contention challenging AmerGen's failure to provide a plan for periodic UT testing in the sand bed region of the drywell. AmerGen subsequently docketed a commitment to adopt aging management procedures that included performing visual and UT testing every 10 years over the 20-year relicensing period, after which it filed a motion to dismiss the contention as moot. Just like Vermont Yankee, the Board granted the mootness motion, but also invited Citizens to file a new contention concerning the adequacy of the new commitment within 20 days. Licensing Board Memorandum and Order (Contention of Omission is Moot, and Motions Concerning Mandatory Disclosure are Moot), LBP-06-16 at 2 (Jun. 6, 2006) (unpublished). In accordance with the Board's

Order, Citizens are now seeking to add this contention challenging the sufficiency of the proposed monitoring regime. Thus, like Vermont Yankee, the ASLB should now find that the new contention is based upon information that was "not previously available," and that is "materially different than information previously available." 10 C.F.R. § 2.309(f)(2)(i)-(ii).

Further supporting the conclusion that the April 4, 2006 commitment is materially different information is that the Board decided that it made Citizens' previously admitted contention moot. Thus, it made a material difference to this litigation. Such a conclusion is further reinforced by noting that "something" (a UT testing plan) cannot be materially the same as "nothing" (no UT testing plan at all), meaning that the newly announced UT plan is "information ... materially different than information previously available." 10 C.F.R. § 2.309(f)(2)(ii). See Vermont Yankee, LBP-05-32, 62 NRC 813, 820.

In addition, at the time the initial Petition was submitted, Citizens had limited information about the drywell corrosion issue. For example, Citizens did not know what the 1996 measurements showed because, despite diligent efforts, Citizens had been unable to obtain those measurements. It was also unclear how AmerGen had changed the acceptance criteria for measurements that showed that the steel shell was already thinner than the initial 0.736 inch criterion. The Exhibits attached to this contention and upon which Dr. Hausler has based his June 23, 2006 memorandum have now clarified these issues, but they were not available to Citizens at the time the initial Petition was submitted. More specifically, Exhibits NC 1 and NC 2 were created in April 2006, Exhibit NC 4 was created in June 2006, and Citizens obtained the rest of the Exhibits from AmerGen through the document disclosure process. Thus, material new information has allowed Citizens to now submit a much more specific new contention, which therefore satisfies 10 C.F.R. § 2.309(f)(2)(i)-(ii).

Finally, because this contention is being filed within the timeframe specified by the Board's Order of June 2, 2006, it satisfies 10 C.F.R. § 2.309(f)(2)(iii). Furthermore, the Order also makes clear that "if NIRS satisfies the remaining factors in section 2.309(f)(2) - the parties need not address the requirements under 10 C.F.R. § 2.309(c), which apply to 'nontimely filings.'" Licensing Board Memorandum and Order (Contention of Omission is Moot, and Motions Concerning Mandatory Disclosure are Moot), LBP-06-16 at n.12 (Jun. 6, 2006) (unpublished).

CONCLUSION

For the foregoing reasons, the ASLB should grant this Petition to add the proposed new contention.

Respectfully submitted

Richard Webster, Esq
RUTGERS ENVIRONMENTAL LAW CLINIC
Attorneys for Petitioners

Dated: June 23, 2006

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

In the Matter of	)	
	)	Docket No. 50-0219-LR
AMERGEN ENERGY COMPANY, LLC	)	
	)	ASLB No. 06-844-01-LR
(License Renewal for the Oyster Creek	)	
Nuclear Generating Station)	)	June 23, 2006
	)	

CERTIFICATE OF SERVICE

I hereby certify that the foregoing Petition with attachments and motion was sent this 23rd day of June, 2006 via email and U.S. Postal Service, as designated below, to each of the following:

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

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

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

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

Email: ajb5@nrc.gov

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

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

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

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

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

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

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

John Covino, DAG (Email and U.S. Postal Service)
State of New Jersey

Department of Law and Public Safety
Office of the Attorney General
Hughes Justice Complex
25 West Market Street
P.O. Box 093
Trenton, NJ 08625
E-mail: john.corvino@dol.lps.state.nj.us

Paul Gunter (Email and U.S. Postal Service)
Nuclear Information and Resource Service
1424 16th St. NW Suite 404
Washington, DC 20036
Email: pgunter@nirs.org

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

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

Kelly McNicholas (Email)
New Jersey Sierra Club
139 West Hanover Street
Trenton New Jersey 08618
Email: Kelly.McNicholas@sierraclub.org

Suzanne Leta (Email)
New Jersey Public Interest Research Group
11 N. Willow St,
Trenton, NJ 08608.
Email: sleta@njpirg.org

Peggy Sturmfels (Email)
New Jersey Environmental Federation
1002 Ocean Avenue
Belmar, New Jersey 073 19
Email: psturmfels@cleanwater.org

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

Signed: _______________________
Richard Webster

Dated: June 23, 2006

CORRO-CONSULTA

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

Rudolf H. Hausler
rudyhau@msn.com

Kaufman, TX 75142
Fax: 972 932 3947

Memorandum

To: Richard Webster, Esq. June 23, 2006

From: Rudy Hausler

Subject: **Discussion of Corrosion Monitoring Methodologies At Oyster Creek Nuclear Plant Dry Well**

SUMMARY

The corrosion on the outside of the Oyster Creek drywell steel liner, particularly in the former sandbed region, is of great concern in regards to the structural integrity of the liner. Various structural integrity calculations had been performed by Amergen/Exelon in the past to arrive at various wall thickness criteria. Subsequently these criteria were compared to actual measurements of remaining wall thicknesses. Going forward, continuing corrosion rates have been discussed, and times at which possible minimum wall thickness, as defined by the criteria, have been derived by the operator.

This study critically reviews what is known about the corrosion in the sandbed area, the way the corrosion measurements had been evaluated, and the conclusions that had been drawn.

As it turns out, only a very small fraction of the total sandbed area had been examined, which poses the problem as to whether in fact the most severely corroded areas had been observed, and whether extrapolation of these observation to the entire surface are justified.

The measurements were performed with a 6inch by 6inch template and consisted of point measurements at one-inch spacings. As a consequence assessments of corrosion flaws could only be made in the z-direction (depth) while the x/y dimensions of the flaws remained unexplored. However, acceptance criteria are based on spatial dimensions, which consequently had to be guessed at.

It had been assumed that pitting corrosion rates in the sand bed area would be constant in time. This assumption is not justified based on an analysis of the corrosion mechanism. It had also been assumed that the pit distribution would be Gaussian, and that therefore the deepest measured pits which were beyond

the 2s limit could be dropped from consideration. This is considered an unprofessional approach for two reasons. First: no measurements should ever be excluded from consideration (on statistical considerations only) unless it can be demonstrated that such measurements are flawed technically. Second: Pit distributions are not Gausian, but exponential, hence the deepest pits are of vital importance.

Amergen/Exelon evaluated corrosion rates based on average remaining wall thickensses. However it is well known that structures do not fail by averages but rather by extremes, namely where due to corrosion the wall thickness had become thinnest.

Consequently, evaluation of the available data by extreme value statistics demonstrated that the most probable deepest pits (corrosion anomalies) were deeper than those assessed by the operator or Oyster Creek.

At this point in time, there are no valid assessments of possible corrosion (pitting) rates. The operator assumed that conditions might have been constant over time and would remain constant in the future. However, this assumption cannot be justified under any condition.

It is, therefore, considered of primary importance that a) the entire drywell surface be examined with UT technology capable of assessing corrosion anomalies spatially. It is furthermore essential that the coating, which is well past its useful lifetime be examined with methodology other than just visual, in order to completely assess whether it is still protective. Programmatic aging surveillance must include such measurements much more frequently than every 10 years, because deterioration of the coating is not linear in time either.

I. Background

It is well established that serious corrosion occurred over the years on the outside of the drywell containment of the nuclear reactor at Oyster Creek [1]. While corrosion occurred in all areas on the outside of the drywell, which experienced temporary or permanent wetting due to water leaks, the most severe damage was observed in the sandbed region [2]. In 1992 the sandbed was removed and the corroded areas were coated with an epoxy coating. The coating was specified to have "an estimated life of 8 to 10 years". Subsequently three UT inspections were performed in 1992, 1994 and 1996. Based these inspection results, projections were made to the effect that no corrosion would occur over the next 10 years. There are many concerns within this paradigm, which need further examination and discussion. The most striking are:

---

[1] see for instance e-mail correspondence from George Beck (Exelon Corp.) to Donnie Ashley (dja1@nrc.gov) 4/5/06)

[2] see for instance GPU Nuclear Corporation letter to US NRC September 15, 1995

- The assertion of no further corrosion based on the '92, '94 and '96 UT measurements was erroneously based on the assumption that conditions would remain constant, i.e. the epoxy coating of the dry well liner and concrete floor, as well as the elastomer used to seal the crevice between the floor and the drywell liner, all part of the sandbed region, would not deteriorate with time.

- The analysis of the results erroneously assumed that averaging 49 individual UT measurements, which were conducted over a 6x6 inch grid at 1 inch spacings would adequately represent the corrosion damage occurring in each bay, and hence these averages could therefore be used to conduct the necessary structural integrity calculations.

Embedded in these major concerns are a number of issues dealing with basic assumptions made in the evaluation of the corrosion measurements. These are listed below and will require some discussion:

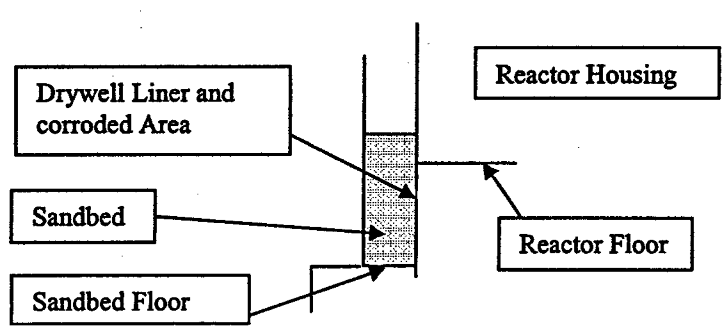
- Amergen/Exelon have assumed that the growth of the observed localized attach (pitting) would be linear with time, hence the corrosion rate) pit penetration rate) would be constant with time. The known pitting mechanisms will not support this assumption

- It has been furthermore assumed and so stated in many supporting documents that the pit size distribution would be normal (Gaussian). This assumption has then led to a number of conclusions and actions, which must be revised.

- It has also been assumed that averages of observed pit sizes would be representative of the corrosion processes, and that such averages from observations over time could be used to extract the "corrosion rate" (or more precisely, the pit penetration rate).

II. Some Comments Regarding the Corrosion Mechanism

A simple model as follows is being considered in order to delineate the major processes and parameters, which control them:



The fact is that the sandbed was essentially soaked with water, either periodically or permanently. This water was initially aerated which caused corrosion, even if the pH is above 7. As corrosion in the wet sandbed continues, the wet environment in the sand becomes depleted of oxygen. However, there is an almost inexhaustible reservoir of oxygen just above the sandbed – the air space. As a consequence, the steel surfaces embedded in the sand become anodic, while the cathodic reaction takes place on the areas which are richer in oxygen – the typical situation for crevice corrosion. The anodic reaction is not uniform, but pits will be forming. Initially, there will be a plethora of small shallow pits. Eventually some grow deeper than others, in fact at the cost of others. The frequency distribution of the pits is not normal, rather one can observe an exponential distribution – the frequency of pit depth decreases exponentially with pit depth. The fact that often a normal distribution is observed is an artifact, simply because the smaller pits are not normally measured, but are attributed to surface roughness and hence not included in the histogram. For this reason it is not proper to evaluate pit depth distribution on the basis of Gaussian statistics, and it is even less proper to discard deep pits outside the 95% confidence limits as atypical. Rather, deep pits, which have been measured, are a fact of life and must be included in any statistical evaluation, unless the measurement can be shown to be faulty for technical (not statistical) reasons. We will therefore show below the application of extreme value statistics to some data obtained from Oyster Creek.

Since pits are anodic areas where iron ions are being generated it stands to reason that anions must migrate into the pit, generally through a corrosion product layer, which fills the pit, such as iron hydroxide (two valent), or iron oxyhydroxide (three valent). The anions, which are present in the water at the highest concentration, are most likely to accumulate at the bottom of the pit where iron ions are being generated. The water in the sand bed is said to have contained as much as 500 ppm of chloride ions. This is more than the concentration the hydroxide ion at a pH of 7 or $1.5x10^{-5}$ mol/l Cl^- vs. 10^{-7} mol/L for OH^-. Chloride therefore will accumulate at the bottom of the pit. This will cause the pH in the pit to decrease to perhaps as little as 1 or 2. (This chemistry is well known and has been described in the literature many times). Lowering of the pH in the pit will accelerate pit growth, provided that the mass transport of water into the pit can sustain a higher corrosion rate at the bottom of the pit.

- It is therefore no forgone conclusion that the pit growth rate is constant with time. In fact, depending on the nature of the corrosion product in the pit, the mass transport into the pit can either be shut down, or sustain an accelerated corrosion rate due to the lower pH.

- Organic coatings will greatly reduce the transfer of both water and oxygen to the pit area. However, as the coating ages, such mass transfer is again accelerated. The unverified assumption that the coating will shut down pit growth for all eternity is totally unjustified. Furthermore, the unverified

assumption that visual observation of the coated areas is sufficient to assert that no corrosion occurs is also unjustified. The assumption that if the coating held for 10 or 15 year it will hold for another 20 years is also unjustified and contradictory to general observations. (Coating life has been specified for 8 to 10 years).

- More disturbing, however, the fact that pit depth of 600 mils can easily be demonstrated statistically. This corresponds locally to a remaining wall thickness of about 550 mils or close to the 490 mil criterion for small areas. (This criterion, as we understand it is based not on buckling considerations, but on pressure calculations.) If isolated pits of that size exist, and extreme value statistics predict such pits with a high probability (see below), then the specter of chloride induced fatigue cracking is raised. Again, the danger is based on the fact that chloride is present in the base of the pit (and has actually been found there), that the pH in the pit is low, and that the stress at the pit tip is approaching a limiting value. All this contributes to stress corrosion and/or fatigue cracking. **It will therefore be necessary to examine the corroded areas, and in fact all areas susceptible to corrosion, for the possible existence of cracks in the dry well liner wall.**

III. Monitoring Frequency Is Too Long And Monitoring Periods Must Adapt To Safety Margins

Because the sand bed region is severely corroded, margins of safety are now much thinner than when the plant was first built. For example, in parts, over 0.5 inches of metal have corroded away from the steel drywell shell over areas larger than just single pits, leaving a metal thickness of just over 0.6 inches. According to AmerGen, no part of the drywell shell in the sand bed region should be thinner than 0.49 inches. Thus, to maintain safety, the monitoring regime must be able to predict how fast the metal could corrode to safety-critical levels, and must ensure that testing of areas that are closest to the margins occurs before there is any possibility that the metal has corroded too much.

The monitoring regime proposed does not achieve this goal because the monitoring frequency is too low and is not adaptive to how close the shell thickness is to the acceptance criteria, degraded areas of the shell would not be systematically identified and tested, the quality assurance for the measurements is inadequate, and the statistical techniques used in data analysis are flawed. This Memorandum discusses these issues in detail.

1. Overview

AmerGen has stated that it derived the proposed one in ten year testing frequency from the standard in service interval. Ex. NC 4 at 63. This is totally inadequate.

To insure that margins of safety are maintained, AmerGen must predict the worst case corrosion rate that could occur before the next scheduled round of monitoring. The monitoring regime should show that in the worst case the acceptance criteria will continue to be met. Interestingly, in the past the reactor operator has recognized this need to some extent. For example, in 1992 a calculation estimated that with 95% confidence, the mean thickness of area 13A would not go below 0.736 inches before June 1995. Ex. NC 7 at 9. The operator also predicted the minimum mean thickness at the 95% confidence level at the date of the next scheduled monitoring to verify that it was less than the acceptance criterion. Id. at 10.

However, more recently AmerGen has not estimated the corrosion rate at the sand bed because it has assumed that it is zero, which, far from being the worst case, is actually the best possible case. See NC 1 at 19 to 30. Furthermore, although the reactor operator used to provide 95%ile confidence limits for its predictions, AmerGen has ceased to do this for the sand bed region, id., while continuing to do this for the upper drywell. Ex. NC 6 at 8. AmerGen attempts to justify this on the basis that visual inspection of the sand bed is sufficient. Ex. NC 1 at 32. However, the coating could deteriorate between inspections, because it is already well past its 8 to 10 year expected life. Ex. NC 8 at 56. In addition, corrosion behind the coating could occur and not be noted visually. Furthermore the committed visual inspection period is once every ten years, the same as the UT testing period. Therefore, visual inspections will not provide any information on changes in conditions between UT tests.

In addition, because past analyses relied on prediction of the mean thickness, they failed to apply a corrosion rate to the measurements at individual points to ensure that even in the worst case they will remain thicker than the 0.490" acceptance criterion before the next scheduled monitoring. Furthermore, they failed to predict the rate of growth of the areas below 0.736 inches in each bay to ensure that they will also remain less than one square foot before the next scheduled monitoring.

At present, AmerGen has insufficient data to predict the worst case corrosion rate without sand. As discussed in more detail below, one reasonable approach to resolve this problem would be to use results taken before the sand was removed, derive a statistically valid worst case corrosion rate, and see how soon acceptance criteria could be violated using that rate. For example, AmerGen has stated that the thinnest individual result that has been measured is 0.603 inches. Ex. NC 1 at 7. The acceptance criterion for individual points is 0.490 inches. The uncertainty in each measurement is around 5% or 0.03 inches meaning that the thinnest real condition consistent with the measurement is around 0.573 inches.[3] This yields a current margin of safety of approximately 0.083 inches. The second highest long term corrosion rate estimated was 0.017 inches per year. Ex. NC 1 at 20. Thus, assuming that the next round of monitoring shows no further deterioration, and that

---

[3] As discussed below, AmerGen should make a more rigorous estimate of this parameter using appropriate statistical measures.

the worst case corrosion rate could be around 0.020 inches per year, further testing would be needed in approximately four years.

Turning to the area below 0.736 inches, bay 13 was closest to the safety margin when measurements were taken from the outside in 1992. The results showed that nine areas below 0.736" were widely scattered over a large area in this bay. Ex. NC 3 at Sheet 26-29. The outside of the shell was found have indentations from a thickness of around 0.800 inches that were "about 12 to 18" in diameter . . . at about 12 inches apart." Id. at Sheet 24. Measurements of nine one to two inch diameter areas at the thinnest parts of these indentations showed thicknesses ranging from 0.618 inches to 0.728 inches. Id. at Sheets 26, 28. The areas below 0.736 inches were "not more than 1 to 2 inches in diameter," except for location 7 which could have been 6 inches square with an average thickness of 0.677 inches. Id. at Sheet 26.

Applying the one square foot below 0.736 inches acceptance criterion to these measurements, the total area measured below 1 square foot was around 0.3 square feet. However, this area is very sensitive to additional corrosion because in a length of around 5 inches, the thickness changed from around 0.736 inches to 0.800 inches. Assuming that the edge of the hole is a straight line, this means that a change of 0.064 inches in depth occurs over about 5 inches in length. Thus, for the radius of the thin area to change by two inches, the depth would have to change by only 0.026 inches. If this occurred the total area below 0.736 inches would be approximately 1.6 square feet, well beyond the current acceptance criterion. Assuming a worst case corrosion rate of 0.020 inches per year shows that the area acceptance criterion could be violated in around a year, even if the thin areas have not grown bigger since they were last measured in 1992.

These results show that the currently proposed monitoring interval of ten years is far too long. If the worst case corrosion rate is around 0.020 inches, the total area under 0.736 inches could increase beyond the safety margin in about a year. Thus, monitoring would be needed at least once per year. Finally, if the next round of measurements shows that the margin of safety is less than it was in when the last valid round of testing occurred (in 1992 or 1994), the testing intervals must be increased accordingly.

2. Proposed Area To Be Measured Is Too Small

Large variations in remaining wall thickness have been observed. Minimum wall thicknesses of as little as 0.603 inches have been reported within the 6x6 inch grids. In addition, many other thin areas, with thickness measurements as low as 0.618, have been observed from the outside of the drywell. It is therefore entirely unreasonable to assume that the small 6x6 inch areas on top of the sandbed are representative of the over 3 foot thickness, Ex. NC 8 at 40, of the entire sandbed area, simply because around two thirds of the sand bed shell below the 6x6 inch grid was not accessible from the inside. See Ex. NC 10.

Furthermore, the spatial scope of the monitoring must be sufficient to allow meaningful comparison with the acceptance criteria that are to be applied to the results. In various submissions AmerGen has laid out how the monitoring was done in the sand bed region in 1992, 1994, and 1996. Initial investigations, carried out before the sand was removed, measured the thickness of the drywell shell in the sand bed region from the inside "at the lowest accessible locations." Ex. NC 5 at 11. However, because the interior concrete floor and curb is over two feet higher than the exterior floor this meant around two thirds of the sand bed area was not tested. To see if the corrosion extended to these areas the reactor operator dug a trench into the floor in bays 17 and 5 and found that the thinning below the floor level in bay 17 was similar to that observed above the floor, but eventually became less severe. Id. This confirmed that much of the area below the interior floor was corroding, showing that this area should not have been omitted from the monitoring regime.

In bays where initial investigations found significant wall thinning, 49 readings were taken within a 6 inch by 6 inch square centered at elevation 11'3". Ex. NC 2 at 5. In other bays, 7 readings were taken along a 7 inch horizontal line at the same elevation. Id. Thus, the initial selection of the points to be monitored periodically was fundamentally flawed because it omitted to establish monitoring of known thin areas below the interior floor level, and failed to even attempt to identify thin areas below the floor level in eight of the ten bays.

Measurements conducted from the outside of the drywell shell in 1992 highlighted these deficiencies in the initial investigations. The 1992 measurements demonstrated that there are extensive areas in bays 1 and 13 that are not proposed to be tested, but are already well below 0.736 inches thick. Ex. NC 3. For example in bay 13, nine areas below 0.736" were widely scattered over a large area. Id. at Sheet 26-29. Measurements of nine one to two inch diameter areas showed thicknesses ranging from 0.618 inches to 0.728 inches. Id. at Sheets 26, 28. Figure 13 on Sheet 29, shows the locations. To give an idea of scale, the distance between locations 5 and 7 was "about 30 inches apart." Id. at Sheet 26. For point 7 alone, the area below 0.736 inches was conservatively estimated to be 6 by 6 inches with a thickness of 0.677 inches on average. Id. at Sheet 26. Similarly, the measurements in bay 1 showed eight areas below 0.736 inches, whose thickness ranged from 0.700 to 0.726 inches. Id. at Sheet 11. The thinnest area was at location 7, which was located well below the "bathtub ring" and so cannot be easily monitored from the inside of the drywell. Id. at Sheet 12.

These results show that the spatial scope of the proposed monitoring is wholly inadequate to assess whether the drywell shell is meeting the acceptance criteria. Many areas that are thinner than 0.736 inches limit are not proposed to be monitored at all. Even those that have been monitored once are not fully characterized. To fully address all the areas that are below 0.736 inches, AmerGen must devise a systematic approach to identify and measure all such areas. Thereafter, each area must be measured and tracked to enable AmerGen to estimate

the worst case corrosion rate and the worst case rate at which the thin areas could expand.

Because AmerGen is now proposing to measure at the same locations that it measured in 1992, 1994, and 1996, the scope of the monitoring will remain inadequate, even though the exterior of the sand bed is now accessible, so that the cause of the initial inadequacy no longer exists. Unless AmerGen can devise a way to monitor through the concrete in the interior of the drywell, it appears likely that future monitoring will need to be conducted from the outside of the shell.

A second, less difficult problem is that the square grid pattern employed in the previous testing may miss extended areas of thinness that are not square. For instance, if a 5 inch by 30 inch horizontal trough were present in the shell and intersected the measured area, its area would only be estimated as 5 inches by 6 inches because of the area limitation of the measurements. Thus, its area would be estimated as 0.2 square feet, whereas the actual area would be over 1 square foot, in violation of an acceptance criterion. This means that if the testing finds points below 0.736 inches on the outside of the grid, it will underestimate the continuous area that is below 0.736 inches. To avoid this error AmerGen should expand the search area where or when readings at the edge of the grids show readings of less than 0.736 inches. It has failed to propose such a change.

3. The Quality Assurance For The Measurements Is Inadequate

Recently, the NRC concluded that the quality of the calibration for the UT measurements taken after 1992 is in question. Transcript of Meeting on June 1, 2006, attached as Citizens' Exhibit NC 4, at 28. Further, NRC said that the 1996 results are anomalous because they show that the drywell shell got dramatically thicker between 1994 and 1996. Id. at 28, 31. AmerGen responded that they had spent a lot of time trying to find the source of the problem, but were unable to explain why the results were so high. Id. at 29. AmerGen also acknowledged that it could not explain the increase between 1994 and 1996, Id. at 31, but would do additional calibration to see if the coatings on the inside and outside of the drywell affected the results. Id. at 29.

The systematically higher wall thicknesses observed in 1996 cannot be explained purely by the presence of the epoxy coating, because the coating was present when the previous two measurements were taken from the inside in 1992 and 1994. One potential explanation for the anomalous 1996 results is the start of coating deterioration. It is known that certain poly-epoxides tend to swell in the presence of humidity and at elevated temperature. It is proposed, as a working hypothesis, that the higher measurements in 1996 may well be due to such swelling, which could not have been calibrated out of the measurements. As a consequence, the actual thickness of the drywell shell in 1996 might well have been lower than the 1994 measurements due to ongoing corrosion, albeit a slower pace than pre-1992. What is clear is that the 1996 results cannot be used to predict future corrosion rates, and that even in the 1992 and 1994 post-coating results are in question.

Had AmerGen had an effective quality assurance program in place when the results were taken in 1996, it would have identified any problems with the data close to the time that they were taken. As illustrated by my memo of May 3, 2006, the anomaly in the 1996 results was not difficult to find, provided systematic rather than random error was the focus. Thus, Amergen obviously did not have an adequate quality assurance program in place. AmerGen has recently stated that the same methodology will be used to analyze the 1992, 1994, and 1996, will be used for the new UT results. Ex. NC 2 at 2. This means that AmerGen will continue to fail to identify questionable data in a timely manner, unless it changes its approach to the identification of systematic error.

Furthermore, although AmerGen realized at some point that there were questions about the reliability of the thickness data taken after 1992, especially the 1996 results, it has continued to use these data to predict the thickness of the drywell shell during any license renewal period. See e.g. Citizens' Exhibit NC 1 at 19-30. This is wholly unjustifiable. Unless questions about calibration of the results taken after the coating can be answered, the post-coating thickness data provide little knowledge about the actual thickness of the drywell shell, let alone the corrosion rate.

4. Statistical Analysis Of Results Is Flawed

a. Background

As the NRC has recognized, uncertainty is the key issue when analyzing the UT results. Ex. NC 4 at 63-64. In fact, there are a number of uncertainties, all of which need to be taken into account in the design of the monitoring regime. The first is that the UT results themselves are subject to uncertainty. This uncertainty means that the thickness at the time the measurement is taken is uncertain and it also means that the rate of corrosion is uncertain. Adding to the uncertainty in the corrosion rate is that conditions may change over time. For example, coatings may deteriorate, or the volume and composition of the water reaching the corroded area may change.

Since the actual original UT measurements were not available for a detailed statistical analysis, a hypothetical 6x6 inch grid was constructed to illustrate a point to be made here. Figure 1 shows hypothetical UT measurements in a 6x6 grid with 1 inch spacings. The average wall thickness over the grid is 0.81 inches. However, as is often the case in real life, a corrosion trough is depicted parallel to the y-axis with an average depth of 0.68 inches and a maximum depth of 0.55 to 0.60 inches. While this example is not a real life observation, it nevertheless illustrates how averages can be misleading. In this particular case, the corrosion trough exceeds the grid, and one could not tell whether corrosion would become more severe or less severe beyond the boundaries of the grid. Similarly, when Amergen talks about "isolated minimum thickness measurements", one does not know where these were recorded and whether there were others, which exceeded the average wall loss, but

may have been above the quoted minimum wall thickness. When the same data shown in Figure 1 are plotted from a different perspective (Figure 2), conclusions may be different, but again it appears that there may be an extensive corrosion phenomenon on one side of the grid.

In the treatment of the current thickness, AmerGen has set various acceptance criteria: one for small areas of around 2.5 inches in diameter (0.490 inches), one for areas of less than 12 by 12 inches (0.535 inches), one for the total area where the wall thickness is less than 0.735 inches (one square foot), and one for the mean thickness of the vessel (0.753 inches). In comparing the measured data to the acceptance criteria, the reactor operator actually evaluated the UT results by comparing the means of the 6 by 6 inch grids to 0.535 inches, and comparing each measurement to the small area criterion. Ex. NC 2 at 11.

b. Modeling

It is generally accepted that failures do not occur as a result of average corrosion, but are generally occasioned by the weakest spot in the system. As a consequence, one cannot interpret the data by calculating averages and standard deviations. Figure 3 for instance shows a histogram of the 49 hypothetical UT measurements. It can clearly be seen that in this example a bimodal distribution exists. The first mode, covering small pit depths, is perhaps Gaussian, as is often observed for pit initiation, because the smallest pits, too difficult to count, are rarely included in the analysis. The second mode is represented by a skewed distribution, perhaps a Weibull distribution with very high extreme values. Again this type of distribution is often observed after pitting has progressed for some time. It would clearly be irrational to try and present data of this kind by a Gaussian distribution and disregard the values that are outside "confidence limits". Rather, data of this kind should be analyzed by Extreme Value statistic. It turned out, as shown in Figure 4 that a reasonably straight line is obtained when the pit depths are plotted as a function of the "reduced variate". Only 49 points were available for the correlation. Extrapolation to the virtual 100th point results in a pit depth of about 0.77 inch, a remaining wall thickness of about 0.4 inches, or in this hypothetical case, a remaining wall thickness of less than minimum allowable. Because a worst case analysis is necessary for a safety-critical condition, the data must be analyzed by a methodology similar to the one demonstrated in the above procedure. Unfortunately, at present AmerGen appears to take no account of the chance that the true value of the remaining wall thickness at each point could actually be substantially less than indicated. See Ex. NC 3 at Sheet 6.

Turning to the corrosion rate, AmerGen attempted to predict corrosion rates based on the '92, '94, and '96 UT measurements. They used the averages for each grid measured in each by over the time period indicated. (This procedure is based on the notion that all pits grow at the same rate, which is quite erroneous since the deepest pits usually grow faster than the smaller ones.) In most instances it turned out that the 92 averages were higher than the 94 averages, while the 96 averages were again

higher then the previous two. This is shown in Figure 5. However, a statistical Analysis of Variance (ANOVA), Figure 6, shows that there is no significance to these variations from date to date if the data are amalgamated. However, the differences from location to location are indeed very significant. On the basis of these data Amergen concluded that the corrosion was arrested following the application of the epoxy coating. It is probably correct that *on average* the corrosion was significantly slowed or even arrested during the four years covered by the measurements. Whether the extreme corrosion rates were also similarly affected remains an open question. Nevertheless, it would be logical to expect that corrosion slowed down following the application of the coating, at least for a period of time. It is, however, stretching credulity to assume that such protection would last in excess of the stated lifetime of the coating, which was specified as 8 to 10 years.

Turning to the details of the analysis, the way in which AmerGen calculated corrosion rates was flawed in at least four ways. The calculation of estimated corrosion rates erroneously assumed that the rate would be constant over time, the means of the 49 point grid were used for curve fitting, the most extreme values were often omitted from the calculation of the means, and a ninety five percentile statistic is used as the appropriate level of uncertainty for future predictions.

Taking each of these flaws in turn AmerGen first made the erroneous assumption that "if corrosion is continuing, the mean thickness will decrease linearly with time." Citizens' Exhibit NC2 at 6. In fact, if the coating starts to fail, the corrosion rate could increase rapidly in a non-linear fashion. The projected coating life is around eight to ten years, and that life has now been exceeded by around four to six years. Ex. NC 8 at 54. In addition, other conditions could change. Thus, the assumption that the corrosion rate will be constant with time is simply invalid.

Second, using the means of the 49 points rather than the individual points to produce the curve fit that is used for future predictions only serves to mask the inherent uncertainty in the data, because the means are less variable than the individual points. <u>See</u> <u>e.g.</u> Ex. NC 1 at 21. The fit statistics from the curve fit program therefore do not fully represent the uncertainty in the fit because the errors are artificially lowered by only feeding in the means, rather than individual measurements. A more appropriate procedure would be to plot all the individual measurements and then do a curve fit and find the predicted errors on the curve fit at an appropriate level of uncertainty.

Third, AmerGen does not include the thinnest points in the means it reports, because it treats pits separately in the analysis when the data are not normally distributed. <u>E.g.</u> Ex. NC 5 at 25. A more recent analysis of upper region results by AmerGen best illustrates the problem. The analysis candidly states "points that were considered pits are . . . excluded from the mean." Ex. NC 6 at 15. Such a procedure obviously leads to an underestimation of the mean value and the corrosion rate. Thus, in some cases the mean values that have been plotted and

fitted are actually thicker than the mean thicknesses of the areas that were measured. This is obviously a major problem with the analysis because one acceptance criterion is based on the mean values of the grids.

Fourth, only the ninety five percentile of extreme values are used for the prediction of the corrosion rate. E.g. Ex. NC 5 at 1. This means that even if the prediction is correct and the 95%ile confidence limit is taken as the worst case corrosion rate, there is a one in twenty chance that the actual corrosion rate will be higher than that calculated. For a safety-critical evaluation, this level of uncertainty is far too high. The statistical procedure must be redesigned to insure that safety margins are met with a substantial degree of certainty.

Further flaws have crept into the analysis over time. In 1992 the reactor operator recognized that to estimate a 95%ile of the corrosion rate, at least four data sets are needed. Ex. NC 5 at 1. It further recognized that where only two points were available, the uncertainty in the individual points should be used to plot a straight line. Id. However, more recently AmerGen concluded the corrosion rate was zero based on only three points, one of which it has now recognized as unreliable. AmerGen now intends to confirm this conclusion by taking one more set of measurements before the start of any license extension period. Because at least four reliable sets of measurements are needed AmerGen would continue to have insufficient data to predict the corrosion rate reliably, even if conditions over time had remained constant.

In fact, it is highly likely that conditions have changed since 1994, therefore realistic wall thickness measurements must be made as soon as possible to establish the current baseline and margins of safety. In addition, a worst case corrosion rate needs to be established for the current time period. This is obviously impossible based on just one point. I therefore suggest a pragmatic solution. AmerGen should use the corrosion data it gathered previously to estimate a statistically valid worst case corrosion rate based on previous conditions, which were with water and sand present and without a coating. This approach should have some inherent conservatism because the removal of the sand and the coating appeared to slow the corrosion for the period from 1992 to 1994. Thus, even if the coating has now become ineffective, the previous conditions should continue to provide a worst case scenario, provided a statistically valid approach is used.

c. Modeling and Statistical Analysis with Actual Data

The calculation sheet (EX NC 3 (DRF 143071)) contains sufficient original data to analyze GPU Nuclear's evaluation of the UT and micrometer pit measurements.

Figure 7 is a schematic of what I understand was done to arrive at a representative remaining wall thickness in the former sandbed region in order to subsequently perform GE type vessel integrity calculations. First: UT measurements were taken from the inside as described earlier. Second: an imprint (or cast) was taken from the

outside in order to characterize the roughness of the corroded surface in addition to the UT measurements. The roughness is also characterized as "dimples". The depth of the dimples was measured from the imprint by means of a micrometer. Thus, Figure 7 shows the UT measurement (1) from the inside, which characterizes the remaining wall thickness. Second, the dimple depths were measured (repeatedly) and averaged (2). This average was added to each UT measurement. Third, a characteristic average dimple depth was determined and used as a global average to be used in all areas were imprints were not available, or where such were performed in a reduced fashion. The reason for this procedure is not entirely clear, other than hopefully arriving at a representative average, which could be the basis for the integrity calculations.

As can be seen from Figure 7, the first location: if the average dimple depth is added to the UT remaining wall thickness, and then a global average dimple depth is being subtracted from the result, the actual pit depth may be reduced. In the second location the actual average pit depth may be increased by this procedure.

However, a more detailed analysis of the some of the available data shows that this procedure performed by GPU Nuclear may show milder corrosion than what actually prevails.

Detailed Data Analysis

Appendix A of above reference document lists the measurements of impressions taken from Bay # 13, presumably the Bay where corrosion was the roughest. The average of all "dimple" measurements is 0.13 in with a standard deviation of 0.07 in. GPU Nuclear used the same average plus one standard deviation to arrive at the value of 0.2 in for the characterization of the average roughness of the corroded surface. It is not clear why only on standard deviation was added to the average when in fact 2 standard deviations represent a confidence limit of 95%. Hence it is my opinion that 0.27 in should have been used to represent worst case, or 270 mils. If this had been done, for instance, for the UT measurements summarized in Table 1-b (page 11) of referenced document, five of the 8 locations cited would have been below the acceptable criterion of 736 mils, while GPU Nuclear found all eight locations acceptable.

It is therefore concluded that the procedure employed by GPU Nuclear is highly arbitrary, since the one vs. two standard deviations has not been explained.

Extreme value Statistics

Figure 8 shows the extreme value statistical evaluation of the UT Measurements in Bays 1 and 13. It can be seen that worst case penetrations can be predicted to be of the order of 550 to 600 mils, or dangerously close to the criteria for the remaining local wall thickness of 490 mils. Hence, predictions of this nature, which in the case of Bay 13 are reasonably accurate, ($R^2 = 0.95$), are considerably less optimistic than those of GPU Nuclear.

Figure 9 shows a comparison of the measurements in Bay 13 of the UT remaining wall thickness and the dimple depths. The correlations are reasonably good. The prediction for the most severe dimple depth is about 300 mils, or 50% larger than the average used by GPU Nuclear, and more in line with the use of 2 standard deviations.

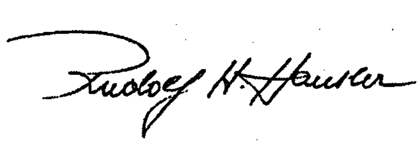
Interestingly, the difference between the UT measured pit depth from the outside and the pit depth arrived at by micrometer measurements using the cast imprint turns out to be 200 mils at the lower pit depths and 300 mils at the higher pit depts. The 300 mil figure results in an average remaining wall thickness over the measured area of 1154 mils minus – 300 mils equals 854 mils, a number which has also been used in integrity calculations aimed at the buckling question. However, as pointed out earlier, this is clearly an average and one does not know how large the area is, which was further reduced by localized pitting.

And herein lies the difficulty of what has been done in the past and what Amergen/Exelon proposes to do in the future. 99% of the sandbed region has not been monitored overtime and even the small areas that have been monitored are incompletely characterized. The overall area of the sandbed region is of the order of 300 ft^2. AmerGen are proposing more measurements at 12 6 inch by 6 inch areas, or a total of 3 ft^2. Thus only 1% of the total area is proposed to be monitored. In those small areas, point UT measurements, as have been done in the past, using a template and positioning the sensor always at the same location give information about the remaining wall thickness at this location (z- direction), but contain no information about the extent of the reduction in wall thickness around the point measurement (x-, y-directions). Hence around 93% of the 0.25 ft^2 area of each template remains unexplored. **For these reasons it is urged that Amergen/Exelon consider using more modern UT methods which are capable of scanning large areas and can generate data in all three directions, x, y, and z.**

Conclusions

This brief analysis of the original data presented in 1993 (measured in 1992) depicts a more severe corrosion situation than was extracted by GPU Nuclear on the basis of averages. Hence we think that a much more detailed analysis of the integrity of the remaining wall thickness is warranted and required, the repeated assertions that the coating has arrested any further corrosion not withstanding.

Signed



Rudolf H. Hausler

Figure 1

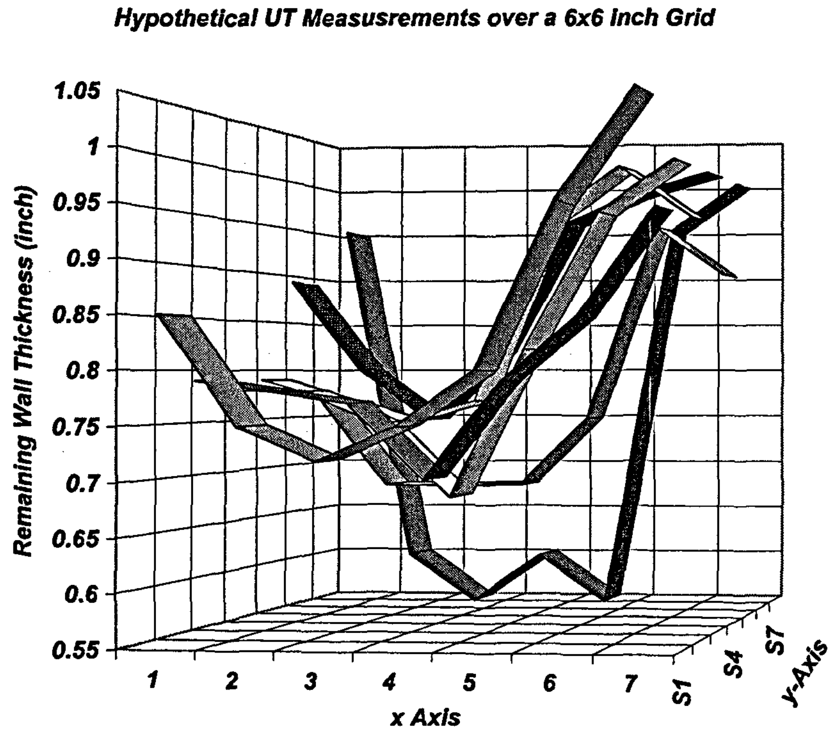


Figure 2

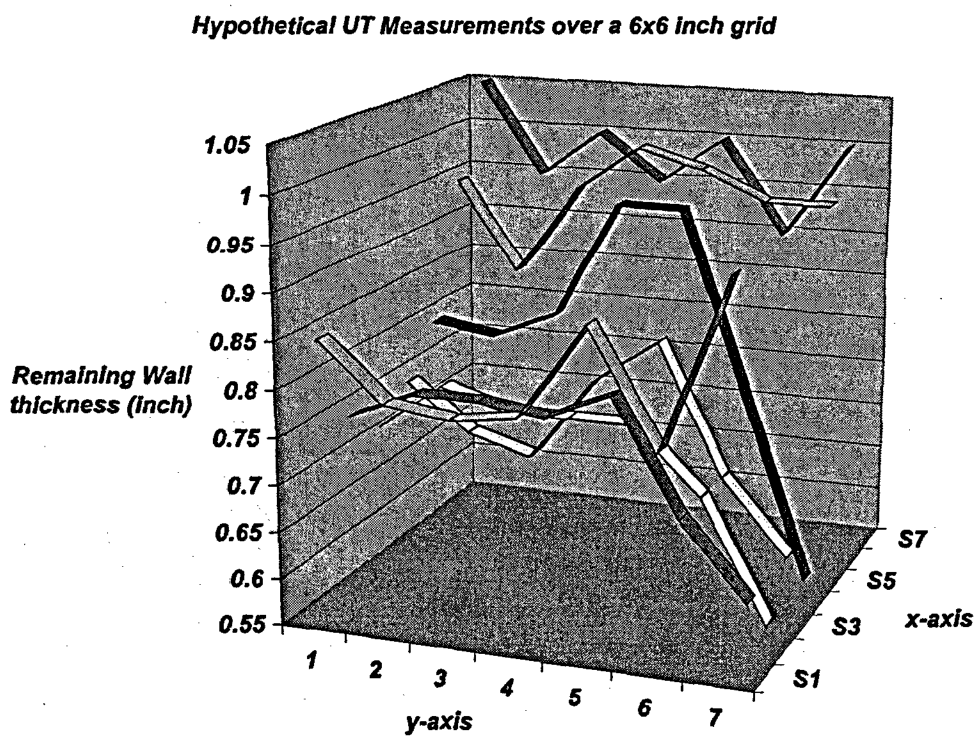
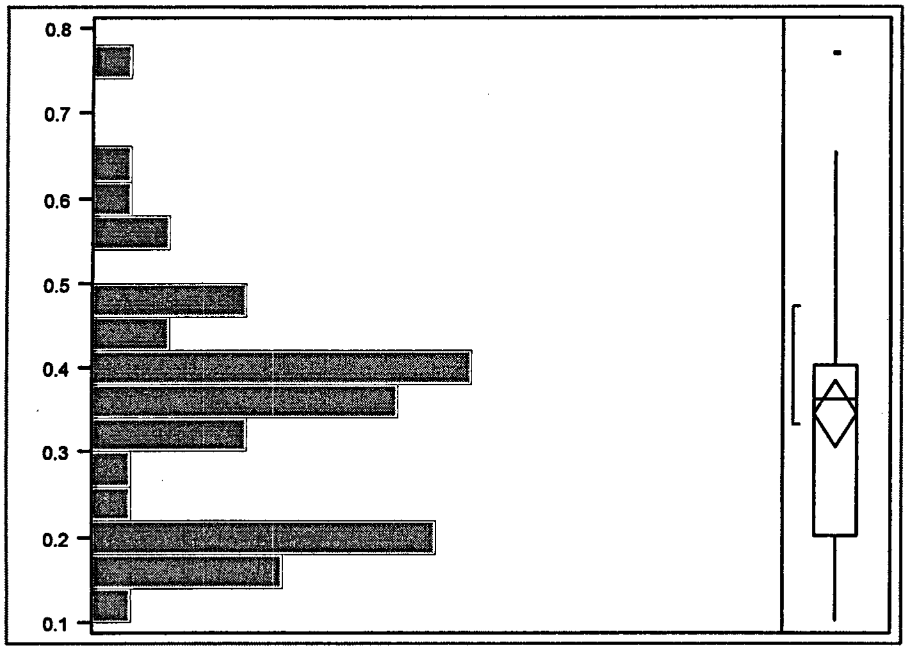


Figure 3

pit depth



Quantiles

Moments

Mean	0.34655
Std Dev	0.14139
Std Error Mean	0.02000
Upper 95% Mean	0.38674
Lower 95% Mean	0.30637
N	50.00000
Sum Weights	50.00000

Test for Normality

Shapiro-Wilk W Test

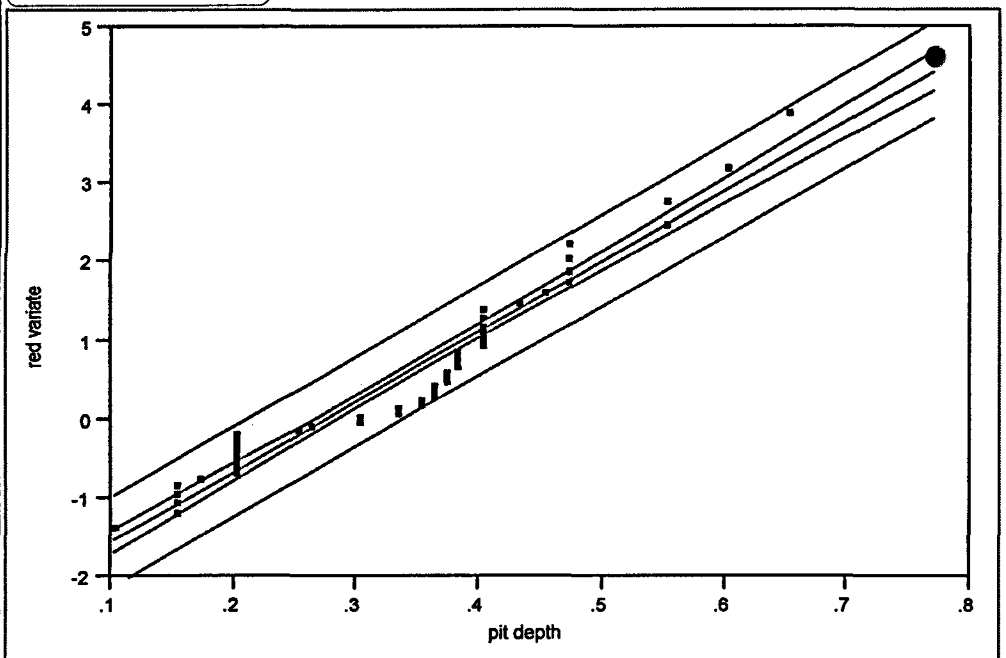
W	Prob<W
0.943173	0.0284

Test Mean=value

Histogram of 49 Hypothetical UT Measurements over a 6x6 inch grid with 1 inch spacing.

a. Figure 4

red variate By pit depth



Linear Fit

Linear Fit

red variate = -2.4687 + 8.93965 pit depth

Summary of Fit

RSquare	0.954781
RSquare Adj	0.953839
Root Mean Square Error	0.277923
Mean of Response	0.629364
Observations (or Sum Wgts)	50

Analysis of Variance

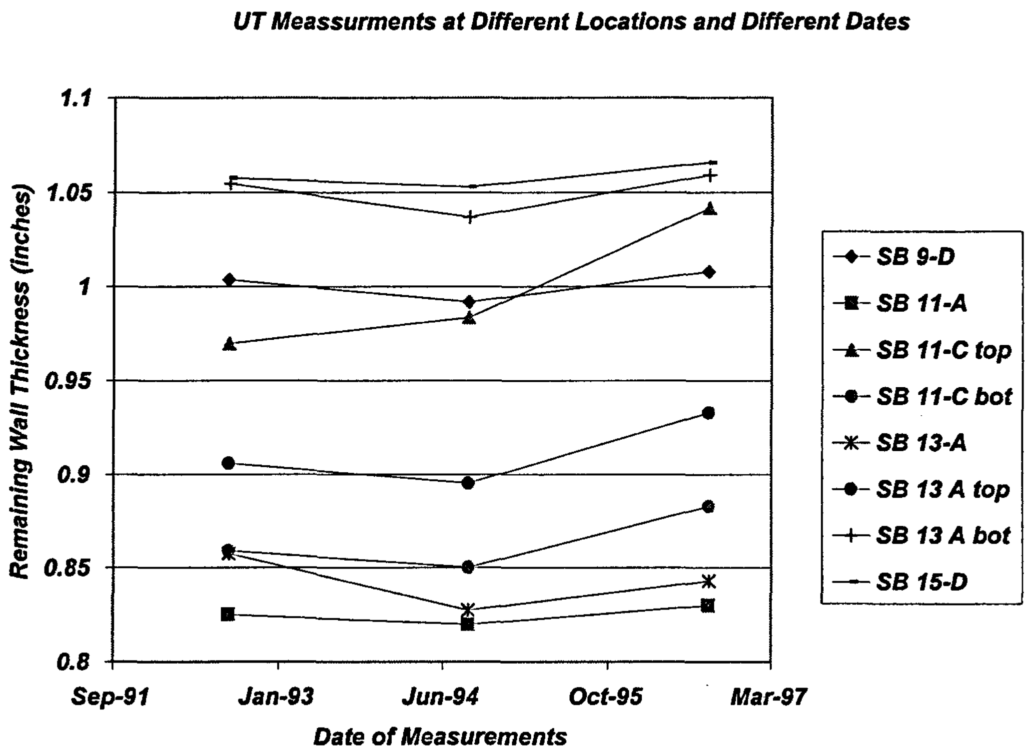
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	78.284650	78.2846	1013.507
Error	48	3.707584	0.0772	Prob>F
C Total	49	81.992234		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-2.468701	0.104952	-23.52	<.0001
pit depth	8.9396488	0.280806	31.84	<.0001

Extreme Value Statistical Plot of 49 Hypothetical UT Measurements over a 6x6 inch grid. The last point at 0.77 inch pit depth is the most probable pit depth obtained by extrapolation if 100 data point had been measured. It is within the statistical 95% boundaries for the fit.

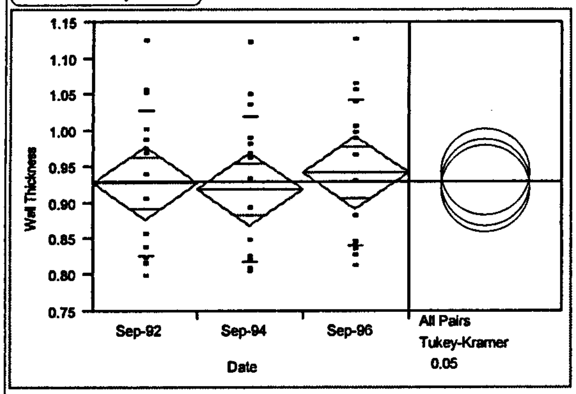
b. Figure 5



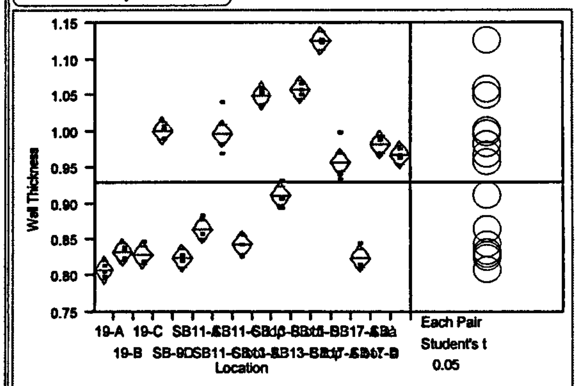
UT Meassurments at Different Locations and Different Dates
Remaining Wall Thickness (inches)
1.1
1.05
1
0.95
0.9
0.85
0.8
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Date of Measurements
SB 9-D
SB 11-A
SB 11-C top
SB 11-C bot
SB 13-A
SB 13 A top
SB 13 A bot
SB 15-D

c. Figure 6

Wall Thickness By Date



Wall Thickness By Location



Oneway Anova (Wall Thickness By Date)

Summary of Fit

RSquare	0.010207
RSquare Adj	-0.03378
Root Mean Square Error	0.101758
Mean of Response	0.930158
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.00480510	0.002403	0.2320
Error	45	0.46596232	0.010355	Prob>F
C Total	47	0.47076742	0.010016	0.7939

Means for Oneway Anova

Level	Number	Mean	Std Error
Sep-92	16	0.927588	0.02544
Sep-94	16	0.919394	0.02544
Sep-96	16	0.943494	0.02544

Std Error uses a pooled estimate of error variance

Means Comparisons

Dif=Mean[i]-Mean[j]	Sep-96	Sep-92	Sep-94
Sep-96	0.000000	0.015906	0.024100
Sep-92	-0.01591	0.000000	0.008194
Sep-94	-0.0241	-0.00819	0.000000

Alpha= 0.05

Comparisons for all pairs using Tukey-Kramer HSD

q*

2.42362

Abs(Dif)-LSD	Sep-96	Sep-92	Sep-94
Sep-96	-0.08719	-0.07129	-0.06309
Sep-92	-0.07129	-0.08719	-0.079
Sep-94	-0.06309	-0.079	-0.08719

Positive values show pairs of means that are significantly different.

Oneway Anova (Wall Thickness By Location)

Summary of Fit

RSquare	0.979337
RSquare Adj	0.969651
Root Mean Square Error	0.017435
Mean of Response	0.930158
Observations (or Sum Wgts)	48

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	15	0.46103987	0.030736	101.1099
Error	32	0.00972755	0.000304	Prob>F
C Total	47	0.47076742	0.010016	<.0001

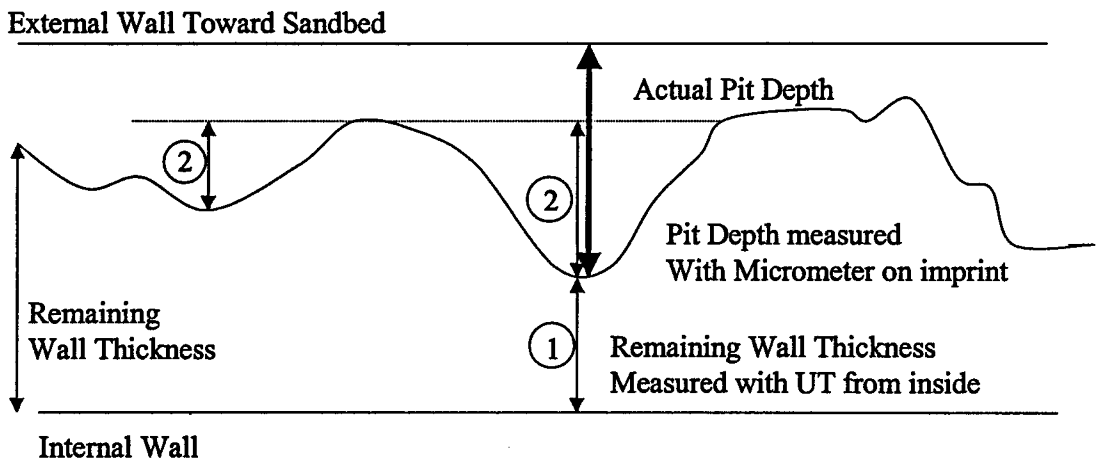
Means for Oneway Anova

Means Comparisons

Statistical Evaluations of all available UT Measurements performed in 1992, 1994 and 1996 on the drywell liner in the sandbed area

Figure 7

Schematic of Evaluation of Pit Depth Measurements and Averaging Procedure



Wall thickness used for integrity evaluations:
(1) + average of (2) – 200 = T (evaluation)

Figure 8

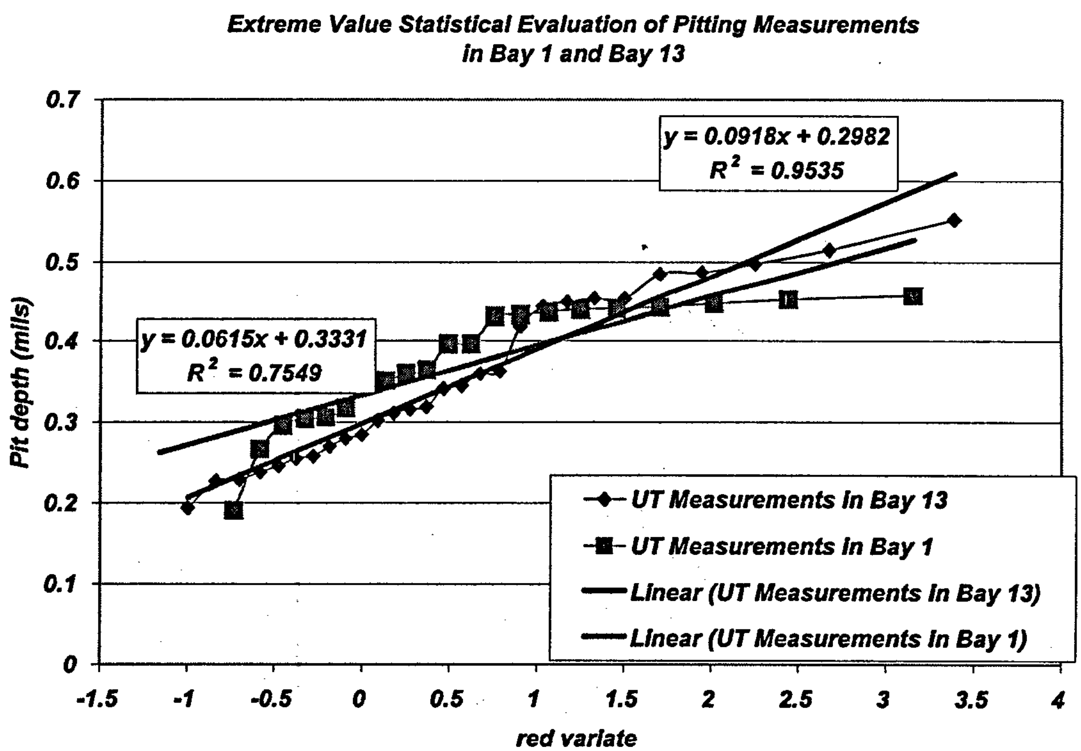
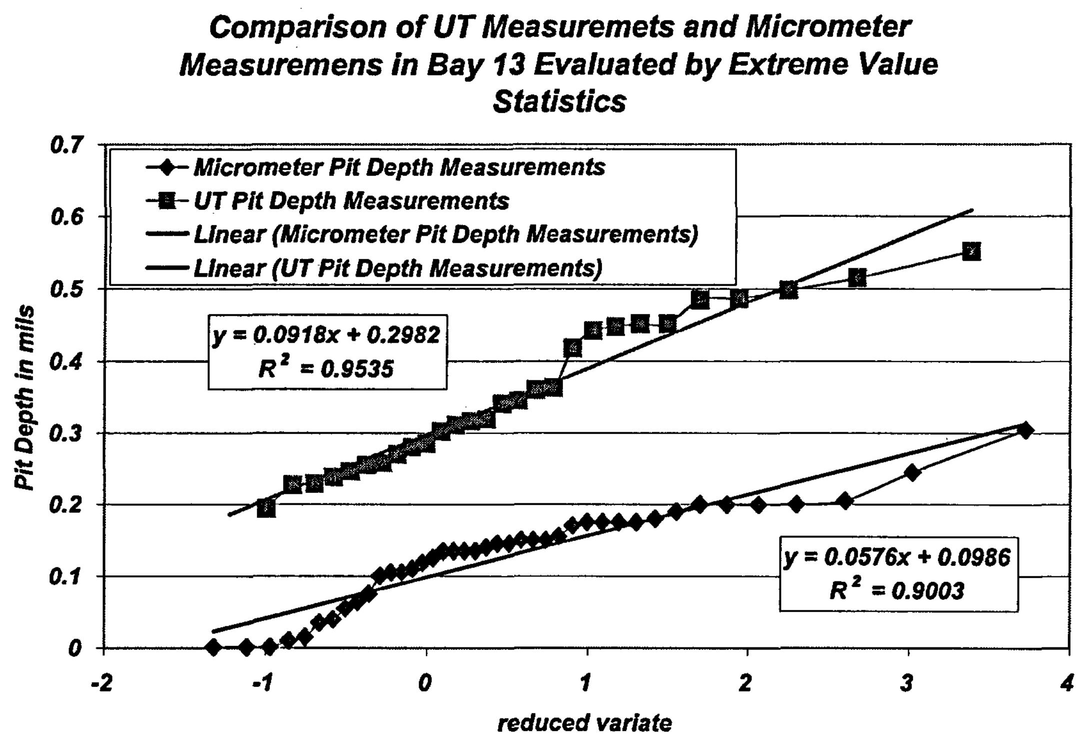


Figure 9


Comparison of UT Measuremets and Micrometer Measuremens in Bay 13 Evaluated by Extreme Value Statistics
Micrometer Pit Depth Measurements
UT Pit Depth Measurements
Linear (Micrometer Pit Depth Measurements)
Linear (UT Pit Depth Measurements)
y = 0.0918x + 0.2982
R² = 0.9535
y = 0.0576x + 0.0986
R² = 0.9003
Pit Depth in mils
reduced variate
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-2
-1
0
1
2
3
4

Citizen's Exhibit NC1

Citizen's Exhibit NC1

From: <George.Beck@exeloncorp.com>
To: <dja1@nrc.gov>, <rkm@nrc.gov>
Date: 04/05/2006 5:02:53 PM
Subject: FW: Audit Q & A (Question Numbers AMP-141, 210, 356)

Note: As originally transmitted this email was undeliverable to the NRC; it exceeded the size limit. It is being retransmitted without the AMP-210.pdf. This file will be reconstituted and sent in smaller ".pdf"s; the first 11 pages are attached.

George

> -----Original Message-----
> From: Beck, George
> Sent: Wednesday, April 05, 2006 4:39 PM
> To: Donnie Ashley (E-mail); 'Roy Mathew (E-mail) ' (E-mail)
> Cc: Ouaou, Ahmed; Hufnagel Jr, John G; Warfel Sr, Donald B; Polaski, Frederick W
> Subject: Audit Q & A (Question Numbers AMP-141, 210, 356)
>
> Donnie/Roy,
>
> Attached are the responses to AMP-210 and AMP-356 in an updated version of the reports from the AMP/AMR Audit database. Also included is a revised version of AMP-141. These answers have been reviewed and approved by Technical Lead, Don Warfel.
>
> Regarding AMP-210, please note:
> As pointed out in our response to NRC Question AMP-210, (8a)(1), "The 0.806" minimum average thickness verbally discussed with the Staff during the AMP audit was recorded in location 19A in 1994. Additional reviews after the audit noted that lower minimum average thickness values were recorded at the same location in 1991 (0.803") and in September 1992 (0.800"). However, the three values are within the tolerance of +/- 0.010" discussed with the Staff."
>
> Regarding AMP-141, please note:
> Our response to AMP-141 has been revised to reflect additional information developed during the ongoing preparation of RAI responses.
>
> Please let John Hufnagel or me know if you have any questions.
>
> George
>
>
>
> >> <<Pages from AMP-210.pdf>>
> >> <<AMP-141.pdf>>
>
>> <<AMP-356.pdf>>
>
>

copying, or action taken in relation to the contents of and attachments to this e-mail is strictly prohibited and may be unlawful. If you have *received this e-mail in error, please notify the sender immediately* and permanently delete the original and any copy of this e-mail and any printout. Thank You.
****

CC: <ahmed.ouaou@exeloncorp.com>, <john.hufnagel@exeloncorp.com>, <donald.warfel@exeloncorp.com>, <fred.polaski@exeloncorp.com>

2

Mail Envelope Properties (44343066.C5F : 19 : 7263)

Subject:	FW: Audit Q & A (Question Numbers AMP-141, 210, 356)
Creation Date:	04/05/2006 5:01:46 PM
From:	<George.Beck@exeloncorp.com>
Created By:	George.Beck@exeloncorp.com

Recipients

nrc.gov
 OWGWPO01.HQGWDO01
  DJA1 (D. Ashley)

nrc.gov
 TWGWPO01.HQGWDO01
  RKM (Roy Mathew)

exeloncorp.com
  fred.polaski CC
  donald.warfel CC
  john.hufnagel CC
  ahmed.ouaou CC

Post Office	**Route**
OWGWPO01.HQGWDO01	nrc.gov
TWGWPO01.HQGWDO01	nrc.gov
	exeloncorp.com

Files	**Size**	**Date & Time**
MESSAGE	2679	05 April, 2006 5:01:46 PM
TEXT.htm	5457	
Pages from AMP-210.pdf	64593	
AMP-141.pdf	47353	
AMP-356.pdf	71556	
Mime.822	262768	

Options

Expiration Date:	None
Priority:	Standard
Reply Requested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

3

NRC Information Request Form

Item No
AMP-210

Date Received: 1/24/2006

Source AMP Audit

Topic:
IWE

Status: Open

Document References:
B.1.27

NRC Representative Morante, Rich

AmerGen (Took Issue): Hufnagel, Joh

Question

Pages 25 through 31 of the PBD present a discussion of the OCGS operating experience.

(8a)The following statements related to drywell corrosion in the sand bed region need further explanation and clarification:
As a result of the presence of water in the sand bed region, extensive UT thickness measurements (about 1000) of the drywell shell were taken to determine if degradation was occurring. These measurements corresponded to known water leaks and indicated that wall thinning had occurred in this region.
Please explain the underlined statement. Were water leaks limited to only a portion of the circumference? Was wall thinning found only in these areas?
After sand removal, the concrete surface below the sand was found to be unfinished with improper provisions for water drainage. Corrective actions taken in this region during 1992 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. UT measurements taken from the outside after cleaning verified loss of material projections that had been made based on measurements taken from the inside of the drywell. There were, however, some areas thinner than projected; but in all cases engineering analysis determined that the drywell shell thickness satisfied ASME code requirements.
Please describe the concrete surface below the sand that is discussed in paragraph above.
Please provide the following information:
(1) Identify the minimum recorded thickness in the sand bed region from the outside inspection, and the minimum recorded thickness in the sand bed region from the inside inspections. Is this consistent with previous information provided verbally? (.806 minimum)
(2) What was the projected thickness based on measurements taken from the inside?
(3) Describe the engineering analysis that determined satisfaction of ASME code requirements and identify the minimum required thickness value. Is this consistent with previous information provided verbally? (.733 minimum)
(4) Is the minimum required thickness based on stress or buckling criteria?
(5) Reconcile and compare the thickness measurements provided in (1) and (3) above with the .736 minimum corroded thickness that was used in the NUREG-1540 analysis of the degraded Oyster

4

Creek sand bed region.

Evaluation of UT measurements taken from inside the drywell, in the in the former sand bed region, in 1992, 1994, and 1996 confirmed that corrosion is mitigated. It is therefore concluded that corrosion in the sand bed region has been arrested and no further loss of material is expected. Monitoring of the coating in accordance with the Protective Coating Monitoring and Maintenance Program, will continue to ensure that the containment drywell shell maintains its intended function during the period of extended operation.
NUREG-1540, published in April 1996, includes the following statements related to corrosion of the Oyster Creek sand bed region: (page vii) However, to assure that these measures are effective, the licensee is required to perform periodic UT measurements. and (page 2) As assurance that the corrosion rate is slower than the rate obtained from previous measurements, GPU is committed to make UT measurements periodically. Please reconcile the aging management commitment (one-time UT inspection and monitoring of the condition of the coating) with the apparent requirement/commitment documented in NUREG-1540.

(8b)The following statement related to drywell corrosion above the sand bed region needs further explanation and clarification:

Corrective action for these regions involved providing a corrosion allowance by demonstrating, through analysis, that the original drywell design pressure was conservative. Amendment 165 to the Oyster Creek Technical Specifications reduced the drywell design pressure from 62 psig to 44 psig. The new design pressure coupled with measures to prevent water intrusion into the gap between the drywell shell and the concrete will allow the upper portion of the drywell to meet ASME code requirements.

Please describe the measures to prevent water intrusion into the gap between the drywell shell and the concrete that will allow the upper portion of the drywell to meet ASME code requirements". Are these measures to prevent water intrusion credited for LR? If not, how will ASME code requirements be met during the extended period of operation?

(8c)The following statements related to torus degradation need further explanation and clarification:
Inspection performed in 2002 found the coating to be in good condition in the vapor area of the Torus and vent header, and in fair condition in immersion. Coating deficiencies in immersion include blistering, random and mechanical damage. Blistering occurs primarily in the shell invert but was also noted on the upper shell near the water line. The fractured blisters were repaired to reestablish the protective coating barrier. This is another example of objective evidence that the Oyster Creek ASME Section XI, Subsection IWE aging management program can identify degradation and implement corrective actions to prevent the loss of the containment's intended function.
While blistering is considered a deficiency, it is significant only when it is fractured and exposes the base metal to corrosion attack. The majority of the blisters remain intact and continues to protect the base metal; consequently the corrosion rates are low. Qualitative assessment of the identified pits indicate that the measured pit depths (50 mils max) are significantly less than the criteria established

NRC Information Request Form

in Specification SP-1302-52-120 (141- 261 mils, depending on diameter of the pit and spacing between pits).

Please confirm or clarify (1) that only the fractured blisters found in this inspection were repaired; (2) pits were identified where the blisters were fractured; (3) pit depths were measured and found to 50 mils max; (4) the inspection Specification SP-1302-52-120 includes pit-depth acceptance criteria for rapid evaluation of observed pitting; (5) the minimum pit depth of concern is 141 mils (.141) and pits as deep as 261 mils (.261) may be acceptable.

Please also provide the following information: nominal design, as-built, and minimum measured thickness of the torus; minimum thickness required to meet ASME code acceptance criteria; the technical basis for the pitting acceptance criteria include in Specification SP-1302-52-120

Assigned To: Ouaou, Ahmed

Response:

(8a) Question: Please explain the underlined statement. Were water leaks limited to only a portion of the circumference? Was wall thinning only in these area?

Response:
This statement was not meant to indicate that water leaks were limited to only a portion of the circumference. The statement is meant to reflect the fact that water leakage was observed coming out of certain sand bed region drains and those locations were suspect of wall thinning.
No. Wall thinning was not limited to the areas where water leakage from the drains was observed. Wall thinning occurred in all areas of the sand bed region based on UT measurements and visual inspection of the area conducted after the sand was removed in 1992. However the degree of wall thinning varied from location to location. For example 60% of the measured locations in the sand bed region (bays 1, 3, 5, 7, 9, and 15) indicate that the average measured drywell shell thickness is nearly the same as the design nominal thickness and that these locations experienced negligible wall thinning; whereas bay 19A experienced approximately 30% reduction in wall thickness.

Question: Please discuss the concrete surface below the sand that is discussed in paragraph above.

Response:
The concrete surface below the sand was intended to be shaped to promote flow toward each of the five sand bed drains. However once the sand was removed it was discovered that the floor was not properly finished and shaped as required to permit proper drainage. There were low points, craters, and rough surfaces that could allow moisture to pool instead of flowing smoothly toward the drains. These concrete surfaces were refurbished to fill low areas, smooth rough surfaces, and coat these surfaces with epoxy coating to promote improved drainage. The drywell shell at juncture of the concrete floor was sealed with an elastomer to prevent water intrusion into the embedded drywell shell.

Question: Please provide the following information:

6

NRC Information Request Form

(1) Identify the minimum recorded thickness in the sand bed region from the outside inspection, and the minimum recorded thickness in the sand bed region from the inside inspections. Is this consistent with previous information provided verbally? (.806 minimum)
(2) What was the projected thickness based on measurements taken from the inside?
(3) Describe the engineering analysis that determined satisfaction of ASME code requirements and identify the minimum required thickness value. Is this consistent with previous information provided verbally? (.733 minimum)
(4) Is the minimum required thickness based on stress or buckling criteria?
(5) Reconcile and compare the thickness measurements provided in (1) and (3) above with the .736 minimum corroded thickness that was used in the NUREG-1540 analysis of the degraded Oyster Creek sand bed region.

Response:
1. The minimum recorded thickness in the sand bed region from outside inspection is 0.618 inches. The minimum recorded thickness in the sand bed region from inside inspections is 0.603. These minimum recorded thicknesses are isolated local measurement and represent a single point UT measurement. The 0.806 inches thickness provided to the Staff verbally is an average minimum general thickness calculated based on 49 UT measurements taken in an area that is approximately 6"x 6". Thus the two local isolated minimum recorded thicknesses cannot be compared directly to the general thickness of 0.806".

The 0.806" minimum average thickness verbally discussed with the Staff during the AMP audit was recorded in location 19A in 1994. Additional reviews after the audit noted that lower minimum average thickness values were recorded at the same location in 1991 (0.803") and in September 1992 (0.800"). However, the three values are within the tolerance of +/- 0.010" discussed with the Staff.

2. The minimum projected thickness depends on whether the trended data is before or after 1992 as demonstrated by corrosion trends provided in response to NRC Question #AMP-356. For license renewal, using corrosion rate trends after 1992 is appropriate because of corrosion mitigating measures such as removal of the sand and coating of the shell. Then, using corrosion rate trends based on 1992, 1994, and 1996 UT data; and the minimum average thickness measured in 1992 (0.800"), the minimum projected average thickness through 2009 and beyond remains approximately 0.800 inches. The projected minimum thickness during and through the period of extended operation will be reevaluated after UT inspections that will be conducted prior to entering the period of extended operation, and after the periodic UT inspection every 10 years thereafter.

3.The engineering analysis that demonstrated compliance to ASME code requirements was performed in two parts, Stress and Stability Analysis with Sand, and Stress and Stability Analyses without Sand. The analyses are documented in GE Reports Index No. 9-1, 9-2, 9-3, and 9-4, were transmitted to the NRC Staff in December 1990 and in 1991 respectively. Index No. 9-3 and 9-4, were revised later to correct errors identified during an internal audit and were resubmitted to the Staff in January 1992 (see attachment 1 & 2). The analyses are briefly described below.

The drywell shell thickness in the sand bed region is based on Stability Analysis without Sand. As

NRC Information Request Form

described in detail in attachment 1 & 2, the analysis is based on a 36-degree section model that takes advantage of symmetry of the drywell with 10 vents. The model includes the drywell shell from the base of the sand bed region to the top of elliptical head and the vent and vent header. The torus is not included in this model because the bellows provide a very flexible connection, which does not allow significant structural interaction between the drywell and the torus. The analysis conservatively assumed that the shell thickness in the entire sand bed region has been reduced uniformly to a thickness of 0.736 inches.

As discussed with the Staff during the AMP audit, the basic approach used in the buckling evaluation follows the methodology outlined in ASME Code Case N-284 revision 0 that was reconciled later with revision 1 of the Code Case. Following the procedure of this Code Case, the allowable compressive stress is evaluated in three steps. In the first step, a theoretical buckling stress is determined, and secondly modified using appropriate capacity and plasticity reduction factors. In the final step, the allowable compressive stress is obtained by dividing the buckling stress calculated in the second step by a safety factor of 2.0 for Design and Level A & B service conditions and 1.67 Level C service conditions.

Using the approach described above, the analysis shows that for the most severe design basis load combinations, the limits of ASME Section III, Subsection NE 3213.10 are fully met. For additional details refer to Attachment 1 & 2.

As described above, the buckling analysis was performed assuming a uniform general thickness of the sand bed region of 0.736 inches. However the UT measurements identified isolated, localized areas where the drywell shell thickness is less than 0.736 inches. Acceptance for these areas was based on engineering calculation C-1302-187-5320-024.

The calculation uses a Local Wall Acceptance Criteria". This criterion can be applied to small areas (less than 12" by 12"), which are less than 0.736" thick so long as the small 12" by 12" area is at least 0.536" thick. However the calculation does not provide additional criteria as to the acceptable distance between multiple small areas. For example, the minimum required linear distances between a 12" by 12" area thinner than 0.736" but thicker than 0.536" and another 12" by 12" area thinner than 0.736" but thicker than 0.536" were not provided.

The actual data for two bays (13 and 1) shows that there are more than one 12" by 12" areas thinner than 0.736" but thicker than 0.536". Also the actual data for two bays shows that there are more than one 2 ½'" diameter areas thinner than 0.736" but thicker than 0.490". Acceptance is based on the following evaluation.

The effect of these very local wall thickness areas on the buckling of the shell requires some discussion of the buckling mechanism in a shell of revolution under an applied axial and lateral pressure load.

To begin the discussion we will describe the buckling of a simply supported cylindrical shell under the influence of lateral pressure and axial load. As described in chapter 11 of the Theory of Elastic Stability, Second Edition, by Timoshenko and Gere, thin cylindrical shells buckle in lobes in both the

axial and circumferential directions. These lobes are defined as half wave lengths of sinusoidal functions. The functions are governed by the radius, thickness and length of the cylinder. If we look at a specific thin walled cylindrical shell both the length and radius would be essentially constants and if the thickness was changed locally the change would have to be significant and continuous over a majority of the lobe so that the compressive stress in the lobe would exceed the critical buckling stress under the applied loads, thereby causing the shell to buckle locally. This approach can be easily extrapolated to any shell of revolution that would experience both an axial load and lateral pressure as in the case of the drywell. This local lobe buckling is demonstrated in The GE Letter Report "Sandbed Local Thinning and Raising the Fixity Height Analysis" where a 12 x 12 square inch section of the drywell sand bed region is reduced by 200 mils and a local buckle occurred in the finite element eigenvalue extraction analysis of the drywell. Therefore, to influence the buckling of a shell the very local areas of reduced thickness would have to be contiguous and of the same thickness. This is also consistent with Code Case 284 in Section –1700 which indicates that the average stress values in the shell should be used for calculating the buckling stress. Therefore, an acceptable distance between areas of reduced thickness is not required for an acceptable buckling analysis except that the area of reduced thickness is small enough not to influence a buckling lobe of the shell. The very local areas of thickness are dispersed over a wide area with varying thickness and as such will have a negligible effect on the buckling response of the drywell. In addition, these very local wall areas are centered about the vents, which significantly stiffen the shell. This stiffening effect limits the shell buckling to a point in the shell sand bed region which is located at the midpoint between two vents.

The acceptance criteria for the thickness of 0.49 inches confined to an area less than 2½ inches in diameter experiencing primary membrane + bending stresses is based on ASME B&PV Code, Section III, Subsection NE, Class MC Components, Paragraphs NE-3213.2 Gross Structural Discontinuity, NE-3213.10 Local Primary Membrane Stress, NE-3332.1 Openings not Requiring Reinforcement, NE-3332.2 Required Area of Reinforcement and NE-3335.1 Reinforcement of Multiple Openings. The use of Paragraph NE-3332.1 is limited by the requirements of Paragraphs NE-3213.2 and NE-3213.10. In particular NE-3213.10 limits the meridional distance between openings without reinforcement to 2.5 x (square root of Rt). Also Paragraph NE-3335.1 only applies to openings in shells that are closer than two times their average diameter.

The implications of these paragraphs are that shell failures at these locations from primary stresses produced by pressure cannot occur provided openings in shells have sufficient reinforcement. The current design pressure of 44 psig for drywell requires a thickness of 0.479 inches in the sand bed region of the drywell. A review of all the UT data presented in Appendix D of the calculation indicates that all thicknesses in the drywell sand bed region exceed the required pressure thickness by a substantial margin. Therefore, the requirements for pressure reinforcement specified in the previous paragraph are not required for the very local wall thickness evaluation presented in Revision 0 of Calculation C-1302-187-5320-024.

Reviewing the stability analyses provided in both the GE Report 9-4 and the GE Letter Report Sand bed Local Thinning and Raising the Fixity Height Analysis and recognizing that the plate elements in the sand bed region of the model are 3" x 3" it is clear that the circumferential buckling lobes for the

NRC Information Request Form

drywell are substantially larger than the 2 ½ inch diameter very local wall areas. This combined with the local reinforcement surrounding these local areas indicates that these areas will have no impact on the buckling margins in the shell. It is also clear from the GE Letter Report that a uniform reduction in thickness of 27% to 0.536" over a one square foot area would only create a 9.5% reduction in the load factor and theoretical buckling stress for the whole drywell resulting in the largest reduction possible. In addition, to the reported result for the 27% reduction in wall thickness, a second buckling analysis was performed for a wall thickness reduction of 13.5% over a one square foot area which only reduced the load factor and theoretical buckling stress by 3.5% for the whole drywell resulting in the largest reduction possible. To bring these results into perspective a review of the NDE reports indicate there are 20 UT measured areas in the whole sand bed region that have thicknesses less than the 0.736 inch thickness used in GE Report 9-4 which cover a conservative total area of 0.68 square feet of the drywell surface with an average thickness of 0.703" or a 4.5% reduction in wall thickness. Therefore, to effectively change the buckling margins on the drywell shell in the sand bed region a reduced thickness would have to cover approximately one square foot of shell area at a location in the shell that is most susceptible to buckling with a reduction in thickness greater than 25%. This leads to the conclusion that the buckling of the shell is unaffected by the distance between the very local wall thicknesses, in fact these local areas could be contiguous provided their total area did not exceed one square foot and their average thickness was greater than the thickness analyzed in the GE Letter Report and provided the methodology of Code Case N284 was employed to determine the allowable buckling load for the drywell. Furthermore, all of these very local wall areas are centered about the vents, which significantly stiffen the shell. This stiffing effect limits the shell buckling to a point in the shell sand bed region, which is located at the midpoint between two vents.

The minimum thickness of 0.733" is not correct. The correct minimum thickness is 0.736".

4. The minimum required thickness for the sand bed region is controlled by buckling.

5. We cannot reconcile the difference between the current (lowest measured) of 0.736" in NUREG-1540 and the minimum measured thickness of 0.806 inches we discussed with the Staff. Perhaps the value in NUREG-1540 should be labeled minimum required by the Code, as documented in several correspondences with the Staff, instead of lowest measured. In a letter dated September 15, 1995, GPU provided the Staff a table that lists sand bed region thicknesses. The table indicates that nominal thickness is 1.154". the minimum measured thickness in 1994 is 0.806", and the minimum thickness required by Code is 0.736". These thicknesses are consistent with those discussed with the Staff during the AMP/AMR audit.

Question: NUREG-1540, published in April 1996, includes the following statements related to corrosion of the Oyster Creek sand bed region: (page vii) However, to assure that these measures are effective, the licensee is required to perform periodic UT measurements. and (page 2) As assurance that the corrosion rate is slower than the rate obtained from previous measurements, GPU is committed to make UT measurements periodically. Please reconcile the aging management commitment (one-time UT inspection and monitoring of the condition of the coating) with the apparent requirement/commitment documented in NUREG-1540.Please reconcile the aging management commitment (one-time UT inspection and monitoring of the condition of the coating) with the apparent requirement/commitment documented in NUREG-1540.

NRC Information Request Form

Response:

Our review of NUREG-1540, page 2 indicates that the statements appear to be based on 1991, or 1993 GPU commitment to perform periodic UT measurements. In fact UT thickness measurements were taken in the sand bed region from inside the drywell in 1992, and 1994. The trend of the UT measurements indicates that corrosion has been arrested. As results GPU informed NRC in a letter dated September 15, 1995 (ref. 2) that UT measurements will be taken one more time, in 1996, and the epoxy coating will be inspected in 1996 and, as a minimum again in 2000. The UT measurements were taken in 1996, per the commitment, and confirmed corrosion rate trend of 1992 and 1994. The results of 1992, 1994, and 1996 UT measurements were provided to the Staff during the AMP/AMR audits.

In response to GPU September 15, 1995 letter, NRC Staff found the proposed changes to sand bed region commitments (i.e. no additional UT measurements after 1996) reasonable and acceptable. This response is documented in November 1, 1995 Safety Evaluation for the Drywell Monitoring Program.

For license renewal, Oyster Creek was previously committed to perform One-Time UT inspection of the drywell shell in the sand bed region prior to entering the period of extended operation. However, in response to NRC Question #AMP-141, Oyster Creek revised the commitment to perform UT inspections periodically. The initial inspection will be conducted prior to entering the period of extended operation and additional inspections will be conducted every 10 years thereafter. The UT measurements will be taken from inside the drywell at same locations as 1996 UT campaign

(8b) Question: Please describe the measures to prevent water intrusion into the gap between the drywell shell and the concrete that will allow the upper portion of the drywell to meet ASME code requirements. Are these measures to prevent water intrusion credited for LR? If not, how will ASME code requirements be met during the extended period of operation?

Response:
The measures taken to prevent water intrusion into the gap between the drywell shell and the concrete that will allow the upper portion of the drywell to maintain the ASME code requirements are,
1. Cleared the former sand bed region drains to improve the drainage path.
2. Replaced reactor cavity steel trough drain gasket, which was found to be leaking.
3. Applied stainless steel type tape and strippable coating to the reactor cavity during refueling outages to seal identified cracks in the stainless steel liner.
4. Confirmed that the reactor cavity concrete trough drains are not clogged
5. Monitored former sand bed region drains and reactor cavity concrete trough drains for leakage during refueling outages and plant operation.

Oyster Creek is committed to implement these measures during the period of extended operation.

(8c) Please confirm or clarify (1) that only the fractured blisters found in this inspection were repaired; (2) pits were identified where the blisters were fractured; (3) pit depths were measured and found to

NRC Information Request Form

50 mils max; (4) the inspection Specification SP-1302-52-120 includes pit-depth acceptance criteria for rapid evaluation of observed pitting; (5) the minimum pit depth of concern is 141 mils (.141) and pits as deep as 261 mils (.261) may be acceptable.

Response:
(1) Specification SP-1302-52-120, Specification for Inspection and Localized Repair of the Torus and Vent System Coating, specifies repair requirements for coating defects exposing substrate and fractured blisters showing signs of corrosion. The repairs referred to in the inspection report included fractured blisters, as well as any mechanically damaged areas, which have exposed bare metal showing signs of corrosion. Therefore, only fractured blisters would be candidates for repair, not those blisters that remain intact. The number and location of repairs are tabulated in the final inspection report prepared by Underwater Construction Corporation.
(2) Coating deficiencies in the immersion region included blistering with minor mechanical damage. Blistering occurred primarily in the shell invert but was also noted on the upper shell near the water line. The majority of the blisters were intact. Intact blisters were examined by removing the blister cap exposing the substrate. Corrosion attack under non-fractured blisters was minimal and was generally limited to surface discoloration. Examination of the substrate revealed slight discoloration and pitting with pit depths less than 0.001. Several blistered areas included pitting corrosion where the blisters were fractured. The substrate beneath fractured blisters generally exhibited a slightly heavier magnetite oxide layer and minor pitting (less than 0.010") of the substrate.

(3) In addition to blistering, random deficiencies that exposed base metal were identified in the torus immersion region coating (e.g., minor mechanical damage) during the 19R (2002) torus coating inspections. They ranged in size from 1/16" to ½" in diameter. Pitting in these areas was qualitatively evaluated and ranged from less than 10 mils to slightly more than 40 mils in a few isolated cases. Three quantitative pit depth measurements were taken in several locations in the immersion area of Bay 1. Pit depths at these sites ranged from 0.008" to 0.042" and were judged to be representative of typical conditions found on the shell.

Prior to 2002 inspection 4 pits greater than 0.040" were identified. The pits depth are 0.058" (1 pit in 1988), 0.05" (2 pits in 1991), and 0.0685" (1 pit in 1992). The pits were evaluated against the local pit depth acceptance criteria and found to be acceptable.

(4) Specification SP-1302-52-120, Specification for Inspection and Localized Repair of the Torus and Vent System Coating, includes the pit-depth acceptance criteria for rapid evaluation of observed pitting. The acceptance criteria are supported by a calculation C-1302-187-E310-038. Locations that do not meet the pit-depth acceptance criteria are characterized based on the size of the area, center to center distance between corroded areas, the maximum pit depth and location in the Torus based on major structural features. These details are sent to Oyster Creek Engineering for evaluation.

(5) The acceptance criteria for pit depth is as follows:
-Isolated Pits of 0.125" in diameter have an allowed maximum depth of 0.261" anywhere in the shell provided the center to center distance between the subject pit and neighboring isolated pits or areas of pitting corrosion is greater than 20.0 inches. This includes old pits or old areas of pitting corrosion that have been filled and/or re-coated.

NRC Information Request Form

-Multiple Pits that can be encompassed by a 2-1/2" diameter circle shall be limited to a maximum pit depth of 0.141" provided the center to center distance between the subject pitted area and neighboring isolated pits or areas of pitting corrosion is greater than 20.0 inches. This includes old pits or old areas of pitting corrosion that have been filled and/or recoated.

Question: Please also provide the following information: nominal design, as-built, and minimum measured thickness of the torus; minimum thickness required to meet ASME code acceptance criteria; the technical basis for the pitting acceptance criteria include in Specification SP-1302-52-120

Response:
Submersed area:
(a) The nominal Design thickness is 0.385 inches
(b) The as-built thickness is 0.385 inches
(c) The minimum uniform measured thickness is,
  0.343 inches - general shell
  0.345 inches - shell - ring girders
  0.345 inches - shell - saddle flange
  0.345 inches - shell - torus straps

(d) The minimum general thickness required to meet ASME Code Acceptance is 0.337 inches.

Technical basis for pitting acceptance criteria included in Specification SP-1302-52-120 is based on engineering calculation C-1302-187-E310-038. At the time of preparation of calculation C-1302-187-E310-038 in 2002 there were no published methods to calculate acceptance standards for locally thinned areas in ASME Section III or Section VIII Pressure Vessel codes. Therefore, the approach in Code Case N-597 was used as guidance in assessing locally thinned areas in the Torus. This is based on the similarity in approaches between Local Thinning Areas described in N597 and Local Primary Stress areas described in Paragraph NE3213.10 of the ASME B&PV Code Section III, particularly small areas of wall thinning which do not exceed 1.0 x (square root of Rt). In addition, the ASME B&PV Code Section III, Subsection NB, Paragraph NB-3630 allows the analysis of pipe systems in accordance with the Vessel Analysis rules described in Paragraph NB-3200 of the same Subsection as an alternate analysis approach. Therefore, the approach used in N597 for local areas of thinning was probably developed using the rules for Local Primary Membrane Stress from paragraph NB-3200 in particular Subparagraph 3213.10. The Local Primary Stress Limits in NB-3213.10 are similar to those discussed in Subsection NE, Paragraph NE-3213.10.

Since the Code Case had not yet been invoked in to the Section XI program, the calculation provided a reconciliation of the results obtained from the code case against the ASME Section III code requirements as discussed above. This reconciliation demonstrated that the approach in N597 used on a pressure vessel such as the Torus would be acceptable since the results are conservative compared to the previous work performed in MPR-953 and Lm(a) (defined in N597 Table- 3622-1) £ (Rmintmin)1/2.

Currently, the maximum pit depth measured in the Torus is a 0.0685" (measured in 1992 in bay 2). It was evaluated as acceptable using the design calculations existing at that time and was not based on

NRC Information Request Form

Calculation C-1302-187-E310-038. This remains the bounding wall thickness in the Torus. The criterion developed in 2002 for local thickness acceptance provides an easier method for evaluating as-found pits. The results were shown to be conservative versus the original ASME Section III and VIII Code requirements for the Torus.

The Torus inspection program is being enhanced per IR 373695 to improve the detail of the acceptance criteria and margin management requirements using the ASME Section III criteria. The approach used in C-1302-187-E310-038 will be clarified as to how it maintains the code requirements. If Code Case N-597-1 is required to develop these criteria for future inspections, NRC review and approval will be obtained. It should also be noted that the program has established corrosion rate criteria and continues to periodically monitor to verify they remain bounded.

LRCR #: ***LRA A.5 Commitment #:***

IR#:

Approvals:

Prepared By: Ouaou, Ahmed 4/ 5/2006

Reviewed By: Miller, Mark 4/ 5/2006

Approved By: Warfel, Don 4/ 5/2006

NRC Acceptance (Date):

NRC Information Request Form

Item No
AMP-356

Date Received: 2/16/2006

Source AMP Audit

Topic:
IWE

Status: Open

Document References:

NRC Representative Morante, Rich

AmerGen (Took Issue):

__Question__

IWE AMP
Question 4 IWE AMP Revised Feb. 17, 2006 R. Morante (AMP-356)

(1) Identify the specific locations around the circumference in the former sandbed region where UT thickness readings have been and will be taken from inside containment. Confirm that all points previously recorded will be included in future inspections.

(2) Describe the grid pattern at each location (meridional length, circumferential length, grid point spacing, total number of point readings), and graphically locate each grid pattern within the former sandbed region.

(3) For each grid location, submit a graph of remaining thickness versus time, using the UT readings since the initiation of the program (both prior to and following removal of the sand and application of the external coating).

(4) Clearly describe the methodology and acceptance criteria that is applied to each grid of point thickness readings, including both global (entire array) evaluation and local (subregion of array) evaluation.

Assigned To: Ouaou, Ahmed

__Response:__

Response:
1. The circumference of the drywell is divided into 10 bays, designated as Bays 1, 3, 5, 7, 9, 11,13, 15, 17, and 19. UT thickness readings have been taken in each bay at one or more locations. The specific locations around the circumference in the former sand bed region where UT thickness reading have been taken from inside containment are Bay 1D, 3D, 5D, 7D, 9A, 9D, 11A, 11C, 13A, 13C, 13D, 15A, 15D, 17A, 17D, 17/19 Frame, 19A, 19B, and 19C. For each location, UT measurements were taken centered at elevation 11'-3". These represent the locations where UT measurements were taken in 1992, 1994, and 1996.

15

NRC Information Request Form

In addition UT measurements were taken one time inside 2 trenches excavated in drywell floor concrete. The purpose of these UT measurements is to determine the extent of corrosion in the lower portions of the sand bed region prior to removing the sand and making accessible for visual inspection.

Future UT thickness measurements will be taken at the same locations as those inspected in 1996 in accordance with Oyster Creek commitment documented in NRC Question #AMP-209.

2. For locations where the initial investigations found significant wall thinning (9D, 11A, 11C, 13A, 13D, 15D, 17A, 17D, 17/19 Frame, 19A, 19B, and 19C) the grid pattern consists of 7 x 7 grid centered at elevation 11'-3 (meridian) and centered at the centerline of the tested location within each bay, which consists of 6"x 6" square template. The grid spacing is 1" on center. There are 49 point readings. For graphical location of the grid, refer to attachment 1.

For locations where the initial investigations found no significant wall thinning (1D, 3D, 5D, 7D, 9A, 13C, and 15A) the grid pattern consists of 1 x 7 grid centered at elevation 11'-3" (meridian) on 1" centers. There are 7 point readings. For graphical location of the grid, refer to attachment 1.

3. A graph representing the remaining thickness versus time using UT reading since the initiation of the program (both prior to and following removal of the sand and application of the external coating) for location 9D, 11A, 11C, 13A, 13D,15D,17A,17D,17/19, 19A, 19B, and 19C is included in the attached graph. Other locations (i.e. 1D, 3D, 5D, 7D, 9A, 13C, and 15A) are not included because wall thinning is not significant and the trend line will be essentially a straight line.

4. The methodology and acceptance criteria that is applied to each grid of point thickness readings, including both global (entire array) evaluation and local (subregion of array) is described in engineering specification IS-328227-004 and in calculation No. C-1302-187-5300-011. These documents were submitted to the NRC in a letter dated November 26, 1990 and provided to the Staff during the AMP/AMR audit. A brief summary of the methodology and acceptance criteria is described below.

The initial locations where corrosion loss was most severe in 1986 and 1987 were selected for repeat inspection over time to measure corrosion rate. For location where the initial investigations found significant wall thinning UT inspection consists of 49 individual UT data points equally spaced over a 6"x 6" area. Each new set of 49 values was then tested for normal distribution.

The mean values of each grid were then compared to the required minimum uniform thickness criteria of 0.736. In addition each individual reading is compared to the local minimum required criteria of 0.49. The basis for the required minimum uniform thickness criteria and the local minimum required criteria is provided in response to NRC Question #AMP-210.

A decrease in the mean value over time is representative of corrosion. If corrosion does not exist, the mean value will not vary with time except for random variations in the UT measurements.

NRC Information Request Form

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

A similar process is applied to the thinnest individual reading in each grid. The curve fit of the data is tested to determine if linear regression is appropriate. If a slope exists, then the lower 95% confidence interval is then projected into the future and compared to the required minimum local thickness criteria of .49.

LRCR #: *LRA A.5 Commitment #:*

IR#:

Approvals:

Prepared By: Ouaou, Ahmed 4/ 4/2006

Reviewed By: Getz, Stu 4/ 5/2006

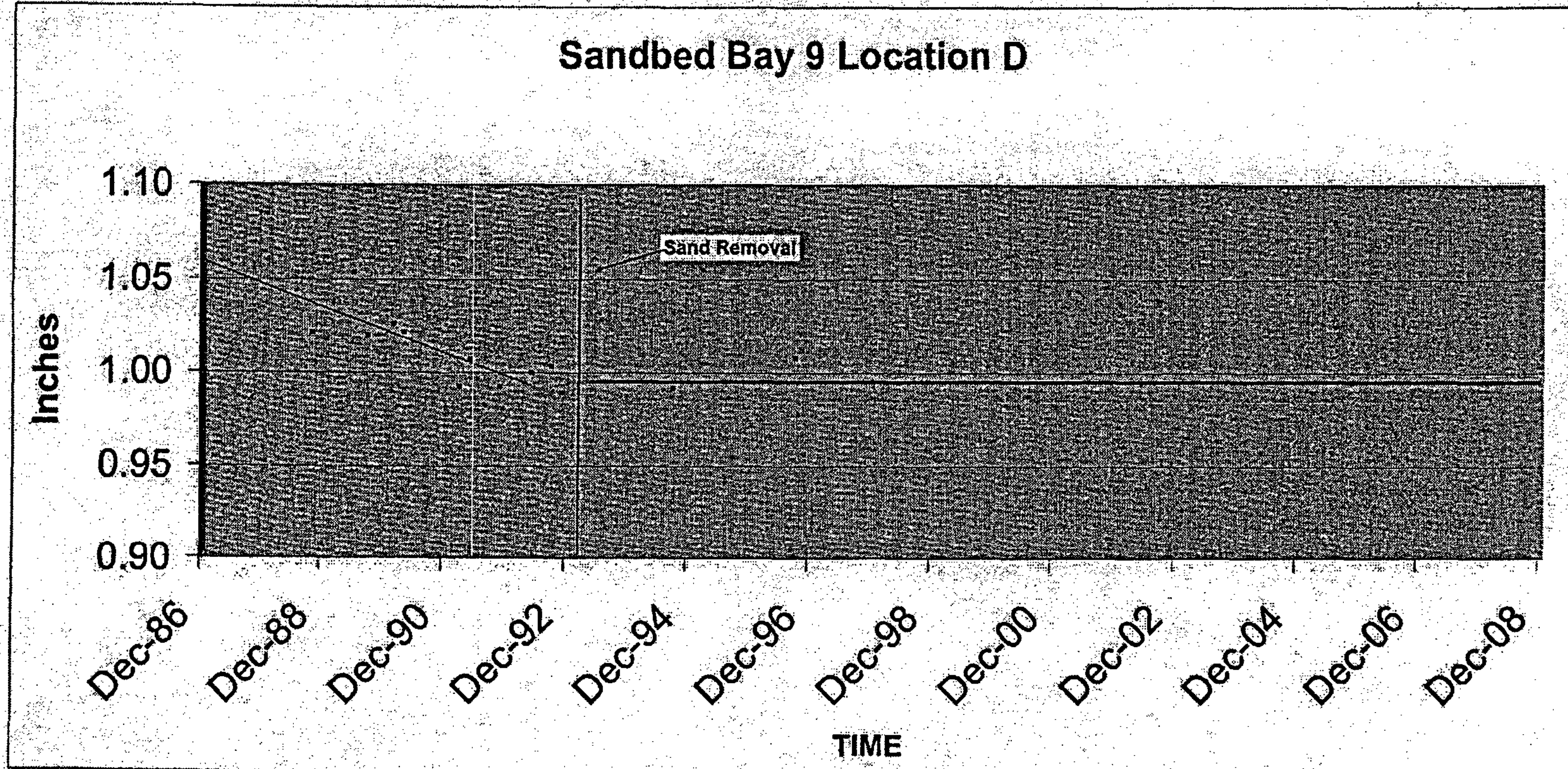
Approved By: Warfel, Don 4/ 5/2006

NRC Acceptance (Date):

Oyster Ceek Drywell Vessel Corrosion Rate Trending Program

Average Measured Thicknesses

Bay	Date	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
1D									1.115										[illegible]	1.151
3D									1.178										1.184	1.181
5D									1.174										1.168	1.173
7D									1.135										1.136	1.138
9A									1.155										1.157	1.155
9D		1.072							1.021	1.054	1.020	1.026	1.022	0.993	1.008	0.992	1.000	1.004	0.992	1.004
11A				0.919	0.905	0.922	0.905	0.913	0.888	0.881	0.892	0.881	0.870	0.845	0.844	0.833	0.842	0.825	0.820	0.830
11C	Bottom				0.917	0.954	0.916	0.906	0.891	0.877	0.891	0.870	0.865	0.858	0.863	0.856	0.882	0.859	0.850	0.883
	Top				1.046	1.109	1.079	1.045	1.009	1.016	1.005	0.952	0.977	0.982	1.018	0.964	1.010	0.970	0.984	1.042
13A		0.919							0.905	0.883	0.883	0.862	0.853	0.855	0.853	0.849	0.865	0.854	0.826	0.843
13C	Bottom													0.909	0.901	0.900	0.931	0.904	0.895	0.933
	Top													1.072	1.049	1.048	1.088	1.055	1.037	1.059
13D									0.962				0.932					1.001	0.954	0.990
15A									1.120										1.114	1.127
15D		[illegible]							1.055	[illegible]	1.061	[illegible]	1.057	[illegible]	[illegible]	1.042	1.065	[illegible]	[illegible]	[illegible]
17A	Bottom	0.999							0.957	0.965	0.955	0.954	0.951	0.935	0.942	0.933	0.948	0.941	0.934	0.997
	Top	0.999							1.133	1.130	1.131	1.128	1.128	1.131	1.129	1.123	1.125	1.125	1.129	1.144
17D			0.922		0.895	0.891	0.895	0.878	0.862	0.857	0.847	0.836	0.829	0.825	0.829	0.822	0.823	0.817	0.810	0.849
17/19	Bottom								1.004	0.999	0.955	1.010	1.006	0.987	0.982	0.971	0.990	0.989	0.975	0.991
	Top								0.982	1.019	1.131	0.990	0.986	0.975	0.969	0.954	0.872	0.976	0.965	0.967
19A			0.884		0.873	0.859	0.858	0.849	0.837	0.829	0.825	0.840	0.806	0.817	0.803	0.803	0.809	0.806	0.806	0.815
19B					0.898	0.892	0.888	0.864	0.857	0.826	0.845	0.812	0.837	0.853	0.844	0.846	0.847	0.840	0.824	0.837
19C					0.901	0.888	0.888	0.873	0.856	0.845	0.845	0.831	0.825	0.843	0.823	0.822	0.832	0.819	0.826	0.848

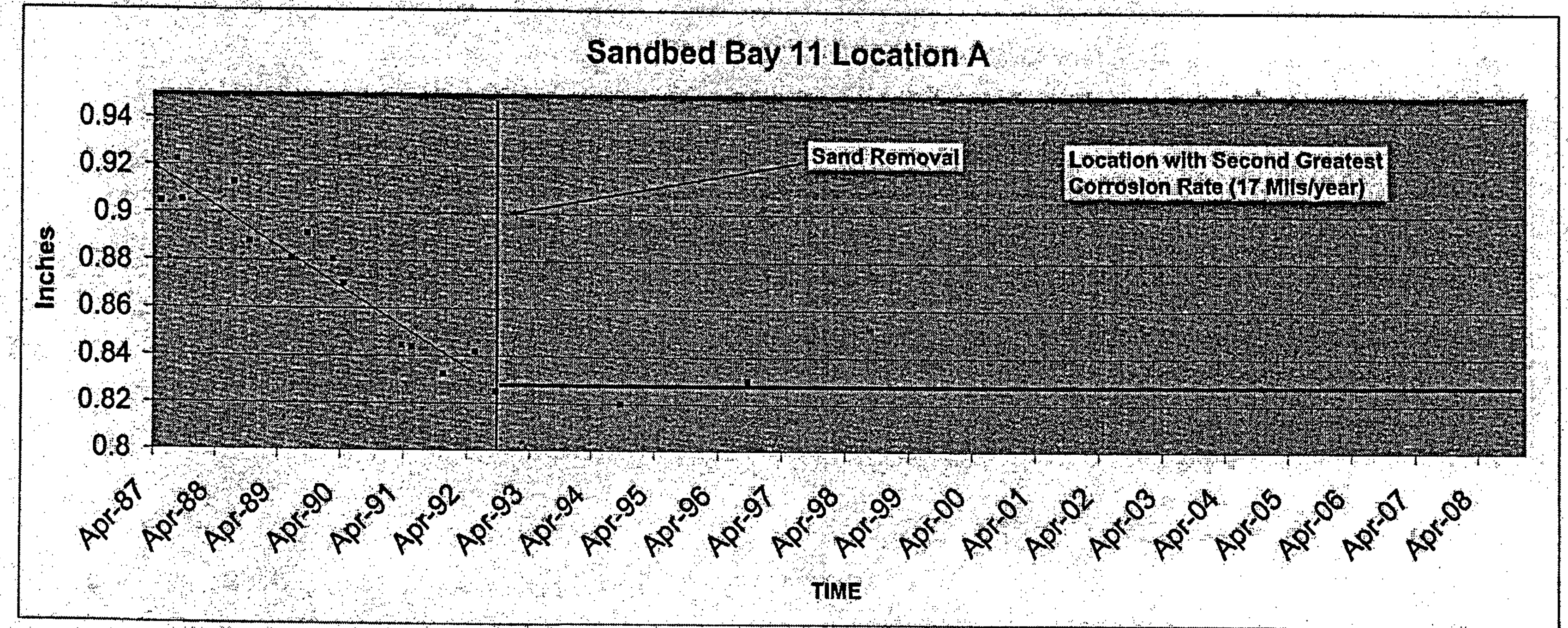


Based on Calculation C-1302-187-5300-021

Slope	Best Est	Date	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.0125	0.9932	05/01/92	1.00012	1.154"	0.736"

Dates	Dec-86	Feb-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
9D	1.0715						1.0214	1.0540	1.0200	1.0260	1.0217	0.9926	1.0075	0.9924	1.0000	1.0036	0.9920	1.0080

17

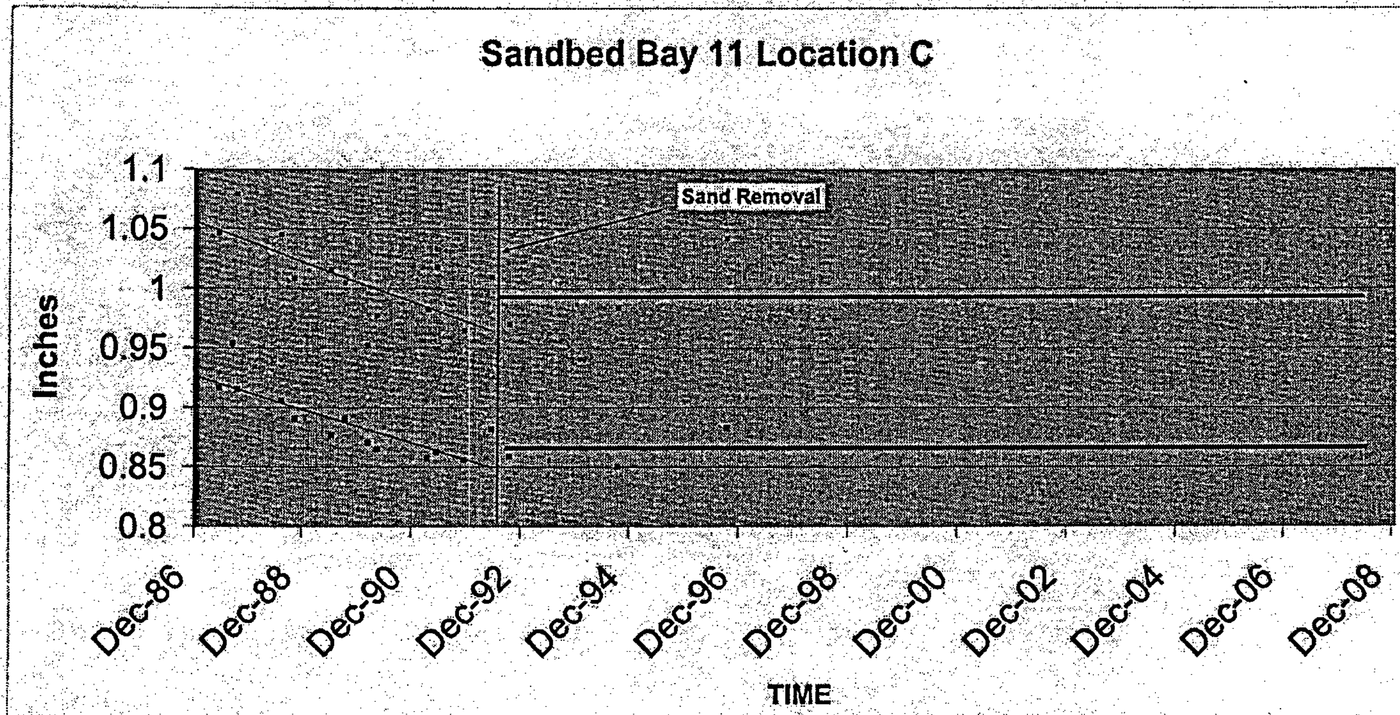


Based on Calculation C-1302-187-5300-021

Slope	Best Est.	Date	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.0171	0.83311	05/01/92	0.8251	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
11A			0.9187	0.90464	0.92209	0.9052	0.913	0.8882	0.881	0.8916	0.8808	0.8704	0.8446	0.844	0.8326	0.842	0.8252	0.82	0.83

20

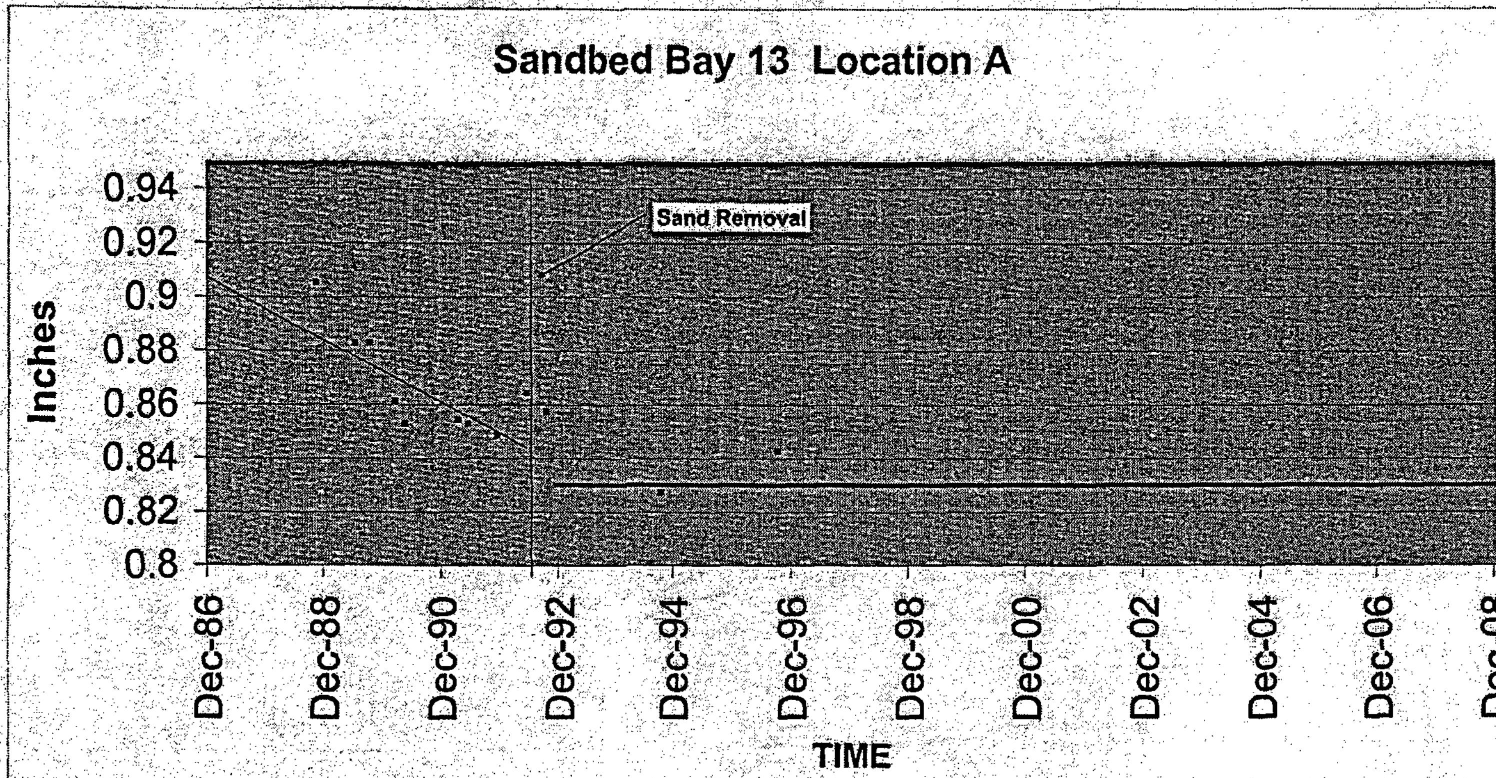


Based on Calculation C-1302-187-5300-021

Slope	Slope	Best Est. Low	Best Est. High	Date	Average Since 1992	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.0143	-0.0171	0.8498	0.9642	05/01/92	0.8641	0.9984	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89
11C Bottom				0.91679	0.95364	0.91571	0.9061	0.8907	0.8768
11C Top				1.046	1.1086	1.0791	1.0454	1.0089	1.0158

Dates	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
11C Bottom	0.8907	0.8703	0.865	0.8575	0.8626	0.8563	0.882	0.8591	0.8503	0.883
11C Top	1.005	0.9522	0.977	0.9817	1.018	0.9643	1.01	0.9597	0.9836	1.0418

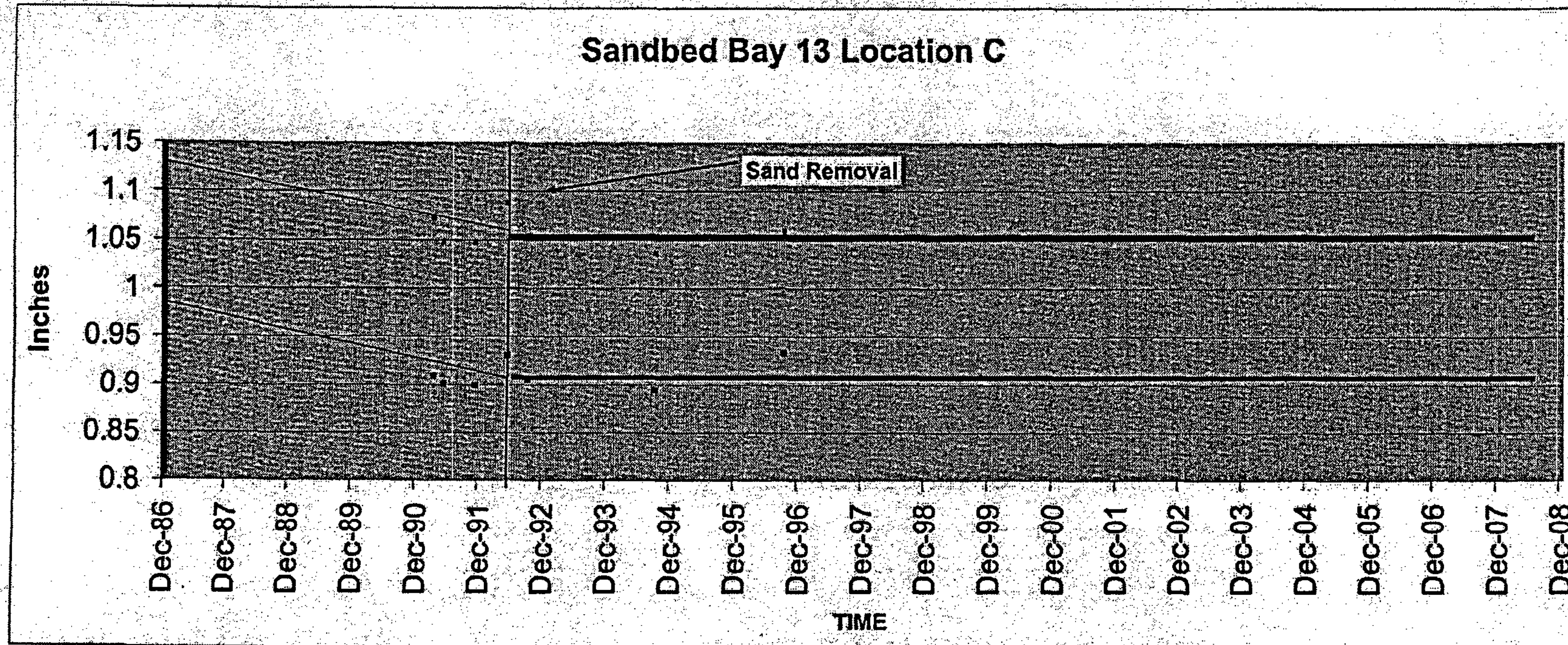


Based on Calculation C-1302-187-5300-021

Slope	Best Est.	Date	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.012	0.8442	05/01/92	0.8386	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
	0.91908							0.9053	0.8828	0.883	0.8615	0.8531	0.8545	0.8529	0.8486	0.8645	0.8576	0.8275	0.843

22

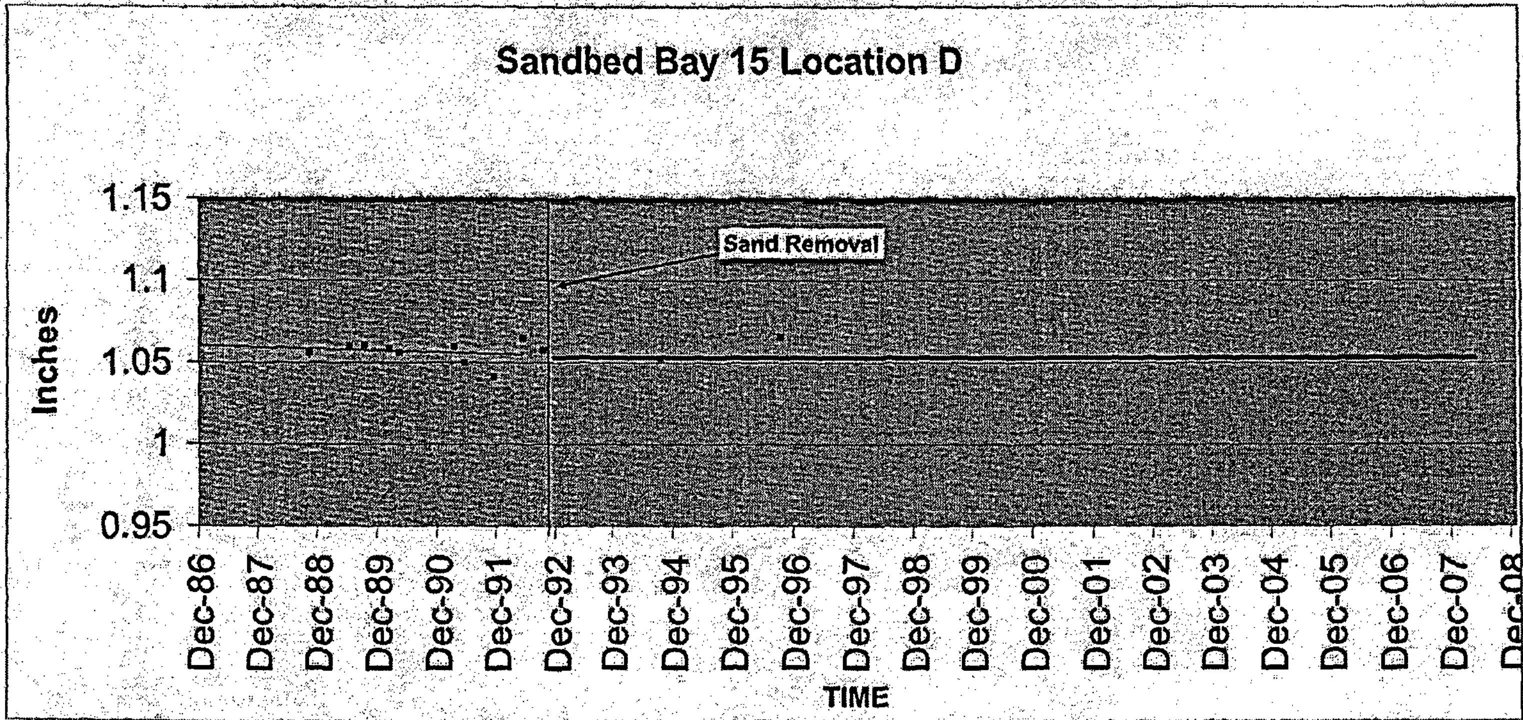


Based on Calculation C-1302-187-5300-021

Slope	Slope	Best Est. Low	Best Est. Hig	Date	Average Since 1992	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.013	-0.0146	0.9073	1.06	05/01/92	1.0505	0.9114	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
13C Bottom													0.9094	0.9013	0.8996	0.9305	0.906	0.8953	0.933
13C Top													1.0722	1.0488	1.0479	1.0882	1.0546	1.037	1.0593

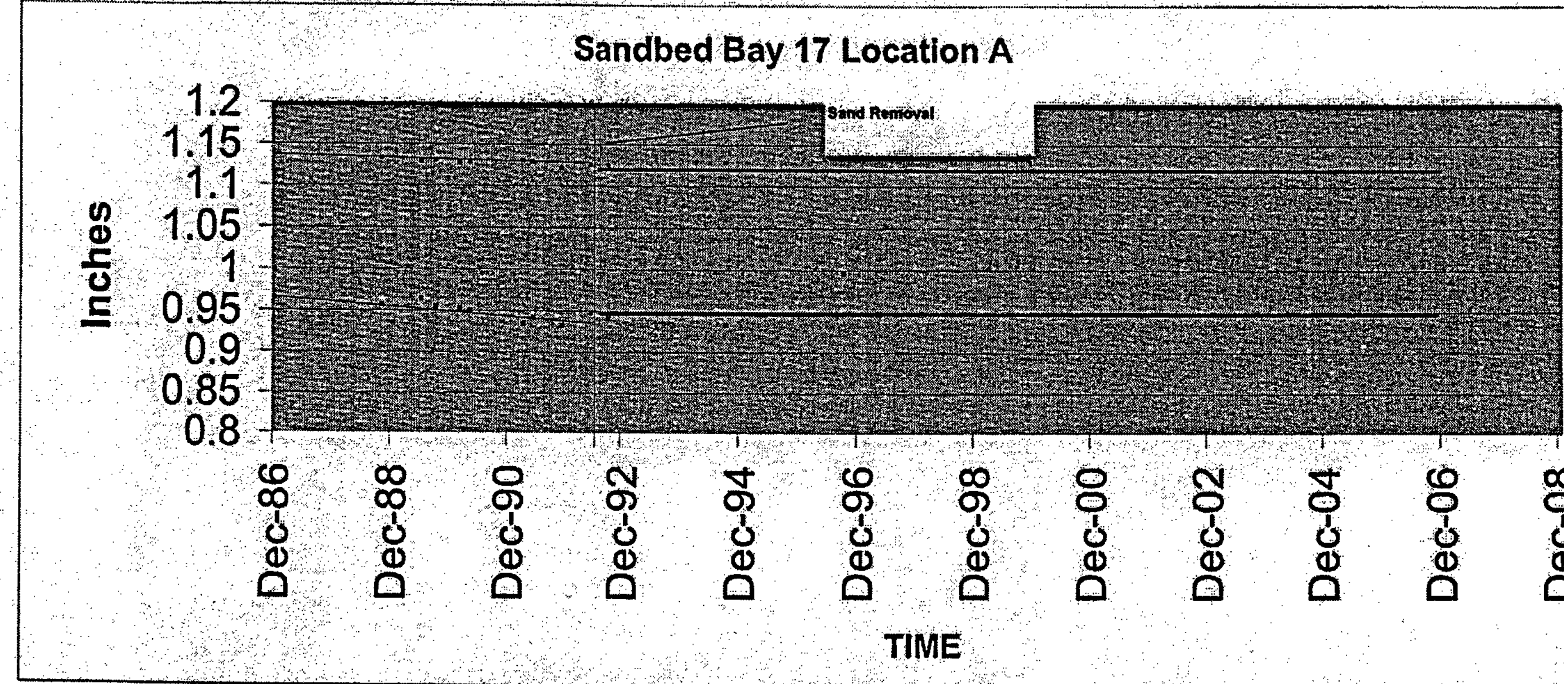
23



Based on Calculation C-1302-187-5300-021

Slope	Best Est.	Date	Average Since 1992	Original Nominal Thickness	Minimum Unform Required Thickness
-0.001	1.055	05/01/92	1.0588	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
	1.089							1.056	1.06	1.0609	1.0586	1.0565	1.0598	1.0502	1.0417	1.0652	1.0577	1.053	1.066

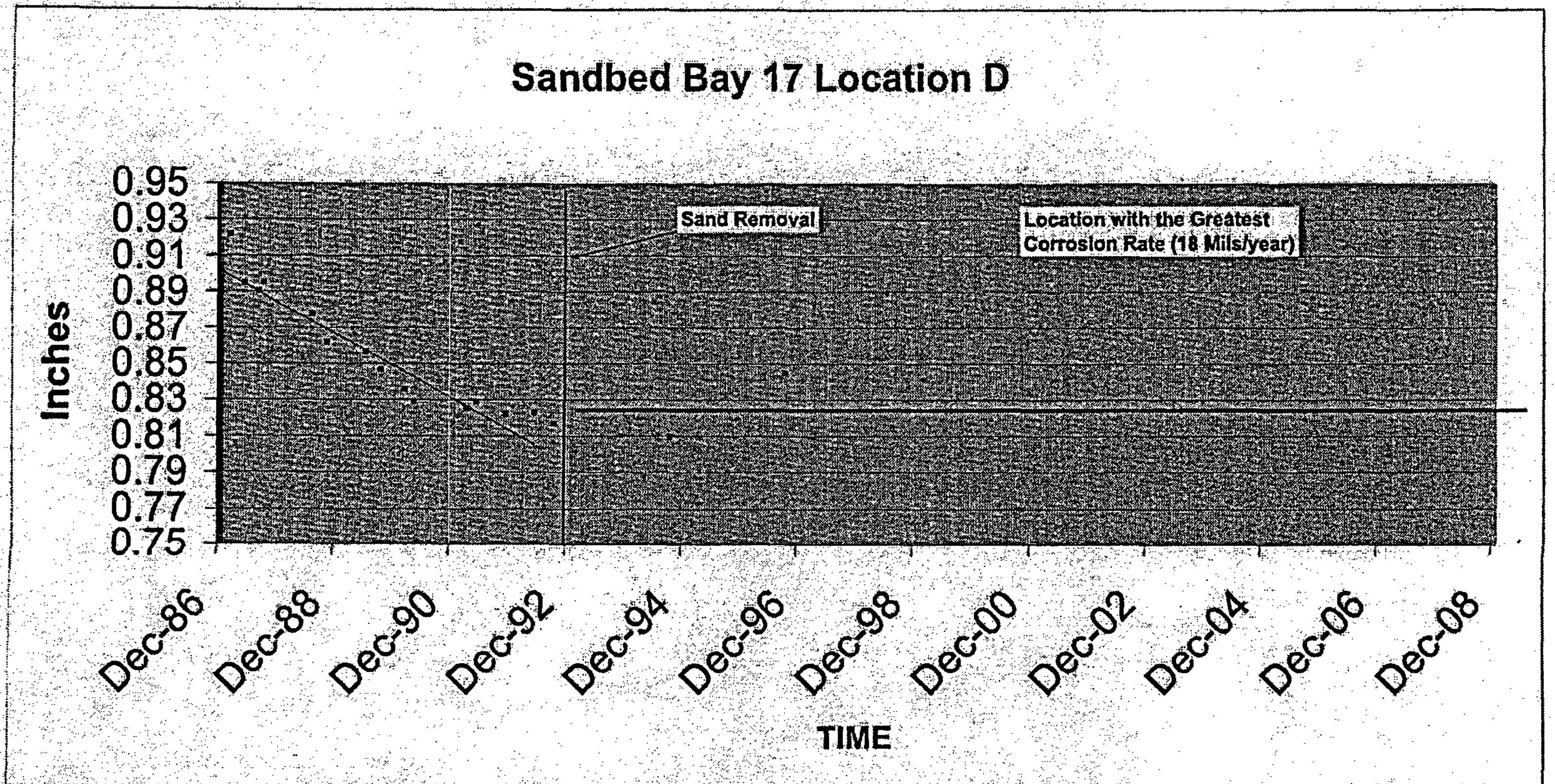


Based on Calculation C-1302-187-5300-021

Slope	Slope	Best Est. Low	Best Est. High	Date	Average Since 1992	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.0058	-0.0017	0.9352	1.1278	05/01/92	1.1326	0.9573	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-06
17A bottom	0.996							0.9574	0.9645	0.9852	0.9536	0.9500	0.9347	0.9424	0.9328	0.9481	0.9413	0.9338	0.9069
17A Top	0.999							1.1331	1.13	1.1308	1.126	1.1283	1.1309	1.1293	1.1226	1.1254	1.1248	1.1289	1.1441

25

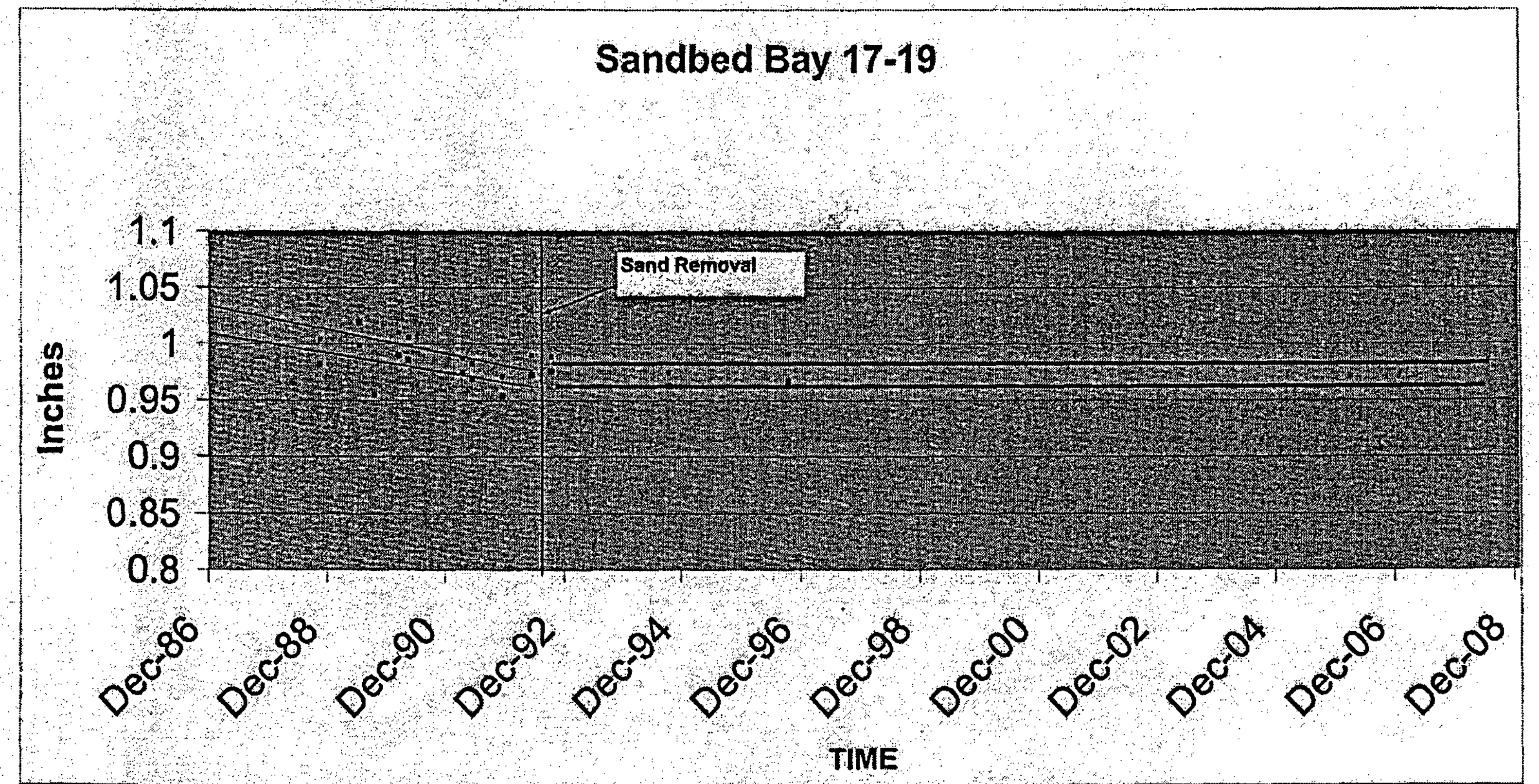


Based on Calculation C-1302-187-5300-021

Slope	Best Est.	Date	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.018	0.8057	05/01/92	0.8239	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
17D		0.92217		0.89507	0.89069	0.89528	0.8779	0.8622	0.8568	0.8471	0.8358	0.829	0.8253	0.8291	0.8222	0.823	0.8172	0.81	0.845

26

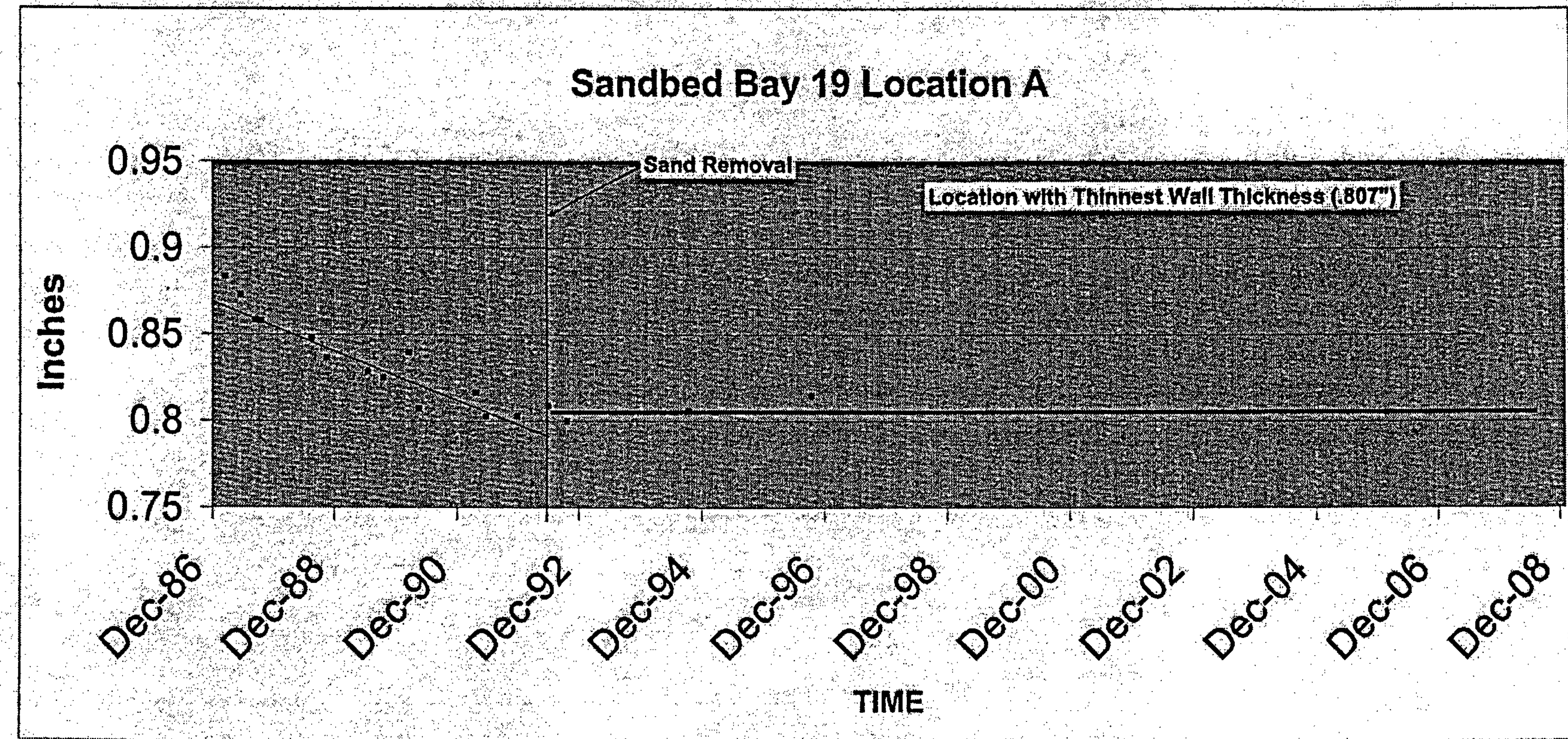


Based on Calculation C-1302-187-5300-021

Slope	Slope	Best Est. Low	Best Est. High	Date	Average Since 1992	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.0087	-0.0107	0.9621	0.9761	05/01/92	0.9871	0.9689	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
17/19 Top								0.9817	1.0191	1.1308	0.9898	0.986	0.9746	0.9693	0.9542	0.9722	0.976	0.963	0.9674
17/19 Bottom								1.0038	0.9988	0.9552	1.01	1.0057	0.987	0.9624	0.9711	0.99	0.9687	0.9748	0.9914

27

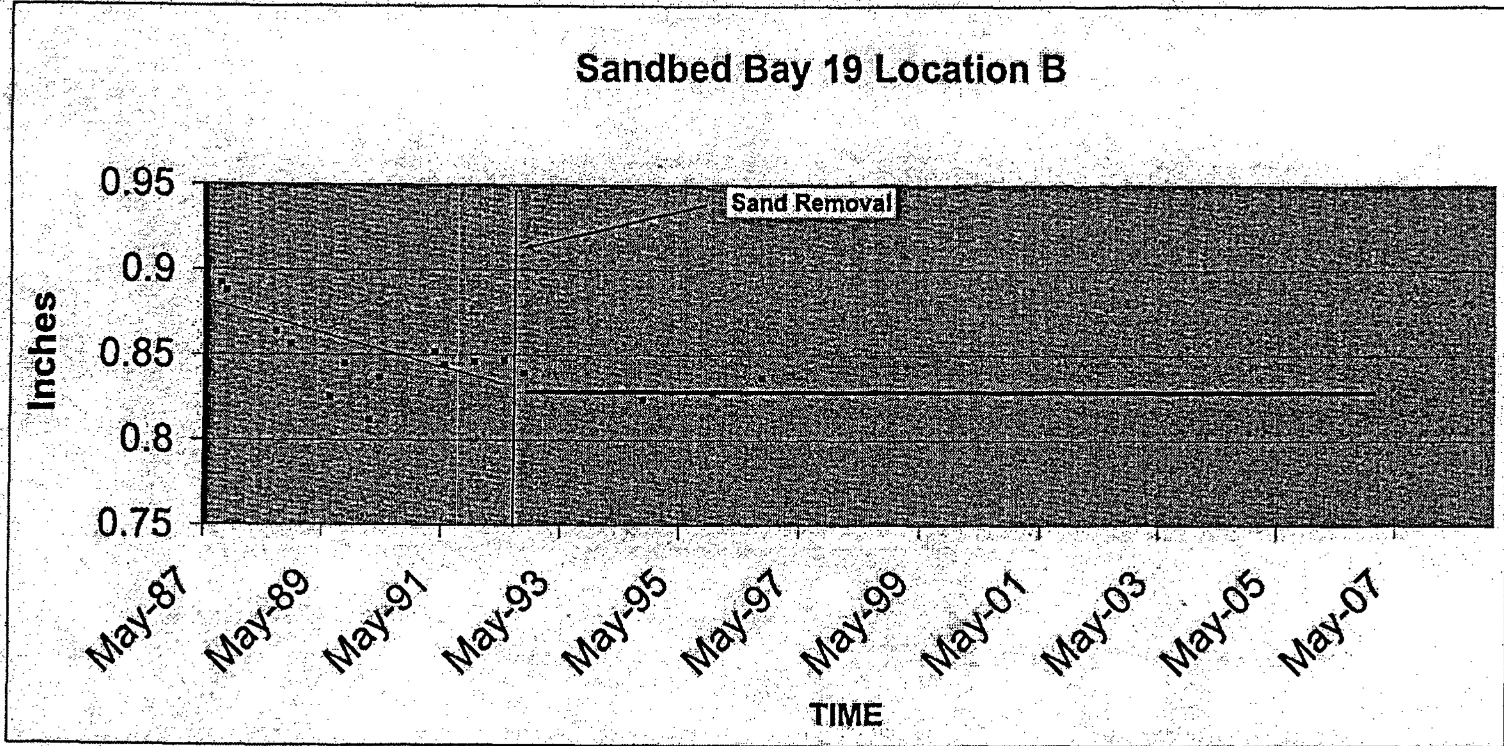


Based on Calculation C-1302-187-5300-021

Slope	Best Est.	Date	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.015	0.7911	05/01/92	0.8071	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
19A		0.88364		0.87293	0.8586	0.85829	0.8486	0.8369	0.8288	0.8254	0.8399	0.8076	0.8167	0.8028	0.8032	0.8091	0.8002	0.806	0.815

28

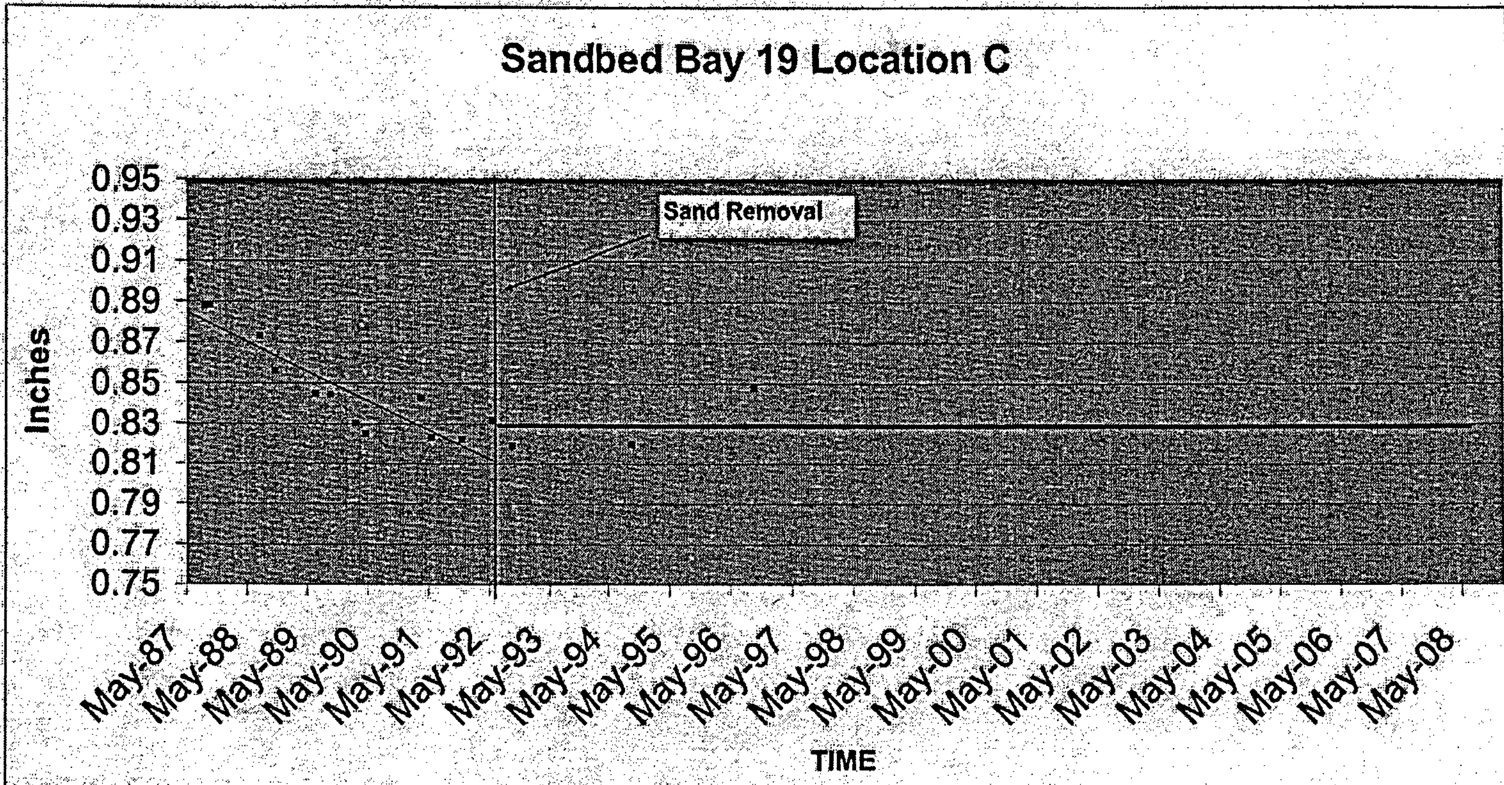


Based on Calculation C-1302-187-5300-021

Slope	Best Est.	Date	Average Since 1992	Original Nominal Thickness	Minimum Uniform Required Thickness
-0.0099	0.8330	05/01/92	0.8337	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89
19B				0.89763	0.89221	0.8876	0.864	0.8565	0.8256

Dates	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
19B	0.84549	0.812	0.8369	0.8525	0.8444	0.8463	0.8472	0.8396	0.824	0.837



Based on Calculation C-1302-187-5300-021

Slope	Best Est.	Date	Average Since 1992	Original Nominal Thickness	Minimum Unform Required Thickness
-0.015	0.8117	05/01/92	0.829	1.154"	0.736"

Dates	Dec-86	Feb-87	Apr-87	May-87	Aug-87	Sep-87	Jul-88	Oct-88	Jun-89	Sep-89	Feb-90	Apr-90	Mar-91	May-91	Nov-91	May-92	Sep-92	Sep-94	Sep-96
19C				0.90051	0.88816	0.88831	0.8735	0.8563	0.845	0.8447	0.8305	0.8251	0.8428	0.8232	0.8223	0.8319	0.8192	0.82	0.848

30

NRC Information Request Form

Item No
AMP-141

Date Received: 10/ 6/2005

Source AMP Audit

Status: Open

Topic:
IWE

Document References:
B.1.27

NRC Representative Morante, Rich

AmerGen (Took Issue): Hufnagel, Joh

Question

AMP B.1.27 IWE

a. Visual inspection of the coatings in the former sandbed region of the drywell is currently conducted under the applicant's protective coatings monitoring and maintenance program; only this AMP is credited for managing loss of material due to corrosion for license renewal. Visual inspection of the containment shell conducted in accordance with the requirements of IWE is typically credited to manage loss of material due to corrosion.

The applicant is requested to provide its technical basis for not also crediting its IWE program for managing loss of material due to corrosion in the former sandbed region of the drywell.

B. During discussions with the applicant's staff on 10/04/05 about augmented inspection conducted under IWE, the applicant presented tabulated inspection results obtained from the mid 1980s to the present, to monitor the remaining drywell wall thickness in the cylindrical and spherical regions where significant corrosion of the outside surface was previously detected.

The applicant is requested to provide (1) a copy of these tabulated inspection results, (2) a list of the nominal design thicknesses in each region of the drywell, (3) a list of the minimum required thicknesses in each region of the drywell, and (4) a list of the projected remaining wall thicknesses in each region of the drywell in the year 2029.

AMP B.1.27 IWE Question on Remaining Wall Thickness in the Former Sandbed Region of the Drywell

c. During discussions with the applicant's staff on 10/05/05, the applicant described the history and resolution of corrosion in the sandbed region. After discovery, thickness measurements were taken from 1986 through 1992, to monitor the progression of wall loss. Remedial actions were completed in early 1993. At that time, the remaining wall thickness exceeded the minimum required thickness. The applicant concluded that it had completely corrected the conditions which led to the corrosion, and terminated its program to monitor the remaining wall thickness. At that time, the remaining years of operation was expected to be no more than 16 years (end of the current license term).

31

NRC Information Request Form

The applicant's aging management commitment for license renewals is limited to periodic inspection of the coating that was applied to the exterior surface of the drywell as part of the remedial actions. The applicant has not made a license renewal commitment to measure wall thickness in the sandbed region in order to confirm the effectiveness of the remedial actions taken.

Assigned To: Ouaou, Ahmed

Response:

a) Visual inspection of the containment drywell shell, conducted in accordance with ASME Section XI, Subsection IWE, is credited for aging management of accessible areas of the containment drywell shell. Typically this inspection is for internal surfaces of the drywell. The exterior surfaces of the drywell shell in the sand bed region for Mark I containment is considered inaccessible by ASME Section XI, Subsection IWE, thus visual inspection is not possible for a typical Mark I containment including Oyster Creek before the sand was removed from the sand bed region in 1992. After removal of the sand, an epoxy coating was applied to the exterior surfaces of the drywell shell in the sand bed region. The region was made accessible during refueling outages for periodic inspection of the coating. Subsequently Oyster Creek performed periodic visual inspection of the coating in accordance with an NRC current licensing basis commitment. This commitment was implemented prior to implementation of ASME Section XI, Subsection IWE. As a result inspection of the coating was conducted in accordance with the Protective Coating Monitoring and Maintenance Program. Our evaluation of this aging management program concluded the program is adequate to manage aging of the drywell shell in the sand bed region during the period of extended operation consistent with the current licensing basis commitment, and that inclusion of the coating inspection under IWE is not required. However we are amending this position and will commit to monitor the protective coating in the exterior surfaces of the drywell in the sand bed region in accordance with the requirements of ASME Section XI, Subsection IWE during the period of extended operation. For details related to implementation of this commitment, refer to the response to NRC AMP Question #188.

b) A tabulation of ultrasonic testing (UT) thickness measurement results in monitored areas of the drywell spherical region above the sand bed region and in the cylindrical region is included in ASME Section XI, Subsection IWE Program Basis Document (PBD-AMP-B.1.27) Notebook. The tabulation contains information requested by the Staff and is available for review during AMP audit. The tabulation is also provided in Table -1, and Table-2 below.

c) In December 1992, with approval from the NRC a protective epoxy coating was applied to the outside surface of the drywell shell in the sand bed region to prevent additional corrosion in that area. UT thickness measurements taken in 1992, and in 1994, in the sand bed region from inside the drywell confirmed that the corrosion in the sand bed region has been arrested. Periodic inspection of the coating indicates that the coating in that region is performing satisfactorily with no signs of deterioration such as blisters, flakes, or discoloration, etc. Additional UT measurements, taken in 1996 from inside the drywell in the sand bed region showed no ongoing corrosion and provided objective evidence that corrosion has been arrested.

NRC Information Request Form

As a result of these UT measurements and the observed condition of the coating, we concluded that corrosion has been arrested and monitoring of the protective coating alone, without additional UT measurements, will adequately manage loss of material in the drywell shell in the sand bed region. However to provide additional assurance that the protective coating is providing adequate protection to ensure drywell integrity, Oyster Creek will perform periodic confirmatory UT inspections of the drywell shell in the sand bed region. The initial UT measurements will be taken prior to entering the period of extended operation and then every 10 years thereafter. The UT measurements will be taken from inside the drywell at the same locations where the UT measurements were taken in 1996. This revises the license renewal commitment communicated to the NRC in a letter from C. N. Swenson Site Vice President, Oyster Creek Generating Station to U. S. Nuclear Regulatory Commission, "Additional Commitments Associated with Application for renewed Operating License - Oyster Creek Generating Station", dated 12/9/2005. This letter commits to one-time inspection to be conducted prior to entering the period of extended operation. The revised commitment will be to conduct UT measurements on a frequency of 10 years, with the first inspection to occur prior to entering the period of extended operation.

This response was revised to incorporate additional commitments on UT examinations for the sand bed region discussed with NRC Audit team on 1/26/2006.
This response was revised to reference response to NRC Question #AMP-188 and RAI 4.7.2-1(d). AMO 4/1/2006.
The response was revised to add Table-1, and Table-2, and delete reference to RAI 4.7.2-1(d) AMO 4/5/2006.

LRCR #: 229 ***LRA A.5 Commitment #:*** 27

IR#:

Approvals:

Prepared By: Ouaou, Ahmed 4/ 5/2006

Reviewed By: Getz, Stu 4/ 5/2006

Approved By: Warfel, Don 4/ 5/2006

NRC Acceptance (Date):

33

Table –1. UT Thickness measurements for the Upper Region of the Drywell Shell

Monitored Elevation	Location	Minimum Required Thickness, inches [5]	Average Measured Thickness [1,2,4], inches											Projected Lower 95% Confidence Thickness in 2029
			1987	1988	1989	1990	1991	1992	1993 [3]	1994	1996	2000	2004	
Elevation 50' 2"		0.541"												
	Bay 5–D12					0.743 0.745 0.746	0.742 0.745 0.748	0.747 0.747		0.741	0.748	0.741	0.743	No Ongoing Corrosion
	Bay 5–5H					0.761 0.761	0.755 0.758 0.760	0.758 0.758		0.754	0.757	0.754	0.756	0.7384
	Bay 5–5L					0.706 0.703	0.703 0.705 0.706	0.703 0.707		0.702	0.705	0.706	0.701	No Ongoing Corrosion
	Bay 13–31H					0.762 0.779	0.760 0.758 0.765	0.765 0.763		0.759	0.766	0.762	0.758	No Ongoing Corrosion
	Bay 13–31L					0.687 0.684	0.689 0.678 0.688	0.685 0.688		0.683	0.690	0.682	0.693	No Ongoing Corrosion
	Bay 15–23H					0.758 0.764	0.762 0.762 0.765	0.767 0.763		0.758	0.760	0.758	0.757	0.738
	Bay 15–23L					0.726 0.728	0.726 0.729 0.725	0.726 0.724		0.728	0.724	0.729	0.727	No Ongoing Corrosion
Elevation 51' 10"		0.541"												

Table –1. UT Thickness measurements for the Upper Region of the Drywell Shell

Monitored Elevation	Location	Minimum Required Thickness, inches [5]	Average Measured Thickness [1,2,4], Inches											Projected Lower 95% Confidence Thickness in 2029
			1987	1988	1989	1990	1991	1992	1993 [3]	1994	1996	2000	2004	
	Bay 13–32H					0.716	0.715 0.715 0.719	0.717 0.717		0.714	0.715	0.715	0.713	No Ongoing Corrosion
	Bay 13–32L					0.686	0.683 0.683 0.682	0.683 0.676		0.680	0.684	0.679	0.687	No Ongoing Corrosion
Elevation 60' 10"		0.518"												
	Bay 1–5-22								0.693	0.711	0.692	0.689	0.689	No Ongoing Corrosion
Elevation 87' 5"		0.452"												
	Bay 9–20		0.619	0.622 0.620	0.619	0.620	0.614 0.612	0.629 0.614		0.613	0.613	0.604	0.612	0.604.
	Bay 13–28		0.643	0.641 0.642	0.645	0.643	0.635 0.629	0.641 0.637		0.640	0.636	0.635	0.640	No Ongoing Corrosion
	Bay 15–31		0.638	0.636 0.636	0.638	0.642	0.628 0.627	0.631 0.630		0.633	0.632	0.628	0.630	0.615

Notes:

1. The average thickness is based on 49 Ultrasonic Testing (UT) measurements performed at each location
2. Multiple inspections were performed in the years 1988, 1990, 1991, and 1992.
3. The 1993 elevation 60' 10" Bay 5-22 inspection was performed on January 6, 1993. All other locations were inspected in December 1992.
4. Accuracy of Ultrasonic Testing Equipment is plus or minus 0.010 inches.
5. Reference SE-000243-002.

Table –1. UT Thickness measurements for the Upper Region of the Drywell Shell

<u>Conclusion:</u>

Summary of Corrosion Rates of UT measurements taken through year 2004

- There is no ongoing corrosion at two elevations (51' 10" and 60' 10")
- Based on statistical analysis, one location at elevation 50' 2" is undergoing a minor corrosion rate of 0.0003 inches per year,
- Based on statistical analysis, two locations at elevation 87' 5" are undergoing minor corrosion rates of 0.0005 and 0.00075 inches per year

Table –2 UT Thickness measurements for the Sand Bed Region of the Drywell Shell

Location Bay	Sub Location	Dec 1986	Feb 1987	Apr 1987	May 1987	Aug 1987	Sep 1987	Jul 1988	Oct 1988	Jun 1989	Sep 1989	Feb 1990	Apr 1990	Mar 1991	May 1991	Nov 1991	May 1992	Sep 1992	Sep 1994	Sep 1996
1D									1.115										1.101	1.1514
3D									1.178										1.184	1.181
5D									1.174										1.168	1.173
7D									1.135										1.136	1.138
9A									1.155										1.157	1.155
9D		1.072							1.021	1.054	1.020	1.026	1.022	0.993	1.008	0.992	1.000	1.004	0.992	1.008
11A				0.919	0.905	0.922	0.905	0.913	0.888	0.881	0.892	0.881	0.870	0.845	0.844	0.833	0.842	0.825	0.820	0.830
11C	Bottom				0.917	0.954	0.916	0.906	0.891	0.877	0.891	0.870	0.865	0.858	0.863	0.856	0.882	0.859	0.850	0.883
	Top				1.046	1.109	1.079	1.045	1.009	1.016	1.005	0.952	0.977	0.982	1.018	0.964	1.010	0.970	0.984	1.042
13A		0.919							0.905	0.883	0.883	0.862	0.853	0.855	0.853	0.849	0.865	0.858	0.828	0.843
13C	Bottom													0.909	0.901	0.900	0.931	0.906	0.895	0.933
	Top													1.072	1.049	1.048	1.088	1.055	1.037	1.059
13D									0.962				0.932					1.001	0.959	0.990
15A									1.120										1.114	1.127
15D		1.089							1.056	1.060	1.061	1.059	1.057	1.060	1.050	1.042	1.065	1.058	1.053	1.066
17A	Bottom	0.999							0.957	0.965	0.955	0.954	0.951	0.935	0.942	0.933	0.948	0.941	0.934	0.997
	Top	0.999							1.133	1.130	1.131	1.128	1.128	1.131	1.129	1.123	1.125	1.125	1.129	1.144
17D			0.922		0.895	0.891	0.895	0.878	0.862	0.857	0.847	0.836	0.829	0.825	0.829	0.822	0.823	0.817	0.810	0.845
17/19	Top								0.982	1.019	1.131	0.990	0.986	0.975	0.969	0.954	0.972	0.976	0.963	0.967
	Bottom								1.004	0.999	0.955	1.010	1.006	0.987	0.982	0.971	0.990	0.989	0.975	0.991
19A			0.884		0.873	0.859	0.858	0.849	0.837	0.829	0.825	0.840	0.808	0.817	0.803	0.803	0.809	0.800	0.806	0.815
19B					0.898	0.892	0.888	0.864	0.857	0.826	0.845	0.812	0.837	0.853	0.844	0.846	0.847	0.840	0.824	0.837
19C					0.901	0.888	0.888	0.873	0.856	0.845	0.845	0.831	0.825	0.843	0.823	0.822	0.832	0.819	0.820	0.848

Citizen's Exhibit NC2

Citizen's Exhibit NC2

From: <john.hufnagel@exeloncorp.com>
To: <dja1@nrc.gov>, <rkm@nrc.gov>
Date: 04/24/2006 6:17:58 PM
Subject: Questions to go over tomorrow...

Roy and Donnie,

These attached questions are those from the database that we currently have statused as Open, but which have responses that should allow closure. Although in the closed status, AMP-071 and AMP-204 were also included because they were updated to reference additional information provided in AMP-072.

Also, we did not send AMP-358, which is the item on Fatigue Analysis. We plan on sending that to you tomorrow.

Hope to talk with you tomorrow PM.

- John.

<<AMP-071.pdf>> <<AMP-072.pdf>> <<AMP-141.pdf>> <<AMP-204.pdf>> <<AMP-209.pdf>> <<AMP-210.pdf>> <<AMP-264.pdf>> <<AMP-356.pdf>> <<AMP-357.pdf>> <<AMP-359.pdf>> <<AMP-360.pdf>> <<AMP-361.pdf>> <<AMP-362.pdf>> <<AMR-164.pdf>> <<AMR-167.pdf>> <<AMR-355.pdf>>

CC: <donald.warfel@exeloncorp.com>, <fred.polaski@exeloncorp.com>

NRC Information Request Form

Item No
AMP-357

Date Received: 2/16/2006
Source AMP Audit

Topic:
IWE

Status: Open

Document References:

NRC Representative Morante, Rich

AmerGen (Took Issue):

Question

(1) When a new set of point thickness readings is taken is the former sandbed region, prior to entering the LR period, what will be the quantitative acceptance criteria for concluding that corrosion has or has not occurred since the last inspection in 1996.

(2) If additional corrosion is detected in the upcoming inspection, describe in detail the augmented inspections and other steps that will be taken to evaluate the extent of the corrosion, and describe the approach to ensuring the continued structural adequacy of the containment.

Assigned To: Ouaou, Ahmed

Response:

(1).The new set of UT measurements for the former sand bed region will be analyzed using the same methodology used to analyze the 1992, 1994, and 1996 UT data. The results will then be compared to the 1992, 1994,1996 UT results to confirm the previous no corrosion trend. Because of surface roughness of the exterior of the drywell shell, experience has shown that UT measurements can vary significantly unless the UT instrument is positioned on the exact point as the previous measurements. Thus acceptance criteria will be based on the standard deviation of the previous data (+/-11 mils) and instrument accuracy of (+/-10 mils) for a total of 21 mils. Deviation from this value will be considered unexpected and requires corrective actions described in item (2) below.

(2). If additional corrosion is identified that exceeds acceptance criteria described above, Oyster Creek will initiate corrective actions that include one or all of the following, depending on the extent of identified corrosion.

a. Perform additional UT measurements to confirm the readings
b. Notify NRC within 48 hours of confirmation of the identified condition
c. Conduct inspection of the coatings in the sand bed region in areas where the additional corrosion was detected.
d. Perform engineering evaluation to assess the extent of the condition and to determine if additional inspections are required to assure drywell integrity.
e. Perform operability determination and justification for continued operation until next scheduled

2

NRC Information Request Form

inspection.

These actions will be completed before restarting from an outage

LRCR #: 293 ***LRA A.5 Commitment #:***

IR#:

<u>Approvals:</u>

Prepared By: Ouaou, Ahmed 4/ 1/2006

Reviewed By: Muggleston, Kevin 4/ 3/2006

Approved By: Warfel, Don 4/ 3/2006

NRC Acceptance (Date):

NRC Information Request Form

Item No
AMP-356

Date Received: 2/16/2006

Source
AMP Audit

Topic:
IWE

Status: Open

Document References:

NRC Representative Morante, Rich

AmerGen (Took Issue):

Question

IWE AMP
Question 4 IWE AMP Revised Feb. 17, 2006 R. Morante (AMP-356)

(1) Identify the specific locations around the circumference in the former sandbed region where UT thickness readings have been and will be taken from inside containment. Confirm that all points previously recorded will be included in future inspections.

(2) Describe the grid pattern at each location (meridional length, circumferential length, grid point spacing, total number of point readings), and graphically locate each grid pattern within the former sandbed region.

(3) For each grid location, submit a graph of remaining thickness versus time, using the UT readings since the initiation of the program (both prior to and following removal of the sand and application of the external coating).

(4) Clearly describe the methodology and acceptance criteria that is applied to each grid of point thickness readings, including both global (entire array) evaluation and local (subregion of array) evaluation.

Assigned To: Ouaou, Ahmed

Response:

Response:
1. The circumference of the drywell is divided into 10 bays, designated as Bays 1, 3, 5, 7, 9, 11,13, 15, 17, and 19. UT thickness readings have been taken in each bay at one or more locations. The specific locations around the circumference in the former sand bed region where UT thickness reading have been taken from inside containment are Bay 1D, 3D, 5D, 7D, 9A, 9D, 11A, 11C, 13A, 13C, 13D, 15A, 15D, 17A, 17D, 17/19 Frame, 19A, 19B, and 19C. For each location, UT measurements were taken centered at elevation 11'-3". These represent the locations where UT measurements were taken in 1992, 1994, and 1996.

4

NRC Information Request Form

In addition UT measurements were taken one time inside 2 trenches excavated in drywell floor concrete. The purpose of these UT measurements is to determine the extent of corrosion in the lower portions of the sand bed region prior to removing the sand and making accessible for visual inspection.

Future UT thickness measurements will be taken at the same locations as those inspected in 1996 in accordance with Oyster Creek commitment documented in NRC Question #AMP-209.

2. For locations where the initial investigations found significant wall thinning (9D, 11A, 11C, 13A, 13D, 15D, 17A, 17D, 17/19 Frame, 19A, 19B, and 19C) the grid pattern consists of 7 x 7 grid centered at elevation 11'-3 (meridian) and centered at the centerline of the tested location within each bay, which consists of 6"x 6" square template. The grid spacing is 1" on center. There are 49 point readings. For graphical location of the grid, refer to attachment 1.

For locations where the initial investigations found no significant wall thinning (1D, 3D, 5D, 7D, 9A, 13C, and 15A) the grid pattern consists of 1 x 7 grid centered at elevation 11'-3" (meridian) on 1" centers. There are 7 point readings. For graphical location of the grid, refer to attachment 1.

3. A graph representing the remaining thickness versus time using UT reading since the initiation of the program (both prior to and following removal of the sand and application of the external coating) for location 9D, 11A, 11C, 13A, 13D,15D,17A,17D,17/19, 19A, 19B, and 19C is included in the attached graph. Other locations (i.e. 1D, 3D, 5D, 7D, 9A, 13C, and 15A) are not included because wall thinning is not significant and the trend line will be essentially a straight line.

4. The methodology and acceptance criteria that is applied to each grid of point thickness readings, including both global (entire array) evaluation and local (subregion of array) is described in engineering specification IS-328227-004 and in calculation No. C-1302-187-5300-011. These documents were submitted to the NRC in a letter dated November 26, 1990 and provided to the Staff during the AMP/AMR audit. A brief summary of the methodology and acceptance criteria is described below.

The initial locations where corrosion loss was most severe in 1986 and 1987 were selected for repeat inspection over time to measure corrosion rate. For location where the initial investigations found significant wall thinning UT inspection consists of 49 individual UT data points equally spaced over a 6"x 6" area. Each new set of 49 values was then tested for normal distribution.

The mean values of each grid were then compared to the required minimum uniform thickness criteria of 0.736. In addition each individual reading is compared to the local minimum required criteria of 0.49. The basis for the required minimum uniform thickness criteria and the local minimum required criteria is provided in response to NRC Question #AMP-210.

A decrease in the mean value over time is representative of corrosion. If corrosion does not exist, the mean value will not vary with time except for random variations in the UT measurements.

5

NRC Information Request Form

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

A similar process is applied to the thinnest individual reading in each grid. The curve fit of the data is tested to determine if linear regression is appropriate. If a slope exists, then the lower 95% confidence interval is then projected into the future and compared to the required minimum local thickness criteria of .49.

LRCR #: *LRA A.5 Commitment #:*

IR#:

Approvals:

Prepared By: Ouaou, Ahmed 4/ 4/2006

Reviewed By: Getz, Stu 4/ 5/2006

Approved By: Warfel, Don 4/ 5/2006

NRC Acceptance (Date):

NRC Information Request Form

Item No		*Date Received:*	*Source*
AMP-210		1/24/2006	AMP Audit
Topic:		*Status:*	Open
IWE			

Document References:
B.1.27

NRC Representative Morante, Rich

AmerGen (Took Issue): Hufnagel, Joh

Question

Pages 25 through 31 of the PBD present a discussion of the OCGS operating experience.

(8a)The following statements related to drywell corrosion in the sand bed region need further explanation and clarification:
As a result of the presence of water in the sand bed region, extensive UT thickness measurements (about 1000) of the drywell shell were taken to determine if degradation was occurring. These measurements corresponded to known water leaks and indicated that wall thinning had occurred in this region.
Please explain the underlined statement. Were water leaks limited to only a portion of the circumference? Was wall thinning found only in these areas?
After sand removal, the concrete surface below the sand was found to be unfinished with improper provisions for water drainage. Corrective actions taken in this region during 1992 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. UT measurements taken from the outside after cleaning verified loss of material projections that had been made based on measurements taken from the inside of the drywell. There were, however, some areas thinner than projected; but in all cases engineering analysis determined that the drywell shell thickness satisfied ASME code requirements.
Please describe the concrete surface below the sand that is discussed in paragraph above.
Please provide the following information:
(1) Identify the minimum recorded thickness in the sand bed region from the outside inspection, and the minimum recorded thickness in the sand bed region from the inside inspections. Is this consistent with previous information provided verbally? (.806 minimum)
(2) What was the projected thickness based on measurements taken from the inside?
(3) Describe the engineering analysis that determined satisfaction of ASME code requirements and identify the minimum required thickness value. Is this consistent with previous information provided verbally? (.733 minimum)
(4) Is the minimum required thickness based on stress or buckling criteria?
(5) Reconcile and compare the thickness measurements provided in (1) and (3) above with the .736 minimum corroded thickness that was used in the NUREG-1540 analysis of the degraded Oyster

Creek sand bed region.

Evaluation of UT measurements taken from inside the drywell, in the in the former sand bed region, in 1992, 1994, and 1996 confirmed that corrosion is mitigated. It is therefore concluded that corrosion in the sand bed region has been arrested and no further loss of material is expected. Monitoring of the coating in accordance with the Protective Coating Monitoring and Maintenance Program, will continue to ensure that the containment drywell shell maintains its intended function during the period of extended operation.
NUREG-1540, published in April 1996, includes the following statements related to corrosion of the Oyster Creek sand bed region: (page vii) However, to assure that these measures are effective, the licensee is required to perform periodic UT measurements. and (page 2) As assurance that the corrosion rate is slower than the rate obtained from previous measurements, GPU is committed to make UT measurements periodically. Please reconcile the aging management commitment (one-time UT inspection and monitoring of the condition of the coating) with the apparent requirement/commitment documented in NUREG-1540.

(8b)The following statement related to drywell corrosion above the sand bed region needs further explanation and clarification:

Corrective action for these regions involved providing a corrosion allowance by demonstrating, through analysis, that the original drywell design pressure was conservative. Amendment 165 to the Oyster Creek Technical Specifications reduced the drywell design pressure from 62 psig to 44 psig. The new design pressure coupled with measures to prevent water intrusion into the gap between the drywell shell and the concrete will allow the upper portion of the drywell to meet ASME code requirements.

Please describe the measures to prevent water intrusion into the gap between the drywell shell and the concrete that will allow the upper portion of the drywell to meet ASME code requirements". Are these measures to prevent water intrusion credited for LR? If not, how will ASME code requirements be met during the extended period of operation?

(8c)The following statements related to torus degradation need further explanation and clarification: Inspection performed in 2002 found the coating to be in good condition in the vapor area of the Torus and vent header, and in fair condition in immersion. Coating deficiencies in immersion include blistering, random and mechanical damage. Blistering occurs primarily in the shell invert but was also noted on the upper shell near the water line. The fractured blisters were repaired to reestablish the protective coating barrier. This is another example of objective evidence that the Oyster Creek ASME Section XI, Subsection IWE aging management program can identify degradation and implement corrective actions to prevent the loss of the containment's intended function.
While blistering is considered a deficiency, it is significant only when it is fractured and exposes the base metal to corrosion attack. The majority of the blisters remain intact and continues to protect the base metal; consequently the corrosion rates are low. Qualitative assessment of the identified pits indicate that the measured pit depths (50 mils max) are significantly less than the criteria established

NRC Information Request Form

in Specification SP-1302-52-120 (141- 261 mils, depending on diameter of the pit and spacing between pits).

Please confirm or clarify (1) that only the fractured blisters found in this inspection were repaired; (2) pits were identified where the blisters were fractured; (3) pit depths were measured and found to 50 mils max; (4) the inspection Specification SP-1302-52-120 includes pit-depth acceptance criteria for rapid evaluation of observed pitting; (5) the minimum pit depth of concern is 141 mils (.141) and pits as deep as 261 mils (.261) may be acceptable.

Please also provide the following information: nominal design, as-built, and minimum measured thickness of the torus; minimum thickness required to meet ASME code acceptance criteria; the technical basis for the pitting acceptance criteria include in Specification SP-1302-52-120

Assigned To: Ouaou, Ahmed

Response:

(8a) Question: Please explain the underlined statement. Were water leaks limited to only a portion of the circumference? Was wall thinning only in these area?

Response:
This statement was not meant to indicate that water leaks were limited to only a portion of the circumference. The statement is meant to reflect the fact that water leakage was observed coming out of certain sand bed region drains and those locations were suspect of wall thinning.
No. Wall thinning was not limited to the areas where water leakage from the drains was observed. Wall thinning occurred in all areas of the sand bed region based on UT measurements and visual inspection of the area conducted after the sand was removed in 1992. However the degree of wall thinning varied from location to location. For example 60% of the measured locations in the sand bed region (bays 1, 3, 5, 7, 9, and 15) indicate that the average measured drywell shell thickness is nearly the same as the design nominal thickness and that these locations experienced negligible wall thinning; whereas bay 19A experienced approximately 30% reduction in wall thickness.

Question: Please discuss the concrete surface below the sand that is discussed in paragraph above.

Response:
The concrete surface below the sand was intended to be shaped to promote flow toward each of the five sand bed drains. However once the sand was removed it was discovered that the floor was not properly finished and shaped as required to permit proper drainage. There were low points, craters, and rough surfaces that could allow moisture to pool instead of flowing smoothly toward the drains. These concrete surfaces were refurbished to fill low areas, smooth rough surfaces, and coat these surfaces with epoxy coating to promote improved drainage. The drywell shell at juncture of the concrete floor was sealed with an elastomer to prevent water intrusion into the embedded drywell shell.

Question: Please provide the following information:

NRC Information Request Form

(1) Identify the minimum recorded thickness in the sand bed region from the outside inspection, and the minimum recorded thickness in the sand bed region from the inside inspections. Is this consistent with previous information provided verbally? (.806 minimum)
(2) What was the projected thickness based on measurements taken from the inside?
(3) Describe the engineering analysis that determined satisfaction of ASME code requirements and identify the minimum required thickness value. Is this consistent with previous information provided verbally? (.733 minimum)
(4) Is the minimum required thickness based on stress or buckling criteria?
(5) Reconcile and compare the thickness measurements provided in (1) and (3) above with the .736 minimum corroded thickness that was used in the NUREG-1540 analysis of the degraded Oyster Creek sand bed region.

Response:
1. The minimum recorded thickness in the sand bed region from outside inspection is 0.618 inches. The minimum recorded thickness in the sand bed region from inside inspections is 0.603. These minimum recorded thicknesses are isolated local measurement and represent a single point UT measurement. The 0.806 inches thickness provided to the Staff verbally is an average minimum general thickness calculated based on 49 UT measurements taken in an area that is approximately 6"x 6". Thus the two local isolated minimum recorded thicknesses cannot be compared directly to the general thickness of 0.806".

The 0.806" minimum average thickness verbally discussed with the Staff during the AMP audit was recorded in location 19A in 1994. Additional reviews after the audit noted that lower minimum average thickness values were recorded at the same location in 1991 (0.803") and in September 1992 (0.800"). However, the three values are within the tolerance of +/- 0.010" discussed with the Staff.

2. The minimum projected thickness depends on whether the trended data is before or after 1992 as demonstrated by corrosion trends provided in response to NRC Question #AMP-356. For license renewal, using corrosion rate trends after 1992 is appropriate because of corrosion mitigating measures such as removal of the sand and coating of the shell. Then, using corrosion rate trends based on 1992, 1994, and 1996 UT data; and the minimum average thickness measured in 1992 (0.800"), the minimum projected average thickness through 2009 and beyond remains approximately 0.800 inches. The projected minimum thickness during and through the period of extended operation will be reevaluated after UT inspections that will be conducted prior to entering the period of extended operation, and after the periodic UT inspection every 10 years thereafter.

3.The engineering analysis that demonstrated compliance to ASME code requirements was performed in two parts, Stress and Stability Analysis with Sand, and Stress and Stability Analyses without Sand. The analyses are documented in GE Reports Index No. 9-1, 9-2, 9-3, and 9-4, were transmitted to the NRC Staff in December 1990 and in 1991 respectively. Index No. 9-3 and 9-4, were revised later to correct errors identified during an internal audit and were resubmitted to the Staff in January 1992 (see attachment 1 & 2). The analyses are briefly described below.

The drywell shell thickness in the sand bed region is based on Stability Analysis without Sand. As

described in detail in attachment 1 & 2, the analysis is based on a 36-degree section model that takes advantage of symmetry of the drywell with 10 vents. The model includes the drywell shell from the base of the sand bed region to the top of elliptical head and the vent and vent header. The torus is not included in this model because the bellows provide a very flexible connection, which does not allow significant structural interaction between the drywell and the torus. The analysis conservatively assumed that the shell thickness in the entire sand bed region has been reduced uniformly to a thickness of 0.736 inches.

As discussed with the Staff during the AMP audit, the basic approach used in the buckling evaluation follows the methodology outlined in ASME Code Case N-284 revision 0 that was reconciled later with revision 1 of the Code Case. Following the procedure of this Code Case, the allowable compressive stress is evaluated in three steps. In the first step, a theoretical buckling stress is determined, and secondly modified using appropriate capacity and plasticity reduction factors. In the final step, the allowable compressive stress is obtained by dividing the buckling stress calculated in the second step by a safety factor of 2.0 for Design and Level A & B service conditions and 1.67 Level C service conditions.

Using the approach described above, the analysis shows that for the most severe design basis load combinations, the limits of ASME Section III, Subsection NE 3213.10 are fully met. For additional details refer to Attachment 1 & 2.

As described above, the buckling analysis was performed assuming a uniform general thickness of the sand bed region of 0.736 inches. However the UT measurements identified isolated, localized areas where the drywell shell thickness is less than 0.736 inches. Acceptance for these areas was based on engineering calculation C-1302-187-5320-024.

The calculation uses a Local Wall Acceptance Criteria". This criterion can be applied to small areas (less than 12" by 12"), which are less than 0.736" thick so long as the small 12" by 12" area is at least 0.536" thick. However the calculation does not provide additional criteria as to the acceptable distance between multiple small areas. For example, the minimum required linear distances between a 12" by 12" area thinner than 0.736" but thicker than 0.536" and another 12" by 12" area thinner than 0.736" but thicker than 0.536" were not provided.

The actual data for two bays (13 and 1) shows that there are more than one 12" by 12" areas thinner than 0.736" but thicker than 0.536". Also the actual data for two bays shows that there are more than one 2 ½'" diameter areas thinner than 0.736" but thicker than 0.490". Acceptance is based on the following evaluation.

The effect of these very local wall thickness areas on the buckling of the shell requires some discussion of the buckling mechanism in a shell of revolution under an applied axial and lateral pressure load.

To begin the discussion we will describe the buckling of a simply supported cylindrical shell under the influence of lateral pressure and axial load. As described in chapter 11 of the Theory of Elastic Stability, Second Edition, by Timoshenko and Gere, thin cylindrical shells buckle in lobes in both the

axial and circumferential directions. These lobes are defined as half wave lengths of sinusoidal functions. The functions are governed by the radius, thickness and length of the cylinder. If we look at a specific thin walled cylindrical shell both the length and radius would be essentially constants and if the thickness was changed locally the change would have to be significant and continuous over a majority of the lobe so that the compressive stress in the lobe would exceed the critical buckling stress under the applied loads, thereby causing the shell to buckle locally. This approach can be easily extrapolated to any shell of revolution that would experience both an axial load and lateral pressure as in the case of the drywell. This local lobe buckling is demonstrated in The GE Letter Report "Sandbed Local Thinning and Raising the Fixity Height Analysis" where a 12 x 12 square inch section of the drywell sand bed region is reduced by 200 mils and a local buckle occurred in the finite element eigenvalue extraction analysis of the drywell. Therefore, to influence the buckling of a shell the very local areas of reduced thickness would have to be contiguous and of the same thickness. This is also consistent with Code Case 284 in Section –1700 which indicates that the average stress values in the shell should be used for calculating the buckling stress. Therefore, an acceptable distance between areas of reduced thickness is not required for an acceptable buckling analysis except that the area of reduced thickness is small enough not to influence a buckling lobe of the shell. The very local areas of thickness are dispersed over a wide area with varying thickness and as such will have a negligible effect on the buckling response of the drywell. In addition, these very local wall areas are centered about the vents, which significantly stiffen the shell. This stiffening effect limits the shell buckling to a point in the shell sand bed region which is located at the midpoint between two vents.

The acceptance criteria for the thickness of 0.49 inches confined to an area less than 2½ inches in diameter experiencing primary membrane + bending stresses is based on ASME B&PV Code, Section III, Subsection NE, Class MC Components, Paragraphs NE-3213.2 Gross Structural Discontinuity, NE-3213.10 Local Primary Membrane Stress, NE-3332.1 Openings not Requiring Reinforcement, NE-3332.2 Required Area of Reinforcement and NE-3335.1 Reinforcement of Multiple Openings. The use of Paragraph NE-3332.1 is limited by the requirements of Paragraphs NE-3213.2 and NE-3213.10. In particular NE-3213.10 limits the meridional distance between openings without reinforcement to 2.5 x (square root of Rt). Also Paragraph NE-3335.1 only applies to openings in shells that are closer than two times their average diameter.

The implications of these paragraphs are that shell failures at these locations from primary stresses produced by pressure cannot occur provided openings in shells have sufficient reinforcement. The current design pressure of 44 psig for drywell requires a thickness of 0.479 inches in the sand bed region of the drywell. A review of all the UT data presented in Appendix D of the calculation indicates that all thicknesses in the drywell sand bed region exceed the required pressure thickness by a substantial margin. Therefore, the requirements for pressure reinforcement specified in the previous paragraph are not required for the very local wall thickness evaluation presented in Revision 0 of Calculation C-1302-187-5320-024.

Reviewing the stability analyses provided in both the GE Report 9-4 and the GE Letter Report Sand bed Local Thinning and Raising the Fixity Height Analysis and recognizing that the plate elements in the sand bed region of the model are 3" x 3" it is clear that the circumferential buckling lobes for the

NRC Information Request Form

drywell are substantially larger than the 2 ½ inch diameter very local wall areas. This combined with the local reinforcement surrounding these local areas indicates that these areas will have no impact on the buckling margins in the shell. It is also clear from the GE Letter Report that a uniform reduction in thickness of 27% to 0.536" over a one square foot area would only create a 9.5% reduction in the load factor and theoretical buckling stress for the whole drywell resulting in the largest reduction possible. In addition, to the reported result for the 27% reduction in wall thickness, a second buckling analysis was performed for a wall thickness reduction of 13.5% over a one square foot area which only reduced the load factor and theoretical buckling stress by 3.5% for the whole drywell resulting in the largest reduction possible. To bring these results into perspective a review of the NDE reports indicate there are 20 UT measured areas in the whole sand bed region that have thicknesses less than the 0.736 inch thickness used in GE Report 9-4 which cover a conservative total area of 0.68 square feet of the drywell surface with an average thickness of 0.703" or a 4.5% reduction in wall thickness. Therefore, to effectively change the buckling margins on the drywell shell in the sand bed region a reduced thickness would have to cover approximately one square foot of shell area at a location in the shell that is most susceptible to buckling with a reduction in thickness greater than 25%. This leads to the conclusion that the buckling of the shell is unaffected by the distance between the very local wall thicknesses, in fact these local areas could be contiguous provided their total area did not exceed one square foot and their average thickness was greater than the thickness analyzed in the GE Letter Report and provided the methodology of Code Case N284 was employed to determine the allowable buckling load for the drywell. Furthermore, all of these very local wall areas are centered about the vents, which significantly stiffen the shell. This stiffing effect limits the shell buckling to a point in the shell sand bed region, which is located at the midpoint between two vents.

The minimum thickness of 0.733" is not correct. The correct minimum thickness is 0.736".

4. The minimum required thickness for the sand bed region is controlled by buckling.

5. We cannot reconcile the difference between the current (lowest measured) of 0.736" in NUREG-1540 and the minimum measured thickness of 0.806 inches we discussed with the Staff. Perhaps the value in NUREG-1540 should be labeled minimum required by the Code, as documented in several correspondences with the Staff, instead of lowest measured. In a letter dated September 15, 1995, GPU provided the Staff a table that lists sand bed region thicknesses. The table indicates that nominal thickness is 1.154". the minimum measured thickness in 1994 is 0.806", and the minimum thickness required by Code is 0.736". These thicknesses are consistent with those discussed with the Staff during the AMP/AMR audit.

Question: NUREG-1540, published in April 1996, includes the following statements related to corrosion of the Oyster Creek sand bed region: (page vii) However, to assure that these measures are effective, the licensee is required to perform periodic UT measurements. and (page 2) As assurance that the corrosion rate is slower than the rate obtained from previous measurements, GPU is committed to make UT measurements periodically. Please reconcile the aging management commitment (one-time UT inspection and monitoring of the condition of the coating) with the apparent requirement/commitment documented in NUREG-1540.Please reconcile the aging management commitment (one-time UT inspection and monitoring of the condition of the coating) with the apparent requirement/commitment documented in NUREG-1540.

NRC Information Request Form

Response:

Our review of NUREG-1540, page 2 indicates that the statements appear to be based on 1991, or 1993 GPU commitment to perform periodic UT measurements. In fact UT thickness measurements were taken in the sand bed region from inside the drywell in 1992, and 1994. The trend of the UT measurements indicates that corrosion has been arrested. As results GPU informed NRC in a letter dated September 15, 1995 (ref. 2) that UT measurements will be taken one more time, in 1996, and the epoxy coating will be inspected in 1996 and, as a minimum again in 2000. The UT measurements were taken in 1996, per the commitment, and confirmed corrosion rate trend of 1992 and 1994. The results of 1992, 1994, and 1996 UT measurements were provided to the Staff during the AMP/AMR audits.

In response to GPU September 15, 1995 letter, NRC Staff found the proposed changes to sand bed region commitments (i.e. no additional UT measurements after 1996) reasonable and acceptable. This response is documented in November 1, 1995 Safety Evaluation for the Drywell Monitoring Program.

For license renewal, Oyster Creek was previously committed to perform One-Time UT inspection of the drywell shell in the sand bed region prior to entering the period of extended operation. However, in response to NRC Question #AMP-141, Oyster Creek revised the commitment to perform UT inspections periodically. The initial inspection will be conducted prior to entering the period of extended operation and additional inspections will be conducted every 10 years thereafter. The UT measurements will be taken from inside the drywell at same locations as 1996 UT campaign

(8b) Question: Please describe the measures to prevent water intrusion into the gap between the drywell shell and the concrete that will allow the upper portion of the drywell to meet ASME code requirements. Are these measures to prevent water intrusion credited for LR? If not, how will ASME code requirements be met during the extended period of operation?

Response:
The measures taken to prevent water intrusion into the gap between the drywell shell and the concrete that will allow the upper portion of the drywell to maintain the ASME code requirements are,
1. Cleared the former sand bed region drains to improve the drainage path.
2. Replaced reactor cavity steel trough drain gasket, which was found to be leaking.
3. Applied stainless steel type tape and strippable coating to the reactor cavity during refueling outages to seal identified cracks in the stainless steel liner.
4. Confirmed that the reactor cavity concrete trough drains are not clogged
5. Monitored former sand bed region drains and reactor cavity concrete trough drains for leakage during refueling outages and plant operation.

Oyster Creek is committed to implement these measures during the period of extended operation.

(8c) Please confirm or clarify (1) that only the fractured blisters found in this inspection were repaired; (2) pits were identified where the blisters were fractured; (3) pit depths were measured and found to

NRC Information Request Form

50 mils max; (4) the inspection Specification SP-1302-52-120 includes pit-depth acceptance criteria for rapid evaluation of observed pitting; (5) the minimum pit depth of concern is 141 mils (.141) and pits as deep as 261 mils (.261) may be acceptable.

Response:
(1) Specification SP-1302-52-120, Specification for Inspection and Localized Repair of the Torus and Vent System Coating, specifies repair requirements for coating defects exposing substrate and fractured blisters showing signs of corrosion. The repairs referred to in the inspection report included fractured blisters, as well as any mechanically damaged areas, which have exposed bare metal showing signs of corrosion. Therefore, only fractured blisters would be candidates for repair, not those blisters that remain intact. The number and location of repairs are tabulated in the final inspection report prepared by Underwater Construction Corporation.
(2) Coating deficiencies in the immersion region included blistering with minor mechanical damage. Blistering occurred primarily in the shell invert but was also noted on the upper shell near the water line. The majority of the blisters were intact. Intact blisters were examined by removing the blister cap exposing the substrate. Corrosion attack under non-fractured blisters was minimal and was generally limited to surface discoloration. Examination of the substrate revealed slight discoloration and pitting with pit depths less than 0.001. Several blistered areas included pitting corrosion where the blisters were fractured. The substrate beneath fractured blisters generally exhibited a slightly heavier magnetite oxide layer and minor pitting (less than 0.010") of the substrate.

(3) In addition to blistering, random deficiencies that exposed base metal were identified in the torus immersion region coating (e.g., minor mechanical damage) during the 19R (2002) torus coating inspections. They ranged in size from 1/16" to ½" in diameter. Pitting in these areas was qualitatively evaluated and ranged from less than 10 mils to slightly more than 40 mils in a few isolated cases. Three quantitative pit depth measurements were taken in several locations in the immersion area of Bay 1. Pit depths at these sites ranged from 0.008" to 0.042" and were judged to be representative of typical conditions found on the shell.

Prior to 2002 inspection 4 pits greater than 0.040" were identified. The pits depth are 0.058" (1 pit in 1988), 0.05" (2 pits in 1991), and 0.0685" (1 pit in 1992). The pits were evaluated against the local pit depth acceptance criteria and found to be acceptable.

(4) Specification SP-1302-52-120, Specification for Inspection and Localized Repair of the Torus and Vent System Coating, includes the pit-depth acceptance criteria for rapid evaluation of observed pitting. The acceptance criteria are supported by a calculation C-1302-187-E310-038. Locations that do not meet the pit-depth acceptance criteria are characterized based on the size of the area, center to center distance between corroded areas, the maximum pit depth and location in the Torus based on major structural features. These details are sent to Oyster Creek Engineering for evaluation.

(5) The acceptance criteria for pit depth is as follows:
-Isolated Pits of 0.125" in diameter have an allowed maximum depth of 0.261" anywhere in the shell provided the center to center distance between the subject pit and neighboring isolated pits or areas of pitting corrosion is greater than 20.0 inches. This includes old pits or old areas of pitting corrosion that have been filled and/or re-coated.

NRC Information Request Form

-Multiple Pits that can be encompassed by a 2-1/2" diameter circle shall be limited to a maximum pit depth of 0.141" provided the center to center distance between the subject pitted area and neighboring isolated pits or areas of pitting corrosion is greater than 20.0 inches. This includes old pits or old areas of pitting corrosion that have been filled and/or recoated.

Question: Please also provide the following information: nominal design, as-built, and minimum measured thickness of the torus; minimum thickness required to meet ASME code acceptance criteria; the technical basis for the pitting acceptance criteria include in Specification SP-1302-52-120

Response:
Submersed area:
(a) The nominal Design thickness is 0.385 inches
(b) The as-built thickness is 0.385 inches
(c) The minimum uniform measured thickness is,
    0.343 inches - general shell
    0.345 inches - shell - ring girders
    0.345 inches - shell - saddle flange
    0.345 inches - shell - torus straps

(d) The minimum general thickness required to meet ASME Code Acceptance is 0.337 inches.

Technical basis for pitting acceptance criteria included in Specification SP-1302-52-120 is based on engineering calculation C-1302-187-E310-038. At the time of preparation of calculation C-1302-187-E310-038 in 2002 there were no published methods to calculate acceptance standards for locally thinned areas in ASME Section III or Section VIII Pressure Vessel codes. Therefore, the approach in Code Case N-597 was used as guidance in assessing locally thinned areas in the Torus. This is based on the similarity in approaches between Local Thinning Areas described in N597 and Local Primary Stress areas described in Paragraph NE3213.10 of the ASME B&PV Code Section III, particularly small areas of wall thinning which do not exceed 1.0 x (square root of Rt). In addition, the ASME B&PV Code Section III, Subsection NB, Paragraph NB-3630 allows the analysis of pipe systems in accordance with the Vessel Analysis rules described in Paragraph NB-3200 of the same Subsection as an alternate analysis approach. Therefore, the approach used in N597 for local areas of thinning was probably developed using the rules for Local Primary Membrane Stress from paragraph NB-3200 in particular Subparagraph 3213.10. The Local Primary Stress Limits in NB-3213.10 are similar to those discussed in Subsection NE, Paragraph NE-3213.10.

Since the Code Case had not yet been invoked in to the Section XI program, the calculation provided a reconciliation of the results obtained from the code case against the ASME Section III code requirements as discussed above. This reconciliation demonstrated that the approach in N597 used on a pressure vessel such as the Torus would be acceptable since the results are conservative compared to the previous work performed in MPR-953 and Lm(a) (defined in N597 Table- 3622-1) £ (Rmintmin)1/2.

Currently, the maximum pit depth measured in the Torus is a 0.0685" (measured in 1992 in bay 2). It was evaluated as acceptable using the design calculations existing at that time and was not based on

NRC Information Request Form

Calculation C-1302-187-E310-038. This remains the bounding wall thickness in the Torus. The criterion developed in 2002 for local thickness acceptance provides an easier method for evaluating as-found pits. The results were shown to be conservative versus the original ASME Section III and VIII Code requirements for the Torus.

The Torus inspection program is being enhanced per IR 373695 to improve the detail of the acceptance criteria and margin management requirements using the ASME Section III criteria. The approach used in C-1302-187-E310-038 will be clarified as to how it maintains the code requirements. If Code Case N-597-1 is required to develop these criteria for future inspections, NRC review and approval will be obtained. It should also be noted that the program has established corrosion rate criteria and continues to periodically monitor to verify they remain bounded.

Supplemental information - 04/19/2006.
This supplements response to item 8a(1) above.
The lowest recorded reading was 0.603 in December 1992. A review of the previous readings for the period 1990 thru 1992 and two subsequent readings taken in September 1994 and 1996 show this point should not be considered valid. The average reading for this point taken in 1994 and 1996 was 0.888 inches.

Point 14 in location 17D was the next lowest value of 0.646 inches recorded during the 1994 outage. A review of readings, at this same point, taken during the period from 1990 through 1992 and subsequent reading taken in 1996 are conistent with this value. Thus the minimum recorded thickness in the sand bed region from inside inspections is 0.646 inches, instead of 0.603 inches.

For additional information on torus coating refer to AMP-072.

LRCR #: *LRA A.5 Commitment #:*

IR#:

Approvals:

Prepared By: Ouaou, Ahmed 4/20/2006

Reviewed By: Miller, Mark 4/20/2006

Approved By: Warfel, Don 4/20/2006

NRC Acceptance (Date):

Citizen's Exhibit NC3

GPU Nuclear

Calculation Sheet

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	1 of 54
Originator MARK YEKTA	Date 01/12/93	Reviewed by S. C. Tumminelli		Date 04/16/93

1.0 PROBLEM STATEMENT:

The purpose of this calculation is to evaluate the UT thickness measurements taken in the sandbed region during the 14R outage in support of O.C drywell corrosion mitigation project. These measurements were taken from the outside of the shell. Access to the sandbed region was achieved by cutting ten holes completely through the shield wall from the torus room.

2.0 SUMMARY OF RESULTS:

This calculation demonstrates that the UT thickness measurements for all bays meet the minimum uniform and local required thicknesses.

The evaluation was performed by evaluating the UT measurements for each bay and dispositioning them relative to the uniform thickness of 0.736 inch used in GE structural analysis reports. Additional acceptance criteria was developed to address measurements below 0.736 inch. The results are summarized in Table 1.

UT measurements for bays 3, 5, 7, 9, and 19 were all above the 0.736 inches and therefore acceptable.

UT measurements for bays 11, 15, and 17 were all above 0.736 inches except for one measurement for each bay. After further evaluation of these three measurements including an examination of adjacent areas, it was determined that they were acceptable as shown on Table 1.

UT measurements for bays 1 and 13 were evaluated using detailed criteria described in this calculation and the results are summarized in Table 1 below:

2.0 SUMMARY OF RESULTS (Continued):

Summary of UT Evaluations

Table (1)

BAY/UT Location	UT Measurement (1)	AVG Micrometer (2)	Mean Depth/Valley (3)	T (Evaluation) (4)=(1)+(2)-(3)	Remarks
Bay 11/ Loc. 1	0.705"	0.246"	0.200"	0.751"	Acceptable
Bay 15/ Loc. 9	0.722"	0.337"	0.200"	0.859"	Acceptable
Bay 17/ Loc. 9	0.720"	0.351"	0.200"	0.871"	Acceptable
Bay 1/ Loc. 1	0.720"	0.218"	0.200"	0.738"	Acceptable
Bay 1/ Loc. 2	0.716"	0.143"	0.200"	0.659"	Acceptable
Bay 1/ Loc. 3	0.705"	0.347"	0.200"	0.852"	Acceptable
Bay 1/ Loc. 5	0.710"	0.313"	0.200"	0.823"	Acceptable
Bay 1/ Loc. 7	0.700"	0.266"	0.200"	0.766"	Acceptable
Bay 1/ Loc. 11	0.714"	0.212"	0.200"	0.726"	Acceptable
Bay 1/ Loc. 12	0.724"	0.301"	0.200"	0.825"	Acceptable
Bay 1/ Loc. 21	0.726"	0.211"	0.200"	0.737"	Acceptable
Bay 13/ Loc. 1	0.672"	0.351"	0.200"	0.823"	Acceptable
Bay 13/ Loc. 2	0.729"	0.360"	0.200"	0.882"	Acceptable
Bay 13/ Loc. 5	0.718"	0.217"	0.200"	0.735"	Acceptable
Bay 13/ Loc. 6	0.655"	0.301"	0.200"	0.756"	Acceptable
Bay 13/ Loc. 7	0.618"	0.257"	0.200"	0.675"	Acceptable
Bay 13/ Loc. 8	0.718"	0.278"	0.200"	0.796"	Acceptable
Bay 13/ Loc. 10	0.728"	0.211"	0.200"	0.739"	Acceptable
Bay 13/ Loc. 11	0.685"	0.256"	0.200"	0.741"	Acceptable
Bay 13/ Loc. 15	0.683"	0.273"	0.200"	0.756"	Acceptable

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	3 of 54
Originator MARK YEKTA	Date 01/12/93	Reviewed by S. C. Tumminelli		Date 04/16/93

3.0 REFERENCES:

3.1 Drywell sandbed region pictures (see Appendix C).

3.2 An ASME Section VIII Evaluation of the Oyster Creek Drywell for Without Sand Case Performed by GE - Part 1 Stress Analysis, Revision 0 dated February, 1991 Report 9-3.

3.3 An ASME Section VIII Evaluation of the Oyster Creek Drywell for Without Sand Case Performed by GE - Part 2 Stability Analysis, Revision 2 dated November, 1992 Report 9-4.

3.4 ASME Section III Subsection NE Class MC Components 1989.

3.5 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.

3.6 GPUN Memo 5320-93-020 From K. Whitmore to J. C. Flynn "Inspection of Drywell Sand Bed Region and Access Hole", Dated January 28, 1993.

4.0 ASSUMPTIONS AND BASIC DATA:

4.1 Raw UT measurements are summarized for each bay in the body of calculation.

4.2 Observations of the outside surface of the drywell shell indicate a rough surface with varying peaks and valleys. In order to characterize an average roughness representing the depth difference of peaks and valleys, two impressions were made at the two lowest UT measurements for bay 13 using Epoxy putty .
Appendix A presents the calculation of the depth of surface roughness using the drywell shell impressions taken in the roughest bay. Two locations in bay 13 were selected since it is the roughest bay. Approximately 40 locations within the two impressions were measured for depth and the average plus one standard deviation was calculated. A value of 0.200 inch was used in this calculation as a conservative depth of uniform dimples for the entire outside surface of the drywell in the sandbed region .

5.0 CALCULATION:

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. 3.2 & 3.3) as well as other GE studies (Ref. 3.5) plus visual observations of the drywell surface (Ref. 3.6 and Appendix C). The GE reports used an assumed uniform thickness of 0.736 inches in the sandbed area. This area is defined to be from the bottom to top of the sandbed, i.e., El. 8'-11½" to El. 12'-3" 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 measurements are below 0.736 inches, more detailed evaluation is performed.

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 is taken considering 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 (Appendix C). Also, the surface contains some depressions 12 to 18 inches in diameter not closer than 12 inches apart, edge to edge (Ref. 3.6). Appendix A presents the calculation of the depth of surface roughness using the drywell shell impressions taken in the roughest bay. Two locations in bay 13 were selected since it 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 inch was used in this calculation as a conservative depth of uniform dimples for the entire outside surface of the drywell in the sandbed region .

5.0 CALCULATION:

ACCEPTANCE CRITERIA - GENERAL WALL: (Continued)

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 as shown in Appendix A. 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.

5.0 CALCULATION:

ACCEPTANCE CRITERIA - LOCAL WALL:

If the thickness for evaluation is less than 0.736 inches, then the use of specific GE studies is employed (Ref. 3.5). 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 sandbed 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 also used to adjust the actual buckling values appropriately. Details are provided in the body of the calculation.

ACCEPTANCE CRITERIA - VERY LOCAL WALL (2½ Inches In 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:

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

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

UT thickness measurements for all ten bays are above 0.490 inches.

5.0 CALCULATION:

UT EVALUATION:

BAY # 1:

The outside surface of this bay is rough and full of dimples similar to the outside surface of golf ball. This observation is made by the inspector who located the thinnest areas for the UT examination. This 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, located 15 to 20 inches below the vent pipe reinforcement plate, i.e, weld line as shown in Figure 1. (Figure 1 and others like figures presented in this calculation are NOT TO SCALE). The bathtub ring is 12 to 18 inches wide and about 30 inches long located in the center of the bay. Beyond the bathtub ring on both sides, the shell appears to be uniform in thickness at a conservative value of 0.800 inches. Above the bathtub ring the shell exhibits no corrosion since the original lead primer on the vent pipe/reinforcement plate is intact. Measurements 14 and 15 confirm that the thickness above the bathtub ring is at 1.154 inches starting at elevation 11'-00". 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 can be recalculated based on the GE report 9-4 (Ref. 3.3). 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 as shown in Appendix B.

5.0 CALCULATION:

UT EVALUATION:

BAY # 1 (Continued):

Locations 1, 2, 3, 4, 5, 10, 11, 12, 13, 20, and 21 are confined to the bathtub ring as shown in Figure 1. 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-a 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.

5.0 CALCULATION:

UT EVALUATION:

BAY # 1 (Continued):

Eight locations shown in Table 1-a (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-a. 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 1-b. 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 0.108 inches reduction from the conservative estimate of 0.800 inches 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. 3.5).

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 sandbed 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 inches 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 inches area used in the analysis. Therefore, this small 4 x 4 inches 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 an 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.

5.0 CALCULATION:

UT EVALUATION:

BAY # 1 (Continued):

Bay # 1 UT Data

Table 1-a

Location	UT Measurement (inches)	Average 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	---

5.0 CALCULATION:

UT EVALUATION:

BAY # 1:(Continued)

SUMMARY OF Measurements BELOW 0.7

Table 1-b

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

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	12 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli		Date: 04/16/93

BAY #1 DATA

NOTES:

1. All "Location" measurements from intersection of the DW shell and vent collar fillet welds.
2. Pit depts are average of four readings taken at 0/45°/90°/135° within 1" band surrounding ground spots. Only measured where remaining wall thk. was below 0.736".

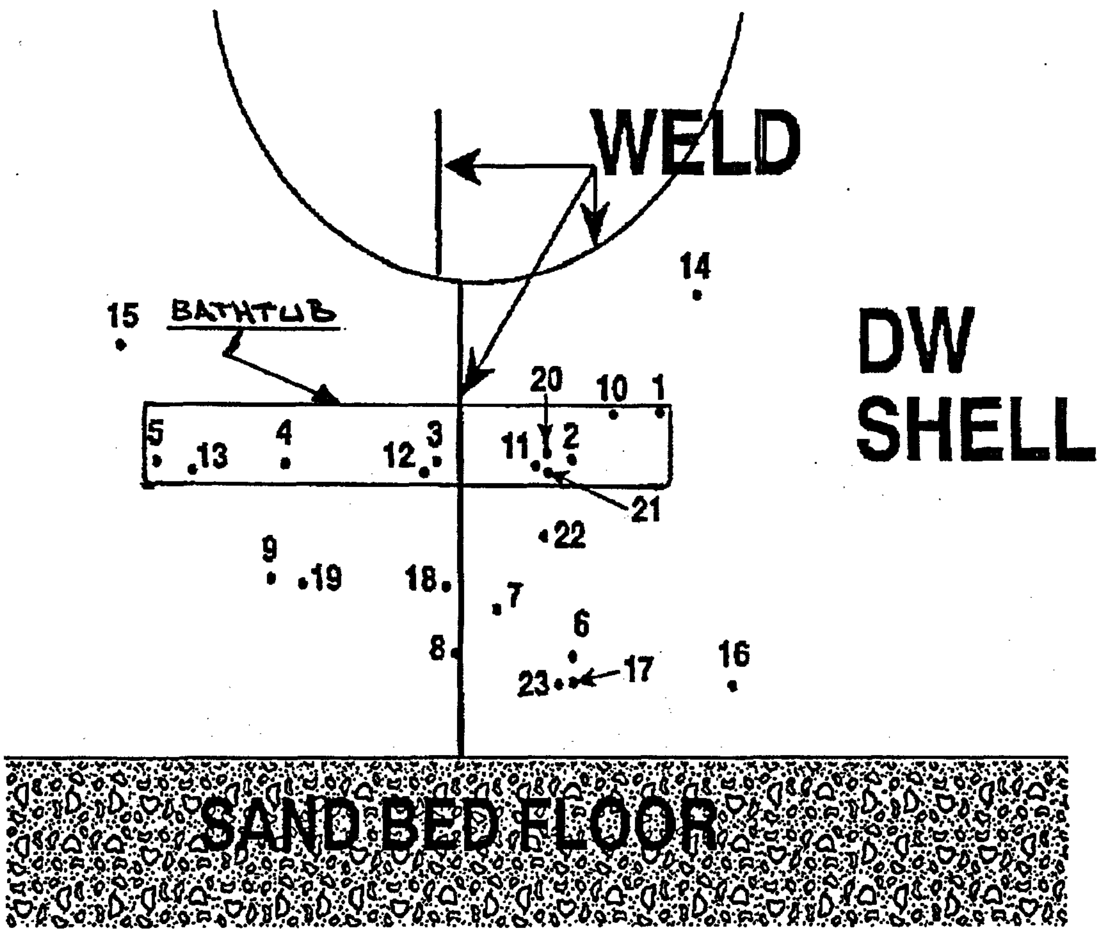


FIGURE (1)

5.0 CALCULATION:

UT EVALUATION:

BAY # 3:

The outside surface of this bay is rough, similar to bay one, full of dimples comparable to the outside surface of golf ball. This observation is made by the inspector who located the thinnest areas for the UT examination. The shell appears to be relatively uniform in thickness except for a bathtub ring 8 to 10 inches wide approximately 6 inches below the vent header reinforcement plate. The upper portion of the shell beyond the band exhibits no corrosion where the original red lead primer is still intact. Eight locations were selected to represent the thinnest areas based on the visual observations of the shell surface (Fig. 3). 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.

Bay # 3 UT Data

Table 3

Location	UT Measurement (inches)	Average 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	---

GPU Nuclear Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed	C-1302-187-5320-024	0	14 of 54

Originator	Date	Reviewed by	Date
MARK YEKTA	01/12/93	S. C. Tumminelli	04/16/93

BAY #3 DATA

NOTES:

1. All "Location" measurements from intersection of the DW shell and vent collar fillet welds.

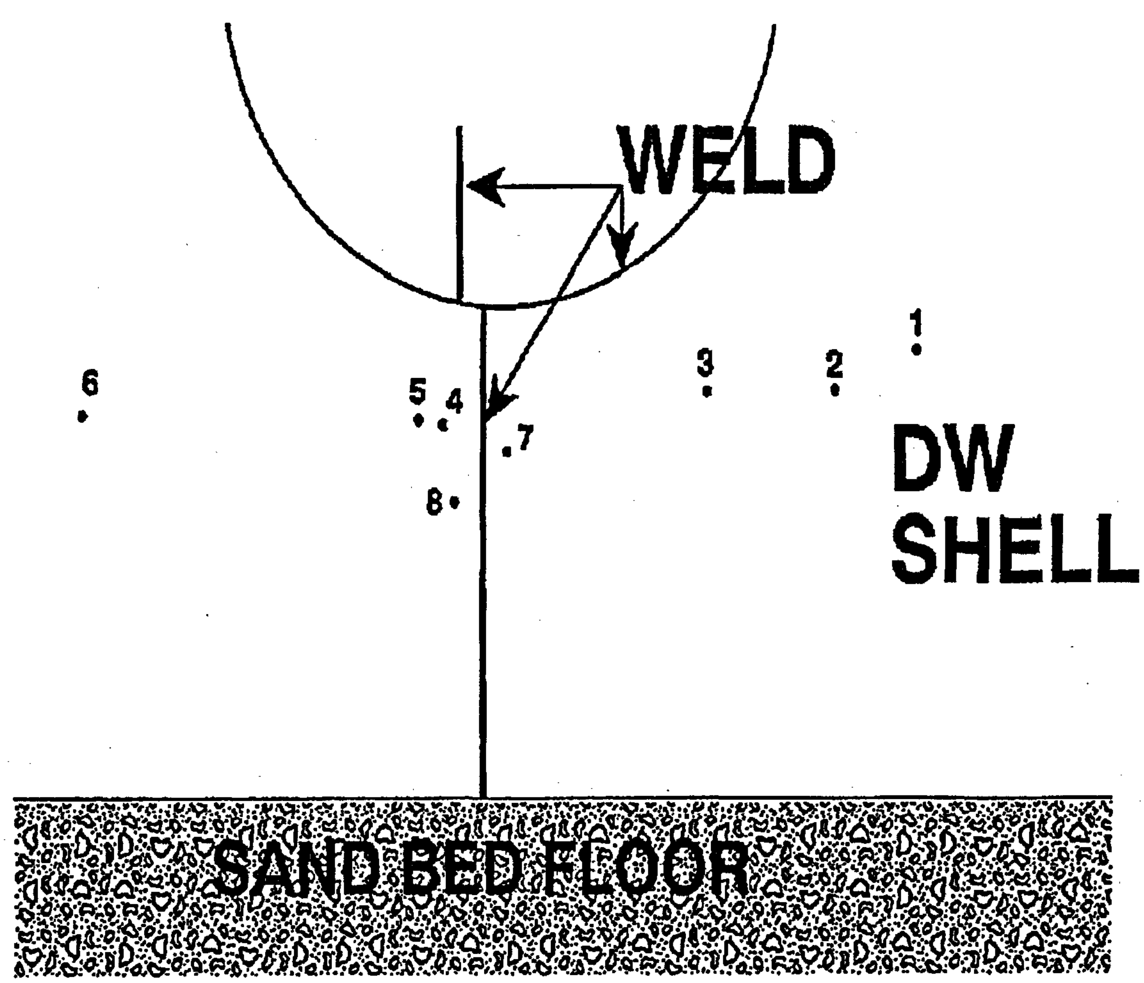


FIGURE (3)

5.0 CALCULATION:

UT EVALUATION:

BAY # 5:

The outside surface of this bay is rough and very similar to bay 3 except that the local areas are clustered at the junction of bays 3 and 5, at about 30 inches above the floor. The shell surface is full of dimples comparable to the outside surface of golf ball. This observation is made by the inspector who located the thinnest areas for the UT examination. The shell appears to be relatively uniform in thickness. Eight locations were selected to represent the thinnest areas based on the visual observations of the shell surface (see Fig. 5). 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 0.950 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

Bay # 5 UT Data

Table 5

Location	UT Measurement (inches)	Average 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	---

BAY #5 DATA

NOTES:

1. In this bay DW shell (butt) weld is about 8" to the right of C/L of vent tube. Therefore - all measurements were taken from a line drawn on shell which approx. coincide with vent tube C/L.

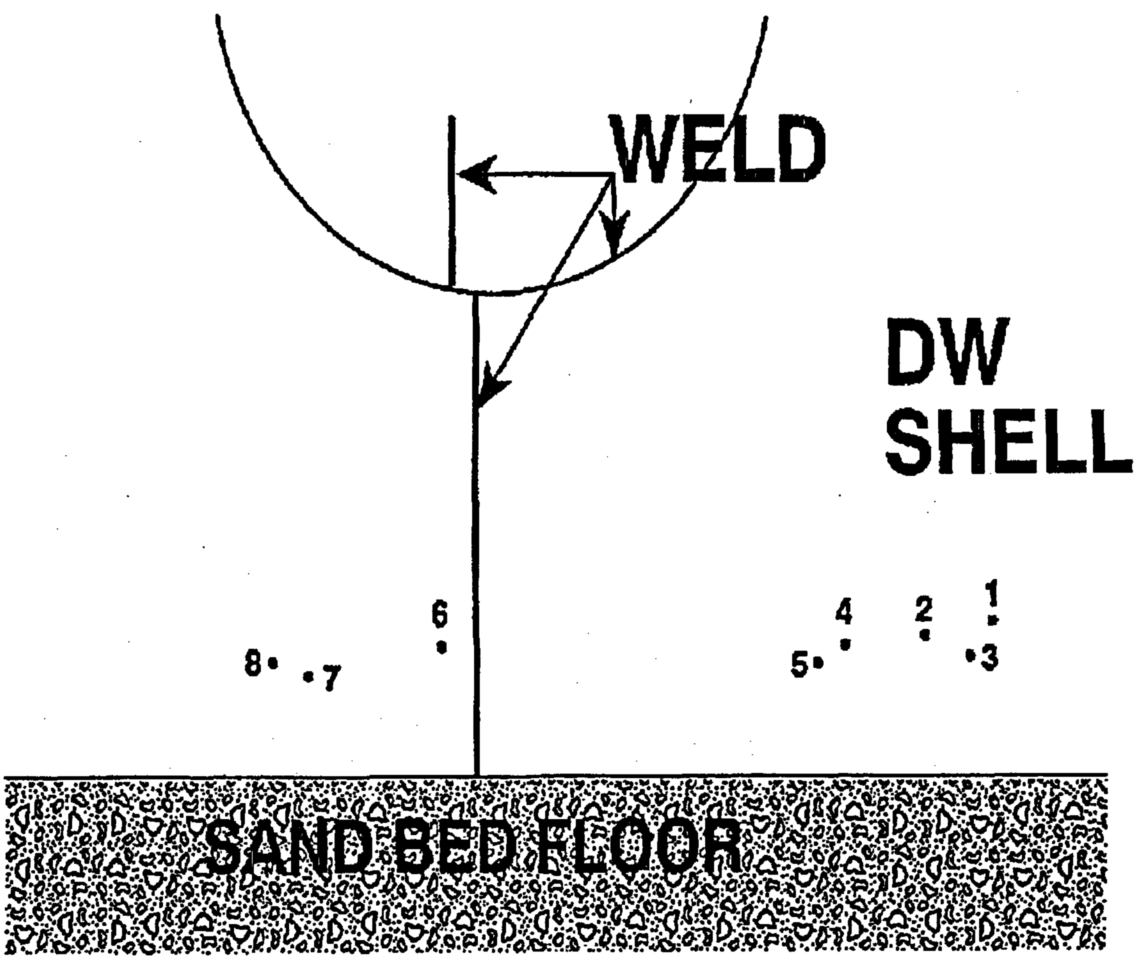


FIGURE (5)

5.0 CALCULATION:

UT EVALUATION:

BAY # 7:

The observation of the drywell surface for this bay showed uniform dimples in the corroded area, but they are shallow compared to those in bay 1. The bathtub ring seen in the other bays, was not very prominent in this bay. This observation is made by the inspector who located the thinnest areas for the UT examination. The shell appears to be relatively uniform in thickness. Seven locations were selected to represent the thinnest areas based on the visual observations of the shell surface (Fig. 7). 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.

Given the UT measurements, a conservative mean evaluation thickness of 1.00 inches is estimated for this bay and therefore, it is concluded that the bay is acceptable.

Bay # 7 UT Data

Table 7

Location	UT Measurement (inches)	Average Micrometer (inches)
1	0.920	---
2	1.016	---
3	0.954	---
4	1.040	---
5	1.030	---
6	1.045	---
7	1.000	---

GPU Nuclear — Calculation Sheet

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	18 of 54
Originator MARK YEKTA	Date 01/12/93	Reviewed by S. C. Tumminelli		Date 04/16/93

BAY #7 DATA

NOTES:

1. All measurements from the Intersection of DW shell (butt) and vent collar (fillet) welds.

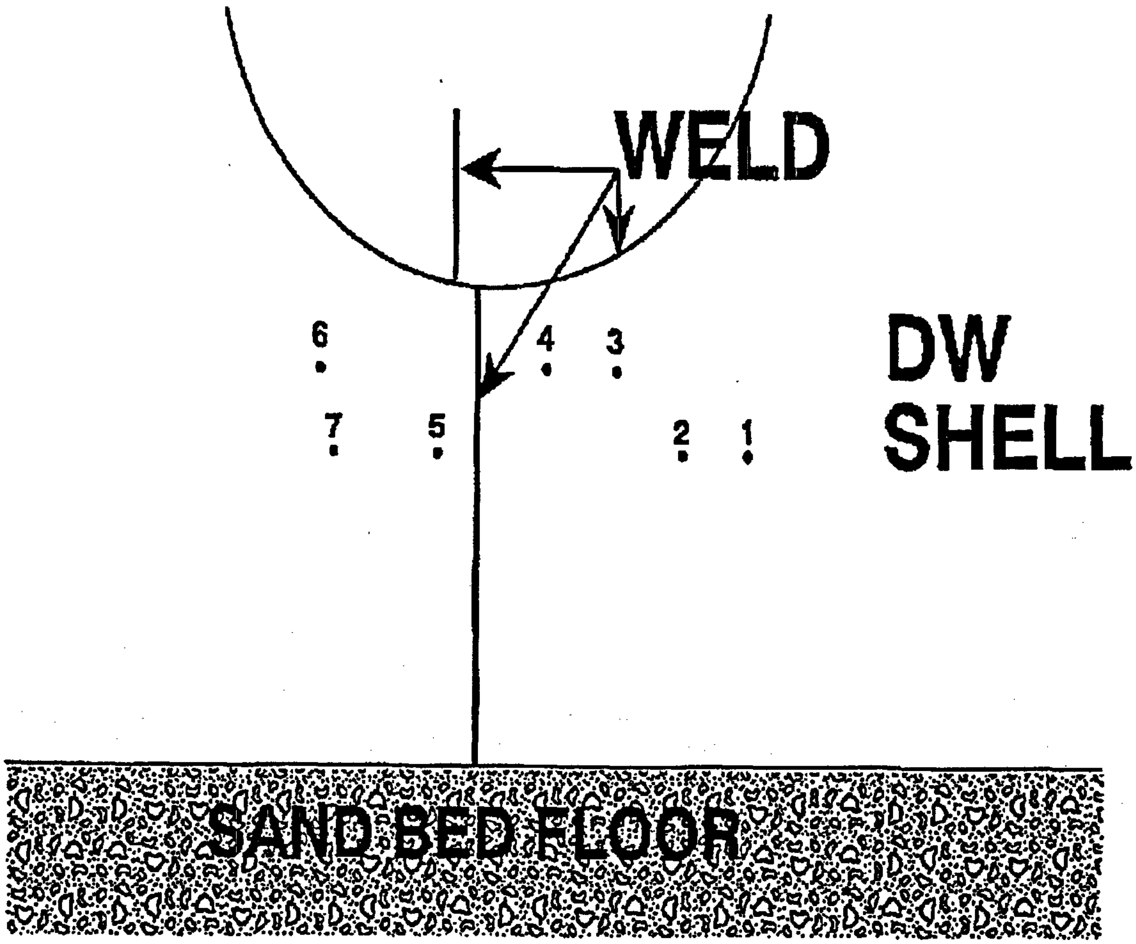


FIGURE (7)

5.0 CALCULATION:

UT EVALUATION:

BAY # 9:

The observation of the drywell shell for this bay was very similar to bay 7 except that the bathtub ring was more evident in this bay. The shell appears to be relatively uniform in thickness except for a bathtub ring 6 to 9 inches wide approximately 6 to 8 inches below the vent header reinforcement plate. The upper portion of the shell beyond the band exhibits no corrosion where the original red lead primer is still intact. Eight locations were selected to represent the thinnest areas based on the visual observations of the shell surface (Fig. 9). These locations are a deliberate attempt to produce a minimum measurement. Table 9 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.

Bay # 9 UT Data

Table 9

Location	UT Measurement (inches)	Average 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	---

GPU Nuclear Calculation Sheet

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	20 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli		Date: 04/16/93

BAY #9 DATA

NOTES:

1. All measurements from intersection of the DW shell (butt) and vent collar (fillet) welds.

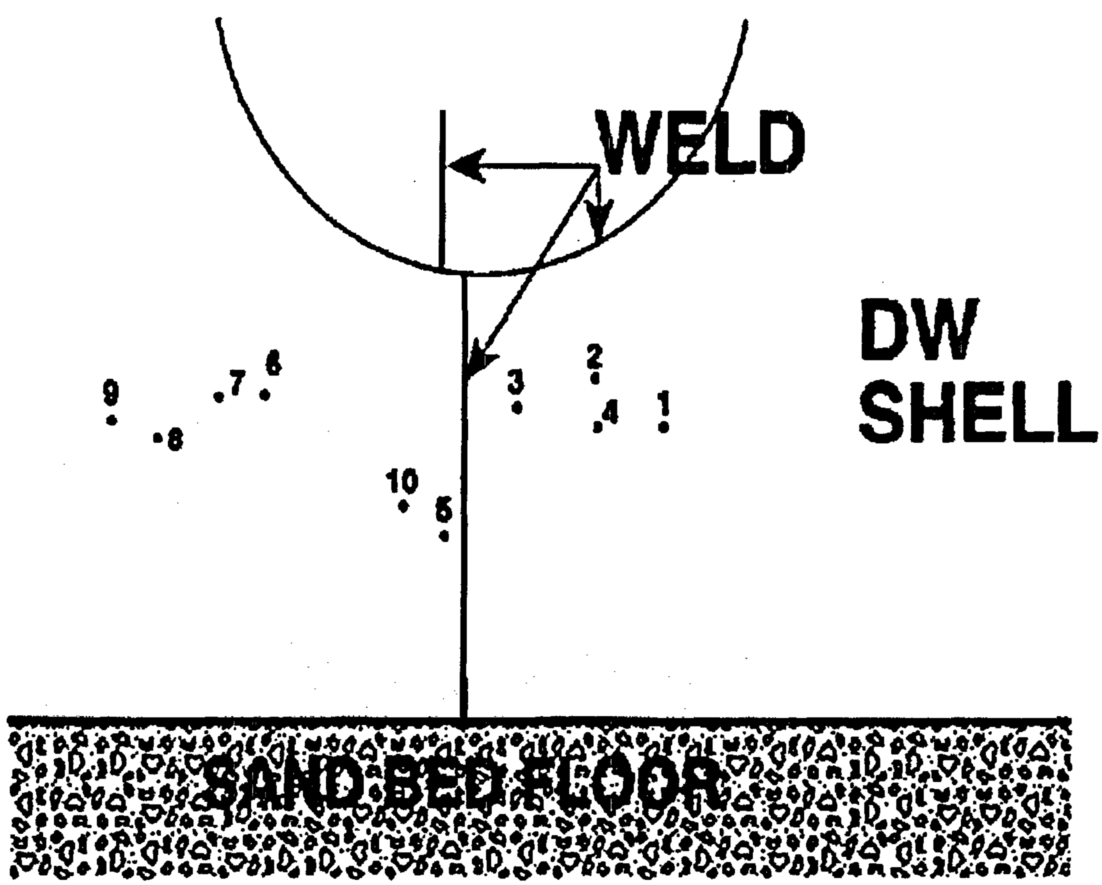


FIGURE (9)

5.0 CALCULATION:

UT EVALUATION:

BAY # 11:

The outside surface of this bay is rough, similar to bay 1, full of uniform dimples comparable to the outside surface of a golf ball. The shell appears to be relatively uniform in thickness except for local areas at the upper right corner of Figure 11, located at about 10 to 12 inches below the vent pipe reinforcement plate.

Eight locations were selected to represent the thinnest areas based on the visual observations of the shell surface (Fig. 11). These locations are a deliberate attempt to produce a minimum measurement. Table 11-a 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 11-a, 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 surroundings was measured at 8 locations around the spot and the average is shown in Table 11-a. 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 11-b.

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.

5.0 CALCULATION:

UT EVALUATION:

BAY # 11 (Continued):

Bay # 11 UT Data

Table 11-a

Location	UT Measurement (inches)	Average 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	---

Summary of Measurements Below 0.736 Inches

Table 11-b

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

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	23 of 54
Originator MARK YEKTA	Date 01/12/93	Reviewed by S. C. Tumminelli		Date 04/16/93

BAY #11 DATA

NOTES:

1. All measurements from intersection of the DW shell (butt) and vent collar (fillet) welds.
2. Pit depths are average of four readings taken at 0/45°/90°/135° within 1" band surrounding the ground spots. This measurement was only taken when wall thickness was below 0.736".

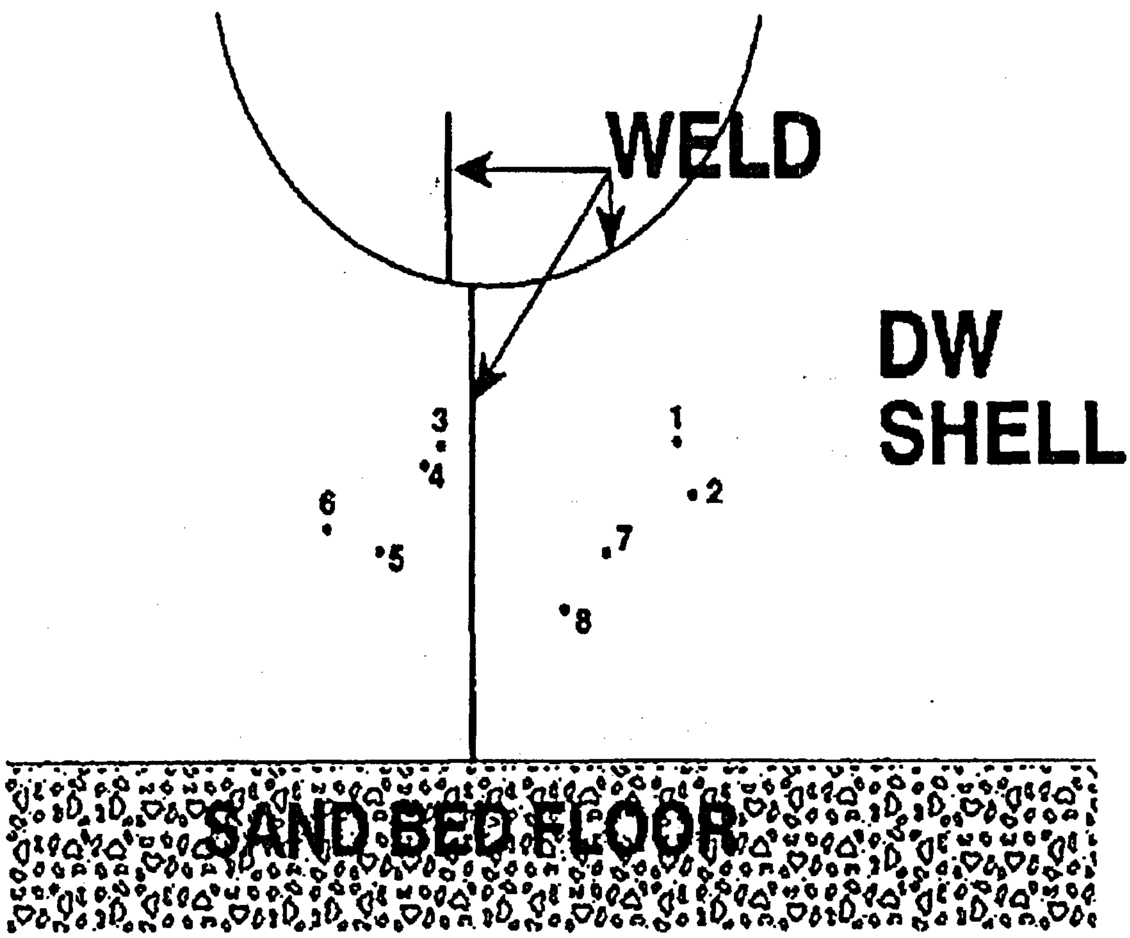


FIGURE (11)

5.0 CALCULATION:

UT EVALUATION:

BAY # 13:

The outside surface of this bay is rough and full of dimples similar to bay 1 as shown in Appendix C. This observation is made by the inspector who located the thinnest areas in deep valleys thereby biasing the remaining wall measurements to the conservative side. This inspection focused on the thinnest areas, even if very local, i.e., the inspection did not attempt to define a shell thickness suitable for 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 sandbed. 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 thickness 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. 3.3). 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 as shown in Appendix B.

5.0 CALCULATION:

UT EVALUATION:

BAY # 13 (Continued):

Locations 5, 6, 7, 8, 10, 11, 14, and 15 are confined to the bathtub ring as shown in Figure 13. 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 Table 13-a. The results indicate that all subsequent measurements were above 0.736 inches. The average micrometer measurements taken for these locations confirm the depth measurements at these locations. In spite of the fact that the original measurements were taken at heavily ground locations they are the ones used in the evaluation.

The individual measurements must also be evaluated for structural compliance. Table 13-a 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.

5.0 CALCULATION:

UT EVALUATION:

BAY # 13 (Continued):

Nine locations shown in Table 13-a (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 13-a. 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 13-b. 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 0.800 inches 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. 3.5).

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 sandbed 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 inches area used in the analysis. Therefore, this small 6 x 6 inch area has a negligible effect on the buckling capacity of the structure.

5.0 CALCULATION:

UT EVALUATION:

BAY # 13 (Continued):

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.

Bay # 13 UT Data

Table 13-a

Location	UT Measurement (inches)	Average 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	---

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	28 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli		Date: 04/16/93

5.0 CALCULATION:

UT EVALUATION:

BAY # 13 (Continued):

Summary of Measurements Below 0.736 Inches

Table 13-b

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

BAY #13 DATA

NOTES:

1. All measurements from intersection of the DW shell (butt) and vent collar (fillet) welds.
2. Spots with suffix (e.g. IA 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.
3. Pit depths are average of four readings taken at 0/45°/90°/135° within 1" distance around ground spot. Taken only where remaining wall showed below 0.736".

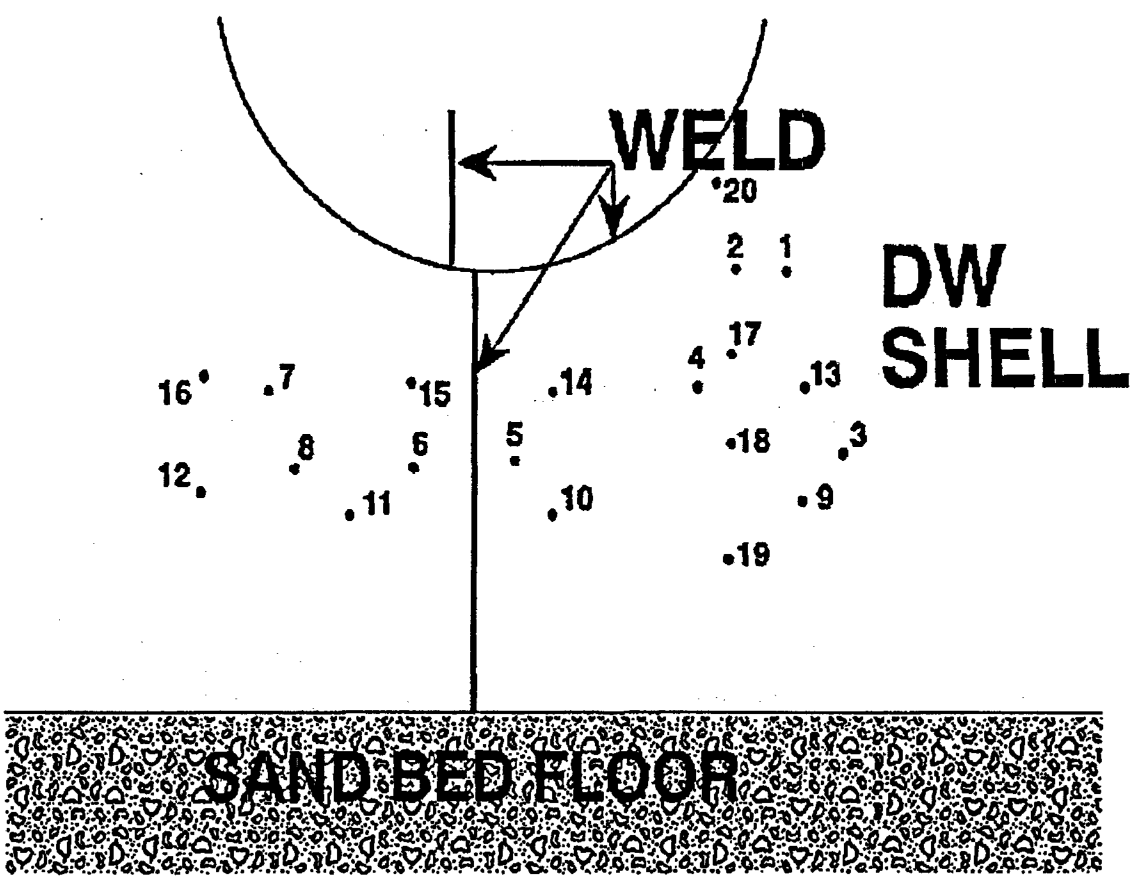


FIGURE (13)

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	30 of 54
Originator MARK YEKTA	Date 01/12/93	Reviewed by S. C. Tumminelli		Date 04/16/93

5.0 CALCULATION:

UT EVALUATION:

BAY # 15:

The outside surface of this bay is rough, similar to bay 1, full of uniform dimples comparable to the outside surface of golf ball (Appendix C). The bathtub ring seen in the other bays, was not very prominent in this bay. This observation is made by the inspector who located the thinnest areas for the UT examination. The upper portion of the shell beyond the ring exhibits no corrosion where the original red lead primer is still intact. The shell appears to be relatively uniform in thickness.

Eleven locations were selected to represent the thinnest areas based on the visual observations of the shell surface (Fig. 15). These locations are a deliberate attempt to produce a minimum measurement. Table 15-a 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 15-a, 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 15-a. 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 15-b.

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.

5.0 CALCULATION:

UT EVALUATION:

BAY # 15:

Bay #15 UT Data

Table 15-a

Location	UT Measurement (inches)	Average 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	---

Summary of Measurements Below 0.736 Inches

Table 15-b

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

GPU Nuclear Calculation Sheet

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	32 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli		Date: 04/16/93

BAY #15 DATA

NOTES:

1. All measurements from intersection of the DW shell and vent collar (fillet) welds.

2. Pit depths are average of four readings taken at 0/45°/90°/135° within 1" distance around ground spots. Taken only when remaining wall thickness shown below 0.736".

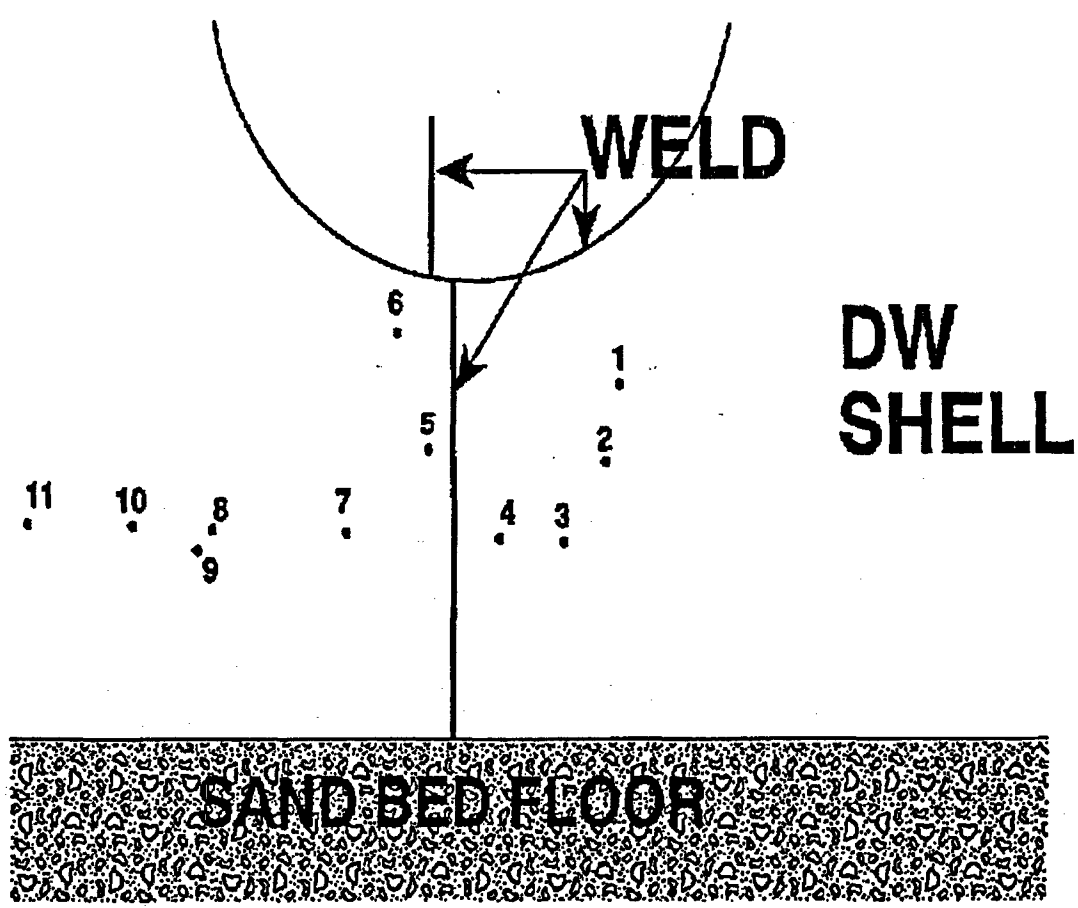


FIGURE (15)

5.0 CALCULATION:

UT EVALUATION:

BAY # 17:

The outside surface of this bay is rough, similar to bay 1, full of uniform dimples comparable to the outside surface of golf ball. The shell appears to be relatively uniform in thickness except for a band 8 to 10 inches wide approximately 6 inches below the vent header reinforcement plate. The upper portion of the shell beyond the band exhibits no corrosion where the original red lead primer is still intact.

Eleven locations were selected to represent the thinnest areas based on the visual observations of the shell surface (Fig. 17). These locations are a deliberate attempt to produce a minimum measurement. Table 17-a 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 17-a, has a reading below 0.736 inches. Observations indicate that this location is very deep and not more than 1 to 2 inches in diameter. The depth of area relative to its immediate surroundings was measured at 8 locations around the spot and the average is shown in Table 17-a. 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 17-b.

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.

5.0 CALCULATION:

UT EVALUATION:

BAY # 17 (Continued):

Bay #17 UT Data

Table 17-a

Location	UT Measurement (inches)	Average 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	---

Summary of Measurements Below 0.736 Inches

Table 17-b

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

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	35 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli		Date: 04/16/93

BAY #17 DATA

NOTES:

1. All measurements from intersection of the DW (butt) shell and vent collar (fillet) welds.

2. Pit depths are average of four readings taken at 0/45°/90°/135° within 1" distance around ground spots. Taken only when remaining wall thickness was below 0.736".

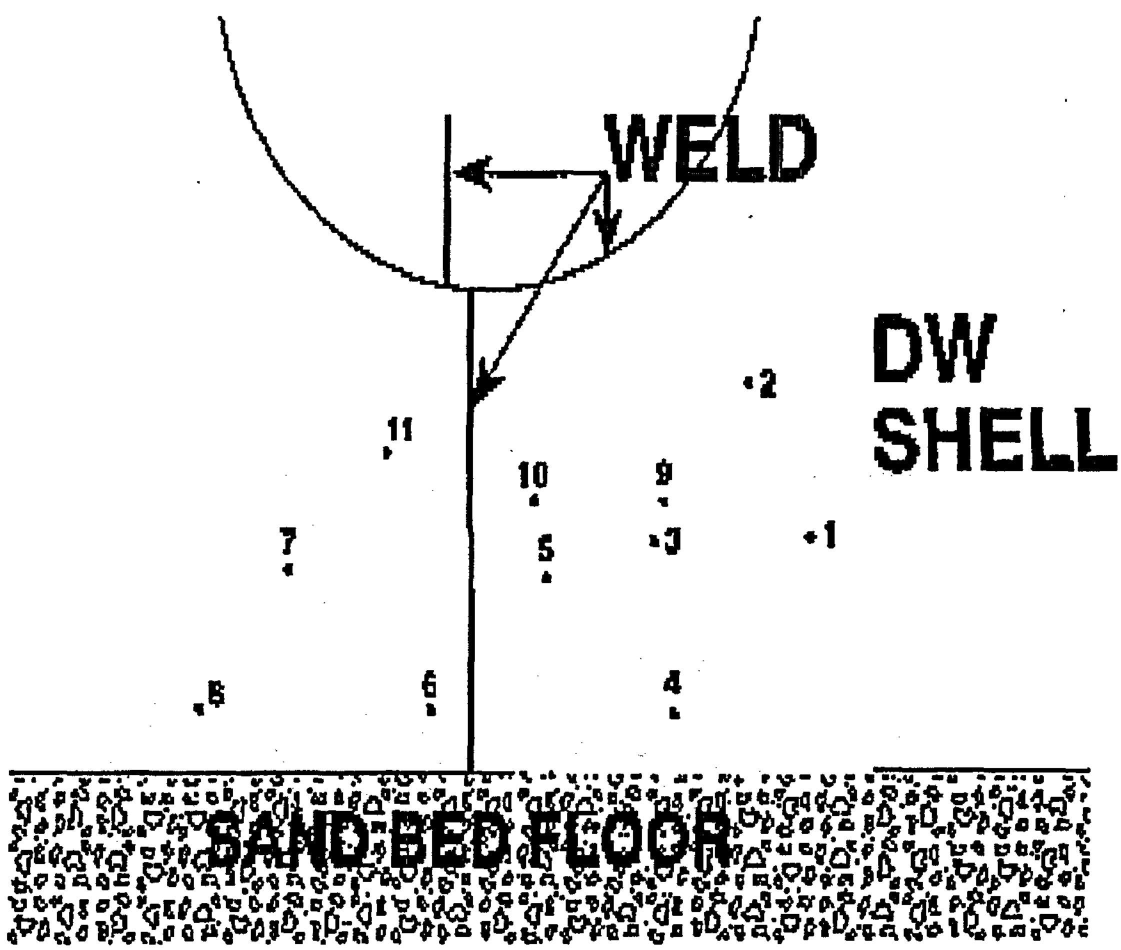


FIGURE (17)

OCLR00000397

5.0 CALCULATION:

UT EVALUATION:

BAY # 19:

The outside surface of this bay is rough and very similar to bay 17. Locations 1 through 7 as shown in Table 19, were ground carefully to minimize loss of good metal. The shell surface is 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. The shell appears to be relatively uniform in thickness. Ten locations were selected to represent the thinnest areas based on the visual observations of the shell surface (Fig. 19). These locations are a deliberate attempt to produce a minimum measurement. Table 19 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.

Bay #19 UT Data

Table 19

Location	UT Measurement (inches)	Average 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	---

BAY #19 DATA

NOTES:

1. All measurements from intersection of the DW shell (butt) and vent collar (fillet) welds.

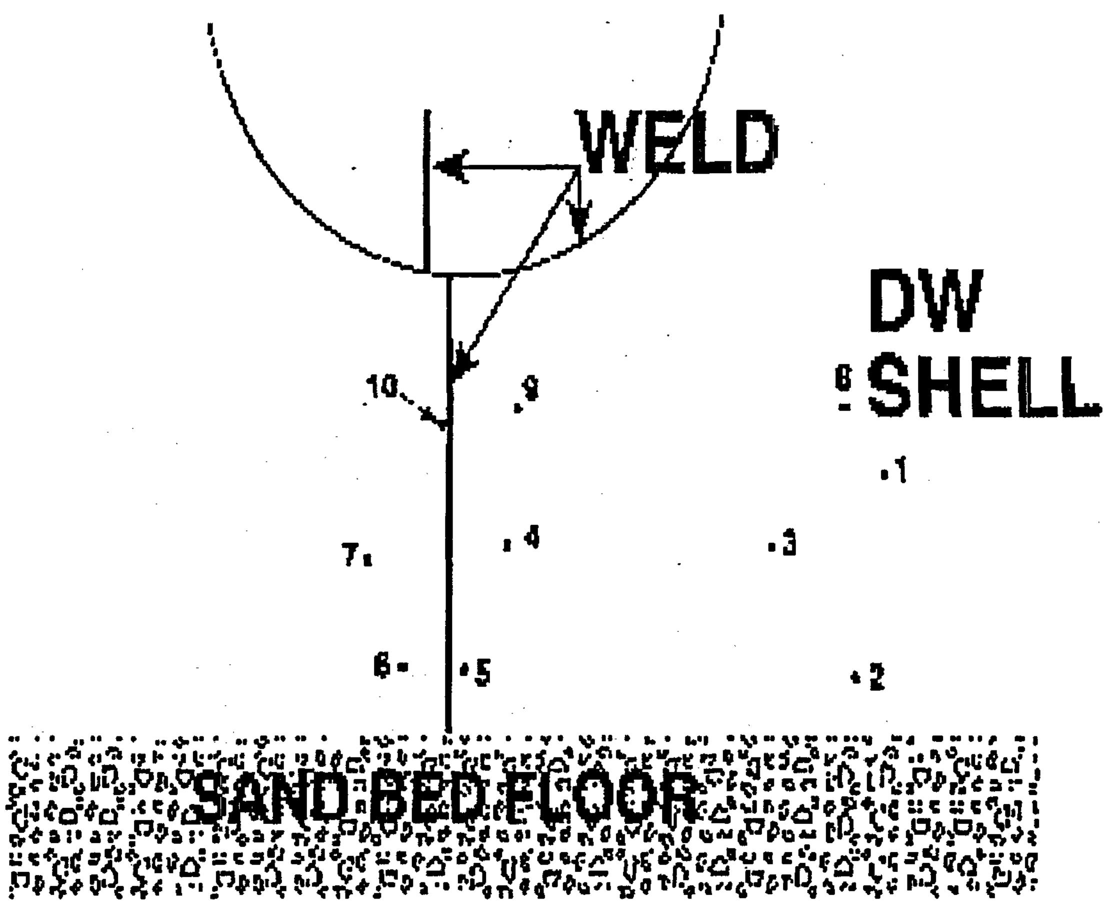


FIGURE (19)

APPENDIX A

SUMMARY OF MEASUREMENTS

OF

IMPRESSIONS TAKEN FROM BAY #13

The purpose of this appendix is to characterize the depth of typical uniform dimples on the shell surface. This depth is used in acceptance criteria to quantify the evaluation thickness for an area where the micrometer readings are available.

Two locations in bay 13 were selected since bay 13 is the roughest bay. Impressions of drywell shell surface using DMR_503 Epoxy Replication Putty manufactured by Dyna Mold Inc were made. These impressions were about 10 inches in diameter and about 1 inch thick. The UT locations 7 and 10 in bay 13 were identified in each of these impression as the reference points. This is a positive impression of the drywell shell surface. The depth of the typical dimples were measured as follows;

READING (Location)	DEPTH # 10 (inches)	DEPTH # 7 (inches)
1	0.150	0.075
2	0.000	0.110
3	0.200	0.135
4	0.140	0.200
5	0.150	0.000
6	0.040	0.000
7	0.150	0.170
8	0.010	0.205
9	0.134	-----
10	0.145	0.145
11	0.118	0.064
12	0.105	0.200
13	0.125	0.045
14	0.200	0.180
15	0.135	0.105
16	0.100	----
17	0.175	0.035
18	0.175	0.015
19	0.155	0.190
20	0.175	0.055
21	0.175	0.305
22	-----	0.135

Location # 10:

Mean Value = 0.131
Standard Deviation = 0.055

Mean Value + One S.D = 0.186

Location # 7:

Mean Value = 0.118

Standard Deviation = 0.082

Mean Value + One S.D = 0.200

Therefore, a value of 0.200 inches was used as the depth of uniform dimples for the entire outside surface of the drywell in the sandbed region.

APPENDIX B

BUCKLING CAPACITY EVALUATION

FOR VARYING

UNIFORM THICKNESS

GPU Nuclear Calculation Sheet

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	42 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli		Date: 04/16/93

CALCULATION OF BUCKLING MARGIN - REFUELING CASE, NO SAND -
GE OYCR1S&T - UNIFORM THICKNESS t= 0.736 Inch

ITEM	PARAMETER	UNITS	VALUE	LOAD FACTOR
	*** DRYWELL GEOMETRY AND MATERIALS			
1	Sphere Radius, R	(in.)	420	
2	Sphere Thickness, t	(in.)	0.736	
3	Material Yield Strength, Sy	(ksi)	38	
4	Material Modolus of Elasticity, E	(ksi)	29600	
5	Factor of Safety, FS		2	
	*** BUCKLING ANALYSIS RESULTS			
6	Theoretical Elastic Instability Stress, Ste	(ksi)	46.590	6.140
	*** STRESS ANALYSIS RESULTS			
7	Applied Meridional Compressive Stress, Sm	(ksi)	7.588	5.588
8	Applied Circumferential Tensile Stress, Sc	(ksi)	4.510	3.300
	*** CAPACITY REDUCTION FACTOR CALCULATION			
9	Capacity Reduction Factor, ALPHAI		0.207	
10	Circumferential Stress Equivalent Pressure, Peq	(psi)	15.806	
11	'X' Parameter, X= (Peq/8E) (d/t)^2		0.087	
12	Delta C (From Figure -)	-	0.072	
13	Modified Capacity Reduction Factor, ALPHA,i,mod		0.326	
14	Reduced Elastic Instability Stress, Se	(ksi)	15.182	2.001
	*** PLASTICITY REDUCTION FACTOR CALCULATION			
15	Yield Stress Ratio, DELTA=Se/Sy		0.400	
16	Plasticity Reduction Factor, NUi		1.000	
17	Inelastic Instability Stress, Si = NUi x Se	(ksi)	15.182	2.001
	*** ALLOWABLE COMPRESSIVE STRESS CALCULATION			
18	Allowable Compressive Stress, Sall = SI/FS	(ksi)	7.591	1.000
19	Compressive Stress Margin, M=(Sall/Sm -1) x 100%	(%)	0.0	

CALCULATION OF BUCKLING MARGIN - REFUELING CASE, NO SAND
GE OCRFST01 - UNIFORM THICKNESS t=0.776 Inch

ITEM	PARAMETER	UNITS	VALUE	LOAD FACTOR
	*** DRYWELL GEOMETRY AND MATERIALS			
1	Sphere Radius, R	(in.)	420	
2	Sphere Thickness, t	(in.)	0.776	
3	Material Yield Strength, Sy	(ksi)	38	
4	Material Modolus of Elasticity, E	(ksi)	29600	
5	Factor of Safety, FS		2	
	*** BUCKLING ANALYSIS RESULTS			
6	Theoretical Elastic Instability Stress, Ste	(ksi)	49.357	6.857
	*** STRESS ANALYSIS RESULTS			
7	Applied meridional Compressive Stress, Sm	(ksi)	7.198	5.588
8	Applied Circumferential Tensile Stress, Sc	(ksi)	4.248	3.300
	*** CAPACITY REDUCTION FACTOR CALCULATION			
9	Capacity Reduction Factor, ALPHAI		0.207	
10	Circumferential Stress Equivalent Pressure, Peq	(psi)	15.697	
11	'X' Parameter, X= (Peq/8E) (d/t)^2		0.078	
12	Delta C (From Figure -)	-	0.066	
13	Modified Capacity Reduction Factor, ALPHA,i,mod		0.316	
14	Reduced Elastic Instability Stress, Se	(ksi)	15.583	2.165
	*** PLASTICITY REDUCTION FACTOR CALCULATION			
15	Yield Stress Ratio, DELTA=Se/Sy		0.410	
16	Plasticity Reduction Factor, NUi		1.000	
17	Inelastic Instability Stress, Si = NUi x Se	(ksi)	15.583	2.165
	ALLOWABLE COMPRESSIVE STRESS CALCULATION			
18	Allowable Compressive Stress, Sall = SI/FS	(ksi)	7.792	1.082
19	Compressive Stress Margin, M=(Sall/Sm -1) x 100%		8.2	

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	44 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli		Date: 04/16/93

CALCULATION OF BUCKLING MARGIN - REFUELING CASE, NO SAND
GPUN EVALUATION FOR UNIFORM THICKNESS t=0.800 Inch USING THICKNESS RATIO

ITEM	PARAMETER	UNITS	VALUE	LOAD FACTOR
	*** DRYWELL GEOMETRY AND MATERIALS			
1	Sphere Radius, R	(in.)	420	
2	Sphere Thickness, t	(in.)	0.800	
3	Material Yield Strength, Sy	(ksi)	38	
4	Material Modolus of Elasticity, E	(ksi)	29600	
5	Factor of Safety, FS		2	
	*** BUCKLING ANALYSIS RESULTS			
6	Theoretical Elastic Instability Stress, Ste 6.857 * (0.800/0.776)^2 = 7.288	(ksi)	50.884	7.288
	*** STRESS ANALYSIS RESULTS			
7	Applied meridional Compressive Stress, Sm	(ksi)	6.982	5.588
8	Applied Circumferential Tensile Stress, Sc	(ksi)	4.120	3.300
	*** CAPACITY REDUCTION FACTOR CALCULATION			
9	Capacity Reduction Factor, ALPHAI		0.207	
10	Circumferential Stress Equivalent Pressure, Peq	(psi)	15.697	
11	'X' Parameter, X= (Peq/8E) (d/t)^2		0.073	
12	Delta C (From Figure -)	-	0.063	
13	Modified Capacity Reduction Factor, ALPHA,i,mod		0.311	
14	Reduced Elastic Instability Stress, Se	(ksi)	15.824	2.266
	*** PLASTICITY REDUCTION FACTOR CALCULATION			
15	Yield Stress Ratio, DELTA=Se/Sy		0.416	
16	Plasticity Reduction Factor, NUi		1.000	
17	Inelastic Instability Stress, Si = NUi x Se	(ksi)	15.824	2.266
	ALLOWABLE COMPRESSIVE STRESS CALCULATION			
18	Allowable Compressive Stress, Sall = SI/FS	(ksi)	7.912	1.133
19	Compressive Stress Margin, M=(Sall/Sm -1) x 100%		13.3	

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	45 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli		Date: 04/16/93

CALCULATION OF BUCKLING MARGIN - REFUELING CASE, NO SAND
GPUN EVALUATION FOR UNIFORM THICKNESS t=0.850 Inch USING THICKNESS RATIO

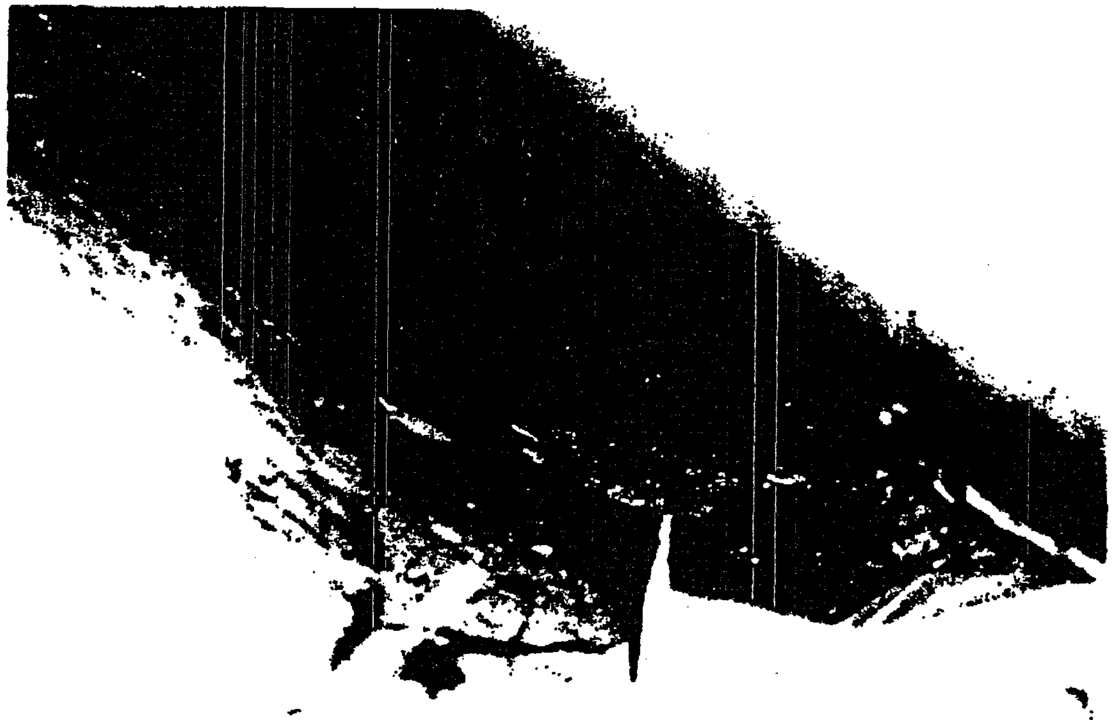
ITEM	PARAMETER	UNITS	VALUE	LOAD FACTOR
	*** DRYWELL GEOMETRY AND MATERIALS			
1	Sphere Radius, R	(in.)	420	
2	Sphere Thickness, t	(in.)	0.850	
3	Material Yield Strength, Sy	(ksi)	38	
4	Material Modolus of Elasticity, E	(ksi)	29600	
5	Factor of Safety, FS		2	
	*** BUCKLING ANALYSIS RESULTS			
6	Theoretical Elastic Instability Stress, Ste 6.857 * (0.800/0.776)^2 = 7.288	(ksi)	54.063	8.227
	*** STRESS ANALYSIS RESULTS			
7	Applied meridional Compressive Stress, Sm	(ksi)	6.571	5.588
8	Applied Circumferential Tensile Stress, Sc	(ksi)	3.878	3.300
	*** CAPACITY REDUCTION FACTOR CALCULATION			
9	Capacity Reduction Factor, ALPHAI		0.207	
10	Circumferential Stress Equivalent Pressure, Peq	(psi)	15.697	
11	'X' Parameter, X= (Peq/8E) (d/t)^2		0.065	
12	Delta C (From Figure -)	-	0.057	
13	Modified Capacity Reduction Factor, ALPHA,i,mod		0.300	
14	Reduced Elastic Instability Stress, Se	(ksi)	16.257	2.474
	*** PLASTICITY REDUCTION FACTOR CALCULATION			
15	Yield Stress Ratio, DELTA=Se/Sy		0.428	
16	Plasticity Reduction Factor, NUi		1.000	
17	Inelastic Instability Stress, Si = NUi x Se	(ksi)	16.257	2.474
	ALLOWABLE COMPRESSIVE STRESS CALCULATION			
18	Allowable Compressive Stress, Sall = SI/FS	(ksi)	8.128	1.237
19	Compressive Stress Margin, M=(Sall/Sm -1) x 100%		23.7	

APPENDIX C

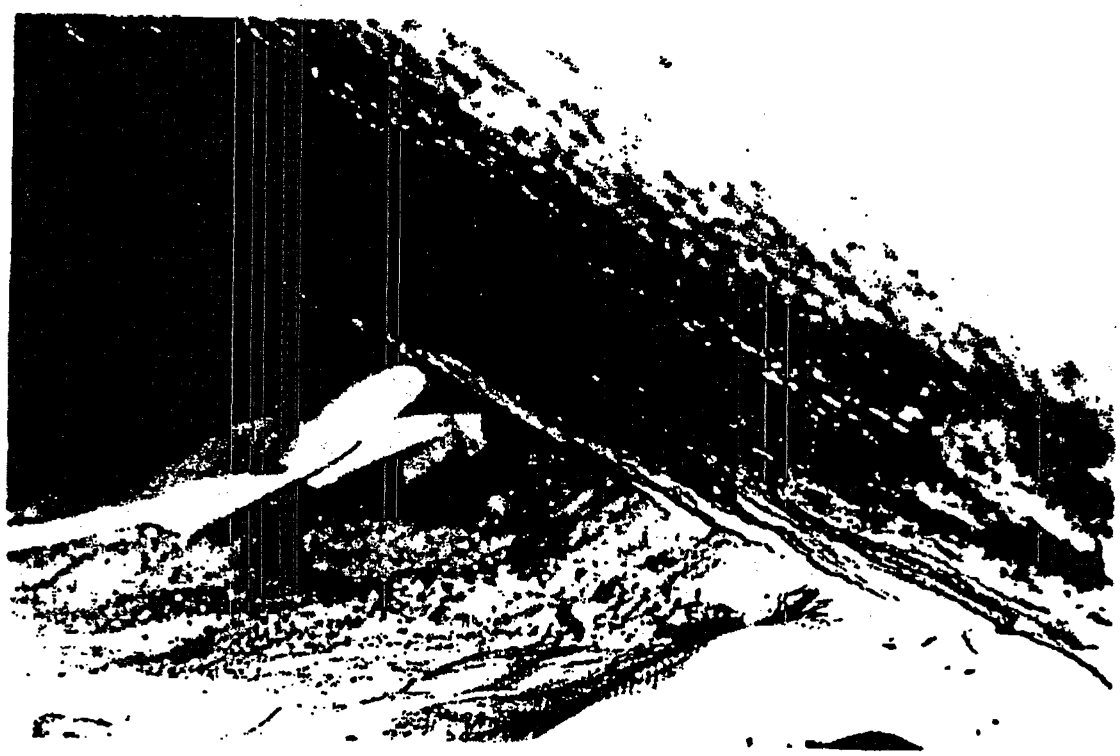
PICTURES SHOWING CONDITION

OF THE DRYWELL

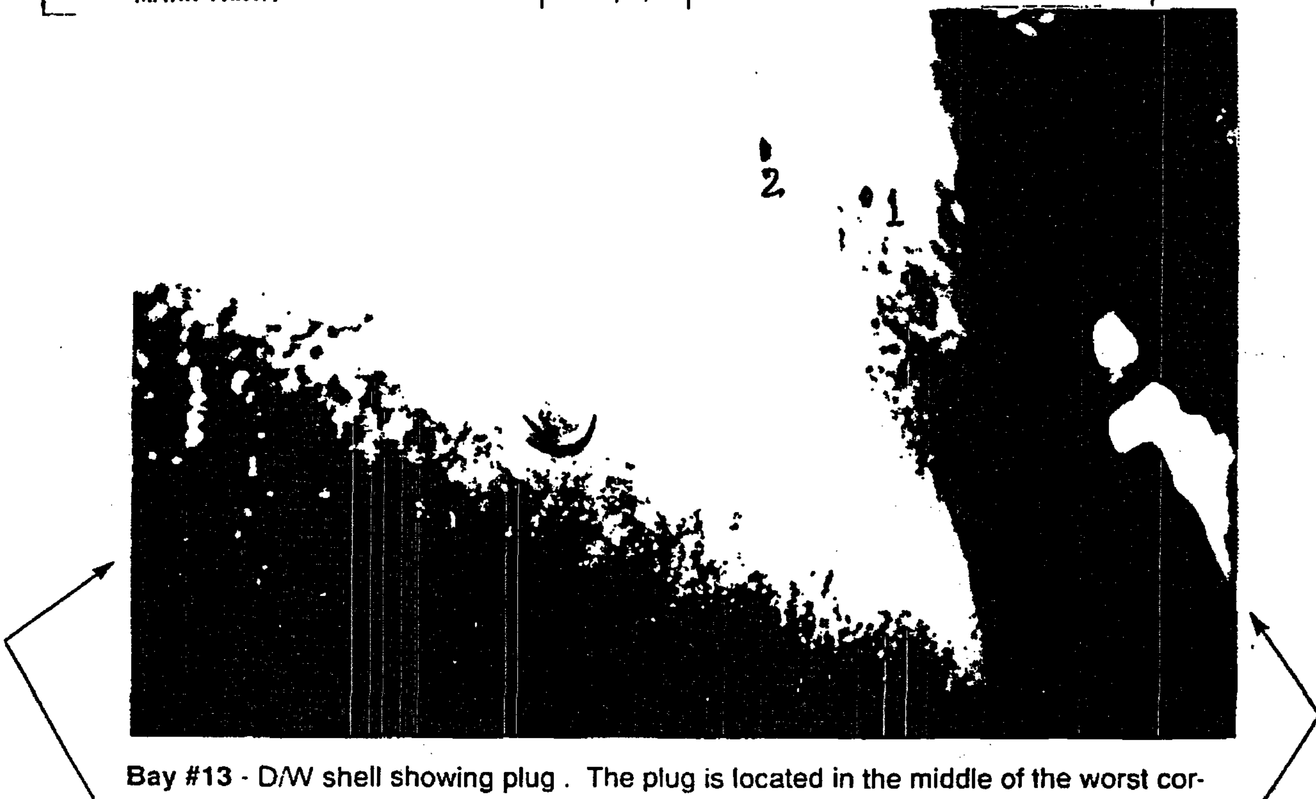
IN THE SANDBED REGION



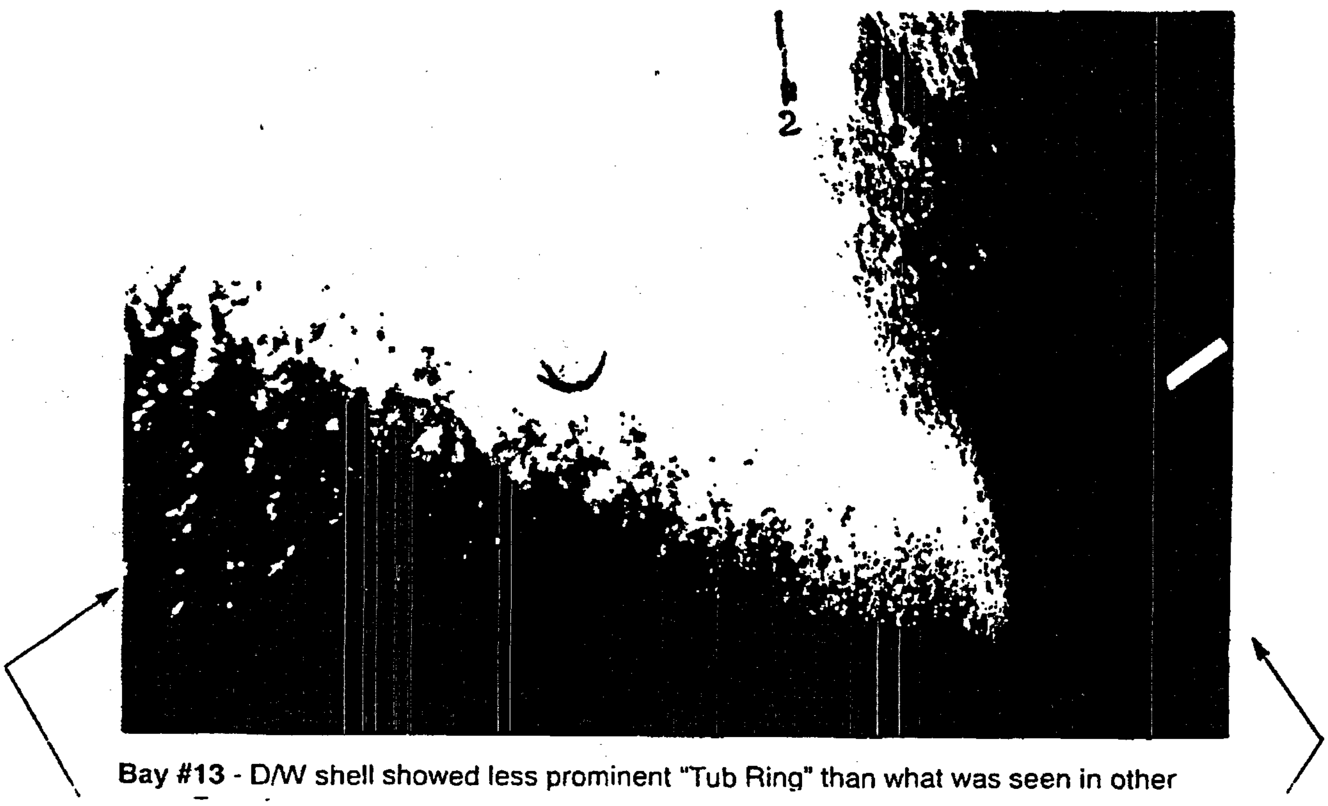
Sand Bed Region - Typical condition found on initial entry.



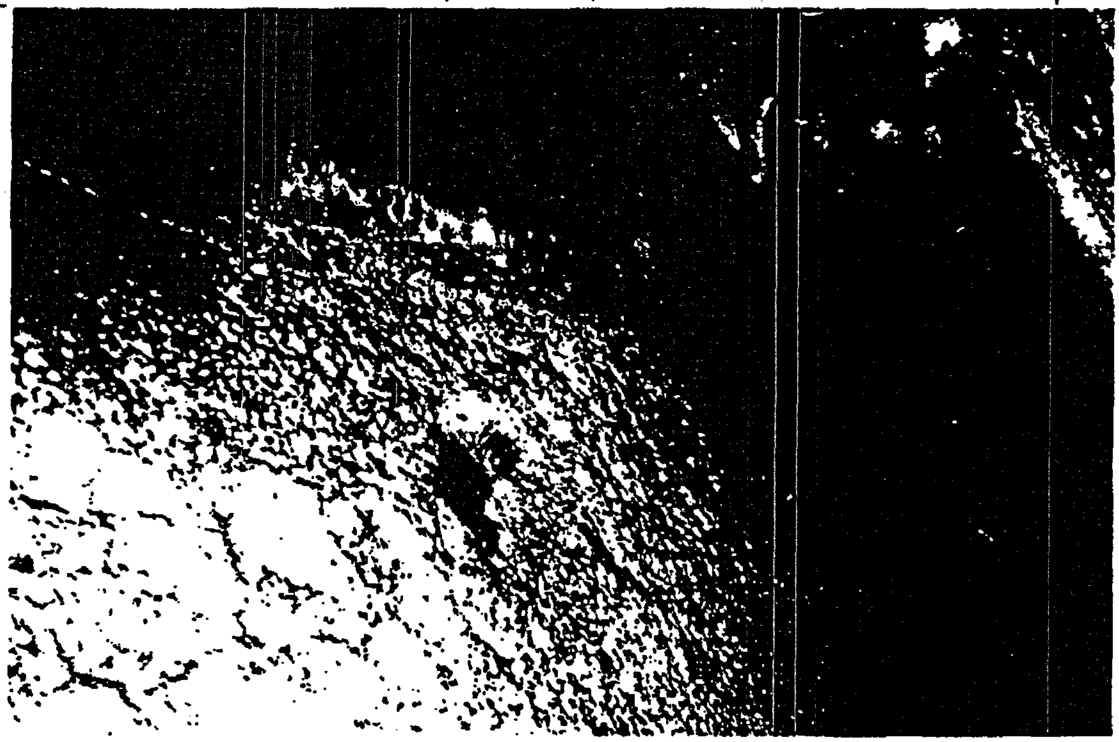
Corrosion product on drywell vessel



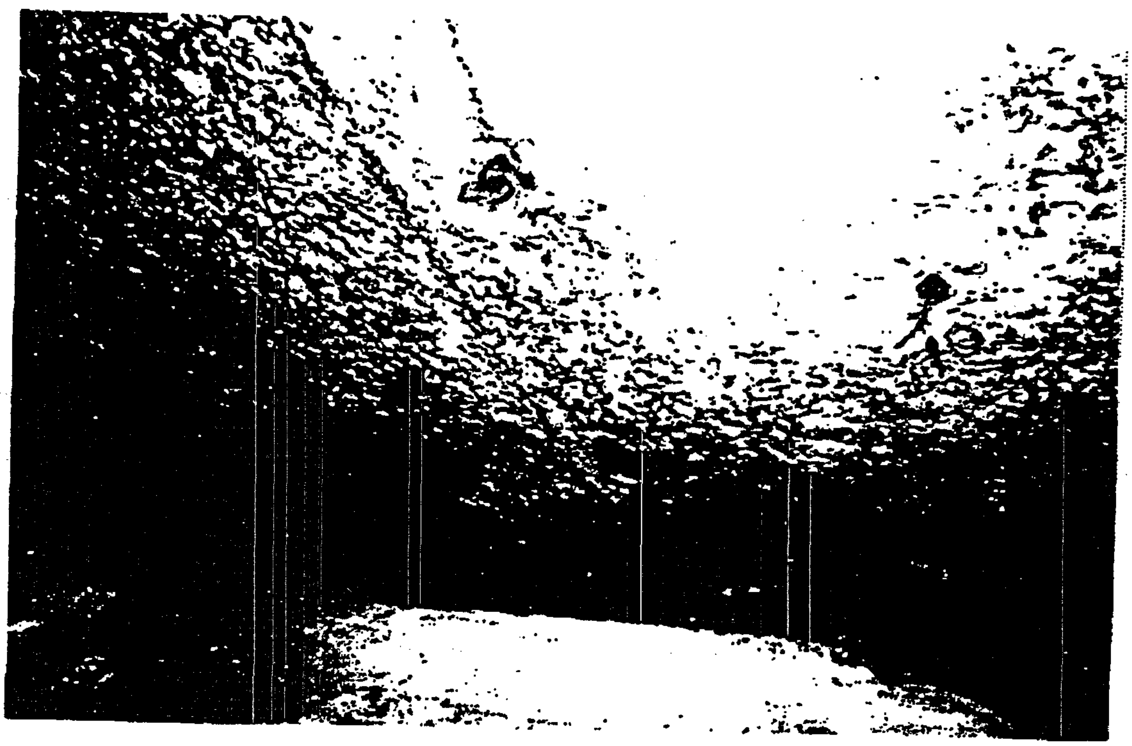
Bay #13 - D/W shell showing plug . The plug is located in the middle of the worst corroded area of the shell The plug showed no sign of corrosion.



Bay #13 - D/W shell showed less prominent "Tub Ring" than what was seen in other



Bay #1 - Looking at the worst corroded area on shell near vent tube collar/ring. The ground spots seen here correspond to UT spot 20/21/2/3

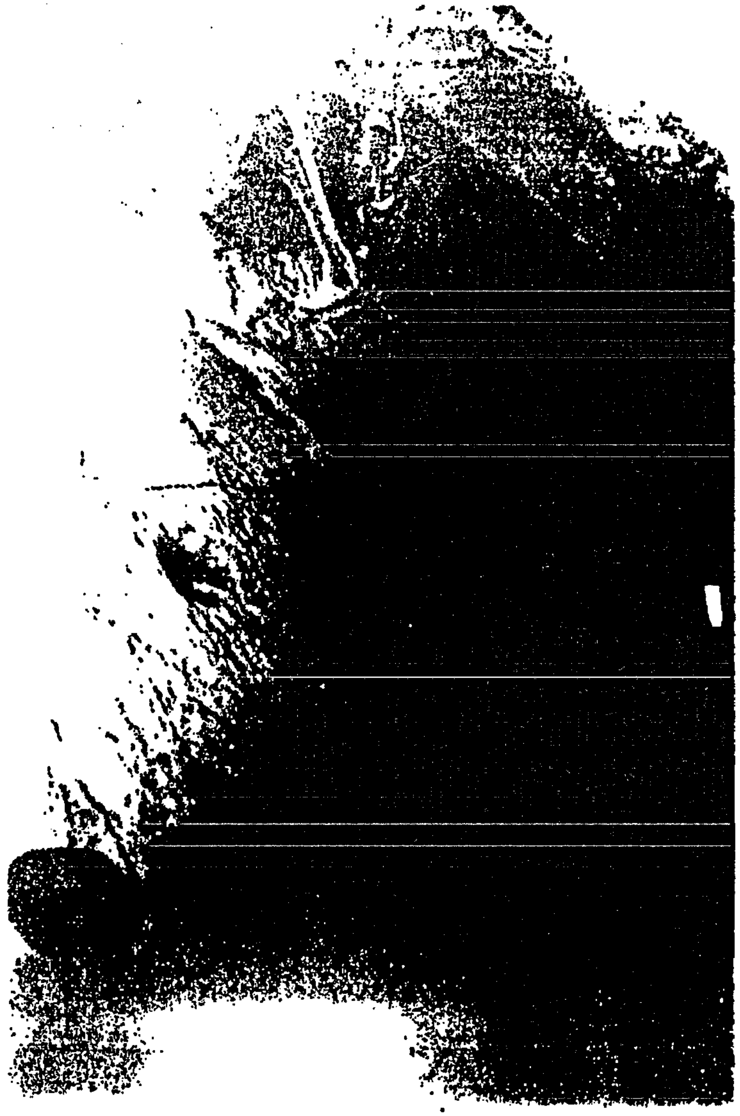


Bay #13 - Lower Mid portion of the D/W shell showing UT spot 5.6 and 10. This close up photo shows the roughness of the corroded surface and how each UT spot has been picked up in the deep valleys thereby biasing the remaining wall readings to the conservative side

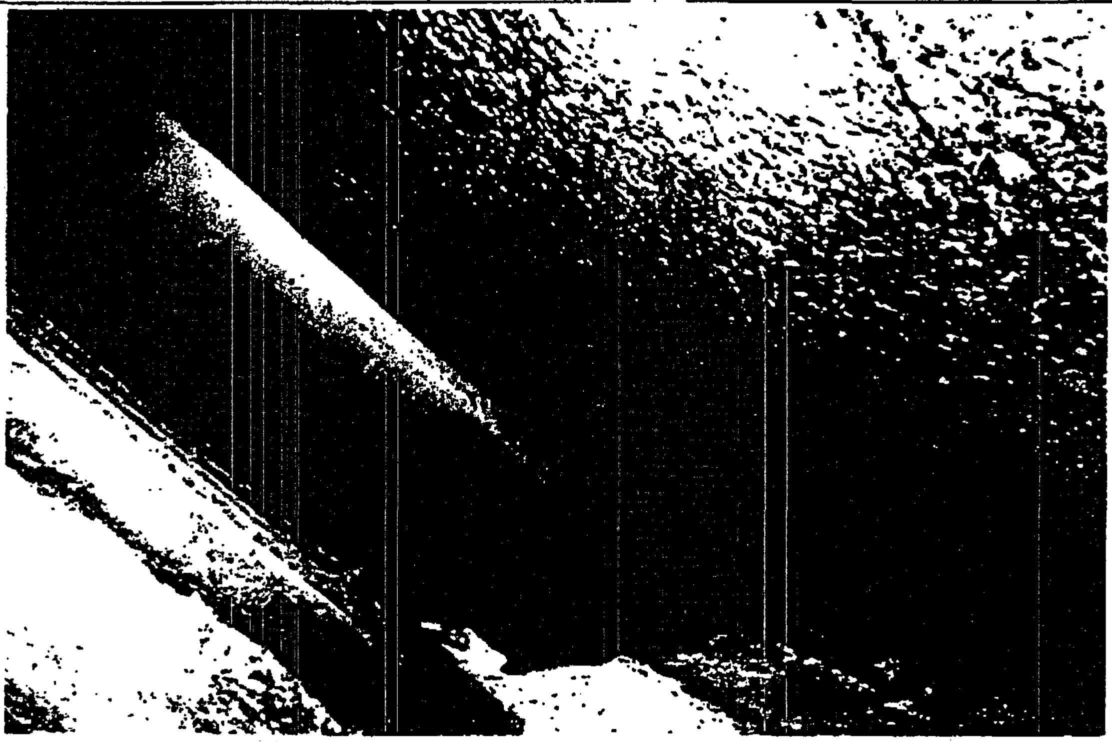
GPU Nuclear

Calculation Sheet

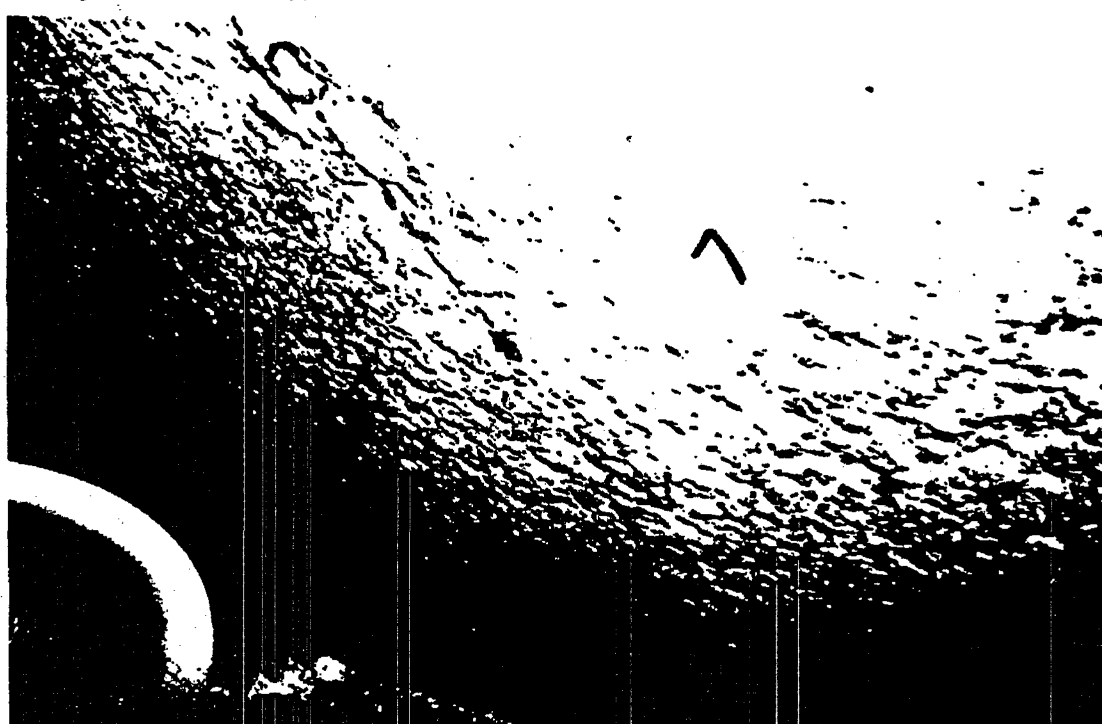
Subject: O.C Drywell Ext. Ut Evaluation in Sandbed	Calc No. C-1302-187-5320-024	Rev. No. 0	Sheet No. 50 of 54
Originator: MARK YEKTA	Date 01/12/93	Reviewed by S. C. Tumminelli	Date 04/16/93



Bay #13 - Looking towards **Bay#11** - Upper right corner of D/W shell. Note ① - Grinding depth on UT spot #1 & 2, ② - A part of "Bath Tub Ring" as delineated by marking and ③ locations of UT spots 3,4,13 & 17. The photo on right (although blurred by flash reflection) shows 1/8" projection of plug.



Bay #15 Looking towards **Bay#17** which has been closed with foam for coating work in **Bay #17**. Note the typical surface of the D/W shell and localized corroded spot

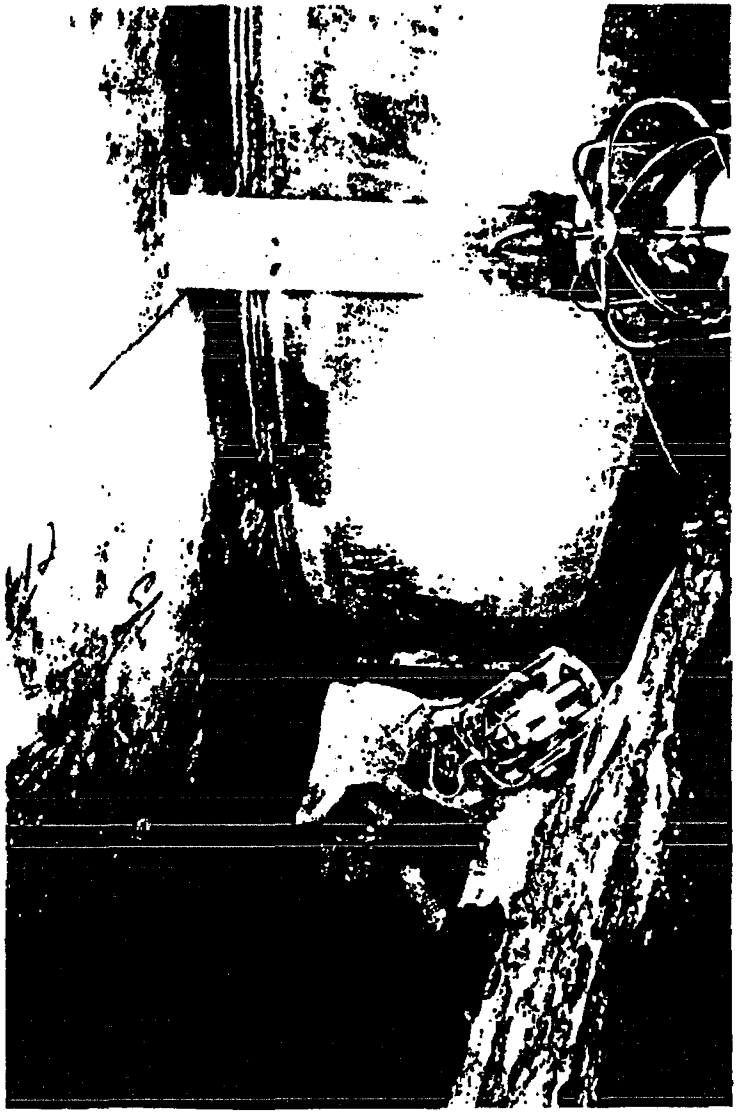


Bay #13 - Looking toward Bay #15 - Lower left corner showing UT spot #7,12 & 16. This close up has captured the peaks and valleys of the corroded shell in vivid detail. Later NDE inspection revealed depth between peaks and valleys in the 0.25" - 0.40"

GPU Nuclear

Calculation Sheet

Subject	Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed	C-1302-187-5320-024	0	52 of 54
Originator: MARK YEKTA	Date: 01/12/93	Reviewed by: S. C. Tumminelli	Date: 04/16/93

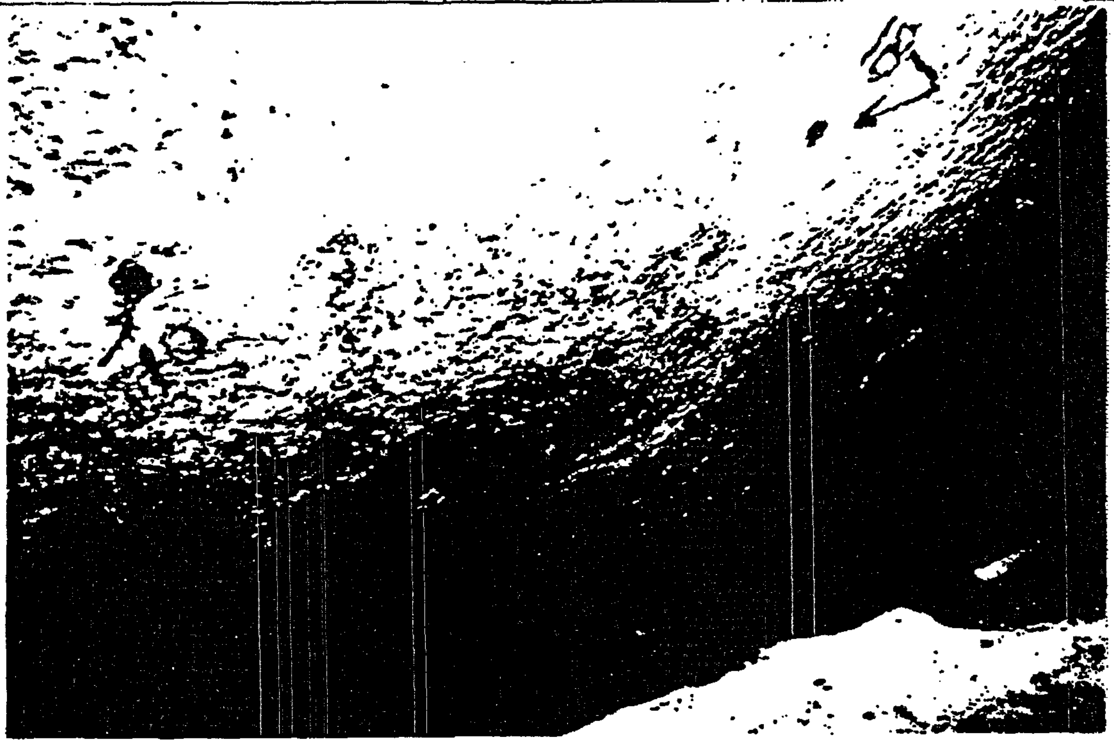


Bay #15 - Note the original lead primer on vent tube OD surface. The "Tub Ring" was less prominent on the shell in this bay except a portion in lower left corner. Also note presence of lead primer on vent collar/ring plate.

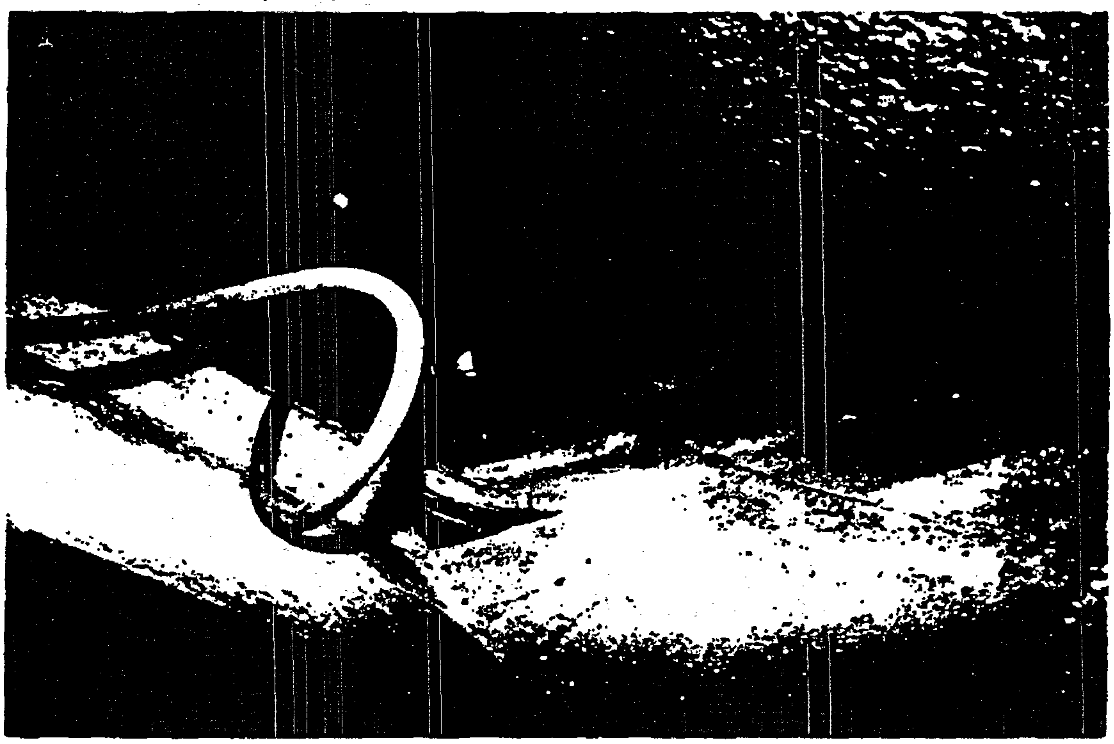
Bay #15 Looking toward **Bay #13** showing portions of D/W shell and concrete floor, after removal of loose debris / sand / rust. The concrete floor in this bay is one of the better ones. However - Note ① no drainage channel and ② cratered holes near shell corner.

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	53 of 54
Originator MARK YEKTA	Date 01/12/93	Reviewed by S. C. Tumminelli		Date 04/16/93



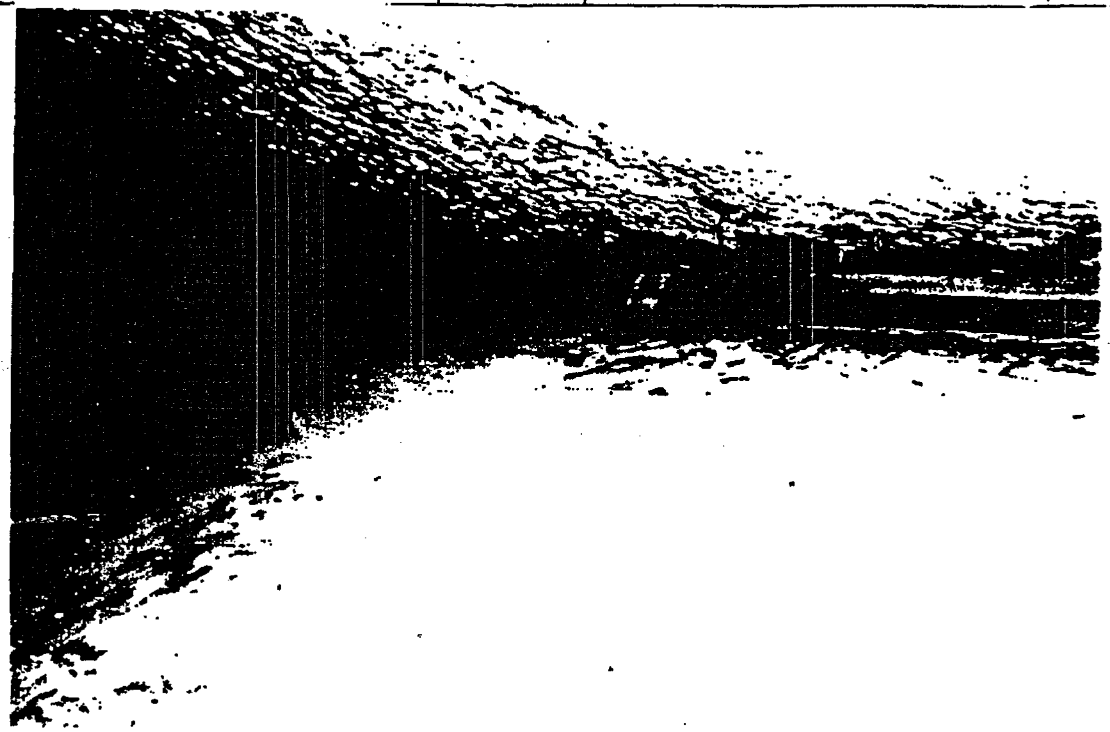
Bay #13 - Looking toward **Bay #11** - Lower right corner of D/W shell showing UT spots 9, 10, 18 & 19 Note the location of these spots - all are located in the valleys of the corroded surface This photo also shows the condition of the concrete floor. It appears



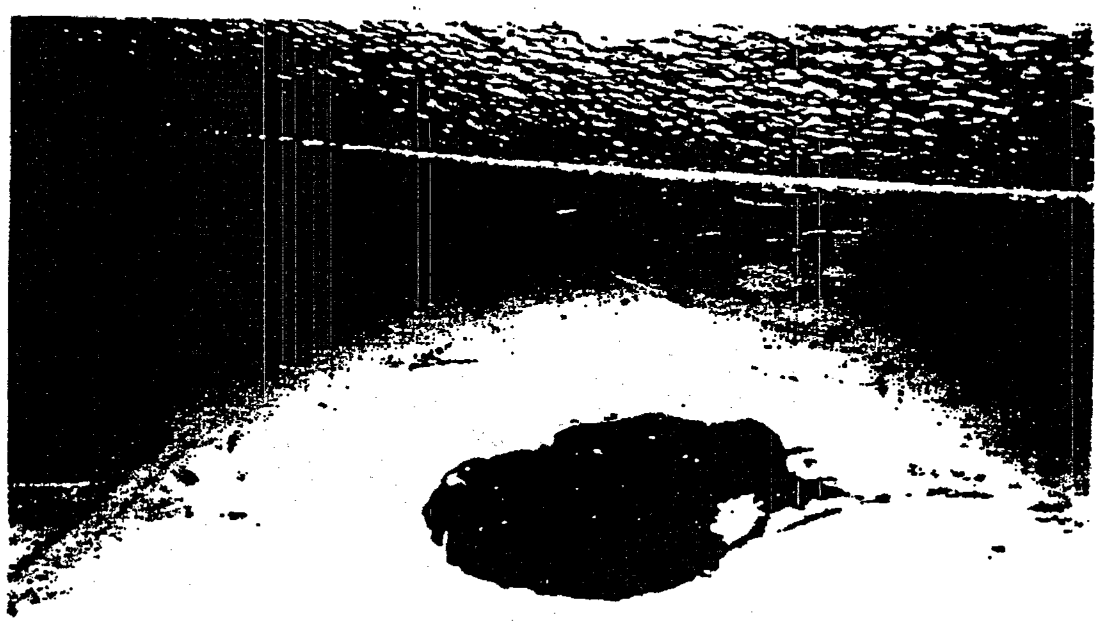
Bay #13 - Looking toward **Bay #15** - This photo captures the concrete floor condition and a portion of lower shell corroded surface in very great detail. The floor in this area

GPU Nuclear **Calculation Sheet**

Subject		Calc No.	Rev. No.	Sheet No.
O.C Drywell Ext. Ut Evaluation in Sandbed		C-1302-187-5320-024	0	54 of 54
Originator MARK YEKTA	**Date** 01/12/93	**Reviewed by** S. C. Tumminelli		**Date** 04/16/93



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



Drain after floor has been refurbished

Citizen's Exhibit NC4

Citizen's Exhibit NC4

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Oyster Creek Generating Station License Renewal
Docket Number:	(05000219)
Location:	Rockville, Maryland
Date:	Thursday, June 1, 2006

Work Order No.: NRC-1087 Pages 1-129

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

CATEGORY 1 PUBLIC MEETING

BETWEEN

U.S. Nuclear Regulatory Commission

AND

AmerGen Energy, LLC,

Applicant for Oyster Creek Generating Station

License Renewal

+ + + + +

THURSDAY,

JUNE 1, 2006

+ + + + +

The meeting was convened in the Commissioners' Conference Room in One White Flint North, 11555 Rockville Pike, Rockville, Maryland, at 9:20 a.m., Donnie Ashley, Presiding Official.

NRC PERSONNEL PRESENT:

DONNIE ASHLEY
HANS ASHAR
FRANK GILLESPIE
REBECCA KARAS
P. T. KUO
LOUISE LUND

AMERGEN AND EXELON PERSONNEL PRESENT:

MICHAEL GALLAGHER
JOHN HUFNAGEL
AHMED OUAOU
FRED POLASKI
HOWIE RAY
PETER TAMBURRO
DONALD WARFEL

ALSO PRESENT:

KYOTO TANABE, Japan NRC

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

P-R-O-C-E-E-D-I-N-G-S

(9:23 a.m.)

MR. ASHLEY: Okay, I'm going to go ahead and get started now. The other two participants can just call in when they can.

This is a public meeting between the NRC and AmerGen who is the applicant for Oyster Creek license renewal.

It's a category one meeting. We will conduct the meeting according to the agenda. At the end of the meeting we will give those people on the phone line and also the folks that are here at headquarters and opportunity to make comments or ask questions of the staff.

This meeting is being transcribed, and as a result, if when you make your statements or you make your presentations, please state your name and who you represent so that the recorder can pick that up for you.

Rather than introducing everybody in the room, probably have maybe 25 or 30 people here, I just want to introduce the participants here today.

And we'll start with our folks, and then we'll give it to you, Mr. Gallagher.

Dr. Kuo.

MR. KUO: P.T. Kuo, division of license renewal.

MS. LUND: I'm Louise Lund, a branch chief in the division of license renewal.

MR. ASHLEY: My name is Donnie Ashley. I'm the project manager for Oyster Creek license renewal project.

MR. GILLESPIE: Frank Gillespie, director,

division license renewal.

MR. ASHAR: Hans Ashar, NRC.

MS. KARAS: Becky Karas. I'm the chief of the GSI and civil engineering branch in the division of engineering.

MR. GALLAGHER: Okay, Frank. Can you hear me?

I'm Mike Gallagher. I'm the vice president of license renewal for AmerGen and Exelon. And I'll turn it over to our team to introduce themselves.

MR. TAMBURRO: I'm Peter Tamburro. I'm senior mechanical engineer at Oyster Creek.

MR. OUAOU: My name is Ahmed Ouaou. I'm a civil structural engineer at Oyster Creek.

MR. RAY: My name is Howie Ray, and I'm at Oyster Creek, the new manager.

MR. POLASKI: For Polaski, Exelon's license renewal manager.

MR. WARFEL: Don Warfel, the technical lead for the Oyster Creek project.

MR. HUFNAGEL: John Hufnager, the licensing lead for the Oyster Creek project.

MR. ASHLEY: Thank you very much. We'll go ahead and get started with the agenda.

We have a very focused agenda today. But first of all, before I get started into the agenda, we really appreciate having the opportunity to meet here at this commissioners' conference room. It's not often we get such nice facilities to meet in.

This particular meeting is the first of two meetings that will be conducted. The next meeting is tentatively scheduled for June the 22nd, and I

think we're going to try to do that in the afternoon so you folks won't have to either drive down early on 95 or the night before.

I'd like to welcome everyone again. We have participants here from the State of New Jersey, from Region 1, and Kyoto Tanabe from the Japanese NRC, NISA.

And of course the people that are on the phone line with us.

We're going to talk about two concerns with you, and they're going to be very focused, and we're not looking for answers from you.

John Hufnagel and I have done this sort of thing many times since the license application was received in July of 2005. Since that time we've had three onsite audits. We've had regional inspection. And I believe that Roy Matthew, the audit team leader, is here. And he is still working on the audit report and the inspection report.

The next step in this process as we go through is collecting all the information that we have garnered over these months in preparing the safety and evaluation report.

Part of that has involved the request for additional information. To date, we've processed about 128 questions, plus or minus a few.

Normally, that's the reason I mentioned John Hufnagel, we usually do these requests for additional information on the phone. And the way that we do that is, we have a discussion of what our concerns are, and make sure that you understand what our concerns are.

When we do the phone calls and meetings

for the request for additional information, we're not looking for the answers at this time. Just that you understand where we're coming from.

In addition, there are several hundred questions that are in the Q&A database, that Matthew and his team and your team put together during the audits that are publicly available in the Adams (phonetic).

The next thing that we do after we have the meetings is, we're going to look for your responses. And then eventually we're going to process the safety evaluation report, and hopefully there won't be any open items. Right now there are probably some open items there that we still have to follow up on. This meeting is going to address some of those.

Because the thing that we have to make sure of is that we have reasonable assurance that all of your assumptions and all of your calculations and all of the programs that you've put in place will be valid for the period of the extended operation.

So with that, I'm going to turn it over to Frank Gillespie, and we'll go ahead and get started on the discussions.

MR. GILLESPIE: Okay, thank you, Donnie.

The way we've organized this is, I'm going to present kind of a bulletized issue, and kind of a broader context. And on those issues where we think we really need to give you some detail on what our issue is, then I'm going to turn to Hans. And we've already coordinated between Hans and I. He knows which issues. And we've got some notes developed on it. And as we go through the meeting, we'll do our best, then potentially, to put out in a rapid way some

meeting minutes to share the notes.

And one of our concerns is, you've been an applicant who has been very responsive to our requests for RAIs. You have always made it on time. And on the particular issue we're going to address today, you almost overwhelmed us with information.

And so Hans in the last two weeks, and we actually had Noel Dudley helping Donnie and Hans, to try to take this large volume of information and say, okay, here are our original questions; map that information into the original questions and say, what's the residual?

And the residual were such - and this is an interesting comment, and I have to thank Mitzi, who's from our general counsel, who put this in perspective when we were kind of going through this for me, she said, gee, this discussion is far more focussed and detailed than the way we traditionally write RAIs.

And from that I said, really, we need to sit face to face, because they are very very specific things that we need blanks filled in, and they are all very technically oriented. And we probably wouldn't do justice in kind of randomizing, because you'd focus on answering the RAI, as opposed to maybe understanding the underlying concern it causes us to write it.

And so that's when I proposed this set of meetings. And so therefore I think today is your opportunity to pummel us with questions to ensure complete understanding of the RAIs.

It is not our opportunity to request from you an answer to them, because I really think you need

time to take - it's very detailed information, and it's the kind of thing you need engineers back at the plant, I think, probably to mull over and look at.

So I do thank you for your responsiveness, and you overwhelmed us with information. We've gone through it all. And it really has narrowed it down.

So now I'm going to go through the bullets, and on specific ones, you're going to see me turning to Hans. But I'm going to go through each bullet and ask you, do you have any questions.

If you don't, then I'm turning to Hans, and he's going to go through the specific details. And some of them are more straightforward, and we can go through even quickly.

As Donnie said, we narrowed our focus down to two concerns, and both of these concerns with I want to call uncertainty. So we are not making a judgement as to adequacy at this time. Or in anyway absolute. I'm going to suggest that much of what we're talking about deals with the uncertainly in the information, because of some voids in the information that have to come in.

So we have dry wall corrosion uncertainties. And then we have some ultrasonic testing issues. And there are two subsets to the ultrasonic testing issues. One is testing in the upper portion, which is really a pressure retention question, and then there is some questions on the lower portion.

And if that doesn't come out clear as I go through the bullets, you need to ask us about that. Because there are two different kinds of points in there, and we're trying to leave this meeting with no

confusion on any part. Because these are really fine tuning now, kind of issues that we're in.

With that, let me -

MR. GALLAGHER: And Frank, just so you know, we have Pete and Ahmed and Howie, and they are like our experts on this issue. So they provided a lot of that information that you're talking about that we provided. So if we really have any detailed questions, these will be the three individuals -

MR. GILLESPIE: But again, I want you asking us questions today, as opposed to putting you in the awkward position of thinking you need to respond.

And so as Donnie said, there's no reason to respond today.

MR. GALLAGHER: Right, and we really appreciate that, Frank, to make sure we really understand the issues.

MR. GILLESPIE: So let me start off.

Dry wall corrosion uncertainties. There were assumptions in the 1991 GE report. Within these assumptions there's uncertainties in the simulations of degradation calculations in the associated analyses. This is not a your action, this is an our action. I just want to let you know that as part of our review, we may be doing an independent calculation or something to reinforce the assumptions in the basic calculation itself.

So that's not an action for you; that's really an action for the staff. And you might say it's by way of almost what we do in other areas of thermal hydraulics and other things, where we'll do a confirmatory calculation.

But so you know it's happening, it's going on, we may be coming back to you for data in support of that calculation later.

Uncertainties in ultrasonic testing results: There are two key issues here that Hans is going to go over in a little more detail.

One, there's a report that's referenced that has a disclaimer in it. And the disclaimer says something like, no one at GE or AmerGen can be held responsible for the accuracy of this report.

It sounds like a boilerplate disclaimer. But nonetheless, it's kind of - again, we're really fine tuning, so I'm being very specific here. The disclaimer raises issues of, well, do you believe the report you referenced.

The second piece, which is probably more important with this, and now I'm going to turn to H ans on this, is what I'm going to call the evaluation of the grid data itself.

And so I've broken this one down into two things: the disclaimer, which I'd like to administratively have you - ask you to please look at it and deal with it. Does it still stand?

And now I'm going to turn to Hans on the grid data evaluation.

Hans.

MR. GALLAGHER: Yes, okay, and Frank, is this in the lower portion? Because you broke it up into upper and lower?

MR. GILLESPIE: In general.

MR. ASHAR: In general.

Let me narrate what I have written, because this is transcribed; I cannot be informed

about it.

So attachment 1-A of the GPU letter dated November 26th, 1990, makes a statistical evaluation of the UT measurements data taken up to 1990.

On the cover page of the report, GPU Nuclear Corporation states in their disclaimer: The work is conducted by individuals for use by GPU. Neither GPU nor the authors of the report warrant that the report is complete or accurate.

In view of this disclaimer, the applicant is requested to provide a detailed description of the way the UT measurements data, whether taken as part of the 6X6 grid, or isolated readings, were evaluated and used in performing the analysis.

Do you understand?

MR. GALLAGHER: I don't.

MR. GILLESPIE: We're open for questions.

MR. ASHAR: Regarding the clarity of the question.

MR. GALLAGHER: Okay. What was the report name again?

MR. ASHAR: It is attachment 1-A to the GPU letter dated November 26th, 1990, which is a statistical inference of the UT data.

MR. GALLAGHER: Okay. And your question is related to the disclaimer itself.

MR. ASHAR: Disclaimer, which is in 1-A has been used, or if something different is used, what kind of confidence level has been used. Because that particular report talks about the mean and confidence level. But whether it is used effectively all the time, we have no idea.

Because we looked at the report. We

didn't interpret report.

MR. ASHAR: Let me see if I can - this is the kind of dialogue we need to have. Because we're down in the details, really, now. Okay?

MR. GALLAGHER: Yeah, this is pretty focused.

MR. GILLESPIE: And Hans and I have spent a lot of time together in the last week or so. So let me say it and then ask him if I've said it right.

Basically in the measurements that were taken it's a scanned area with a grid array of measurements. And it's not clear whether that's a 95 percent confidence interval, is it a median value? It's not clear how those area level calculations were used. And much of the information that we used in the 1991 report, and in fact in the graphs that you sent in in your RAIs literally takes the result of this calculation.

But there is really no description of what - how these data points were combined.

MR. GALLAGHER: This would be to determine the average thickness for the -

MR. GILLESPIE: Thickness data, yes, and the projection of that thickness data as applicable to the liner.

MR. GALLAGHER: Now I thought we had provided a description of that in one of our Q&As. Ahmed or Pete, do you guys recall that?

MR. OUAOU: My name is Ahmed Ouaou. I'm with Exelon Oyster Creek.

We did - this question came up, we did provide response to the question, what type of statistical analysis did you do.

It's also in the RAI, and it's part of the - that's why we submit that report.

MR. GILLESPIE: So is there anything beyond that that we provided?

MR. OUAOU: Well, my main question is, have you used that particular report? Or you use something different?

MR. TAMBURRO: My name is Pete Tamburro. The attachment one to that letter, is there a document number.

MR. ASHAR: Yeah, I think you sent to me. It came to us.

MR. GALLAGHER: This is in your application.

MR. OUAOU: Again, this is Ahmed. We just don't recall what Attachment 1-A is. And what that is.

MR. ASHAR: I think title is statistical inference.

MR. GALLAGHER: That calculation was submitted previously. It's part of the original approach that was developed to calculate the average thickness in thinned areas, submitted back in 1991.

But that's the calculation we use, and Pete can talk about that.

MR. TAMBURRO: This is Pete Tamburro.

The words that you reference about no claims made by the author, that sounds like a technical data report which describes methodology. It's not intended to be a calculation.

So I think we owe it to you to go do the research and see what the intent of that report was. I believe we later did calculations which normally

treated the data.

MR. ASHAR: This is what we would like to know, that is the question, basically.

MR. GALLAGHER: So specifically about that report, how we arrive at our statistical analysis.

MR. ASHAR: And what actually you used.

MR. GALLAGHER: And what we used, okay. And I just want to make sure, because I think we provided a lot of that. So I want to make sure we don't just provide the same information, and we're missing something.

So if it's just that we can make sure we sharpen our response .

MR. GILLESPIE: Yes, we're trying to be very - this is really a very incremental meeting. We're really trying to deal with the piece that we don't feel that we have.

And right now if this is the grid, and you take a six by six measurement -

MR. ASHAR: There's 49 probes in it.

MR. GILLESPIE: There's 49 probes. I think, Hans, a fundamental question was, but you come up with a single point that is than used in the next level of calculation. We're not pushing the next level of calculation; what we're doing is saying, how was that point come up with? Was it a 95 percent? There's a number of ways that are actually all valid to do it. Was it the median of the 49 measurements? Was it a 95 percent confidence level? How were those 49 points combined to get to the one point which was than used at the next calculational level.

And by the way if there is anything that you want to actually respond to in writing like, we

really didn't understand that. We think we answered it in response this, this and this, following this meeting, feel free to send us that.

MR. GALLAGHER: Okay.

MR. GILLESPIE: That's quite - because what I really want to do is, this is a starting point, to get clarity in every one of these details. Because I think we are down in the details. I will fully concede we are really fine tuning it.

MR. GALLAGHER: And that's what I was getting at in how that 49 point array, how the statistical analysis is done. I think we've provided that answer. We can look at it.

And then about the disclaimer, we can specifically talk about that. Because I think like Pete said, the intent on that was, the data was taken in the field, and that was validated. And that data was used in this analysis.

And it's just saying, we didn't take the data. All we did was do a statistical analysis.

MR. GILLESPIE: So just make it clear on how that report was used, and then we're kind of okay there.

And if you write us a letter and it says, in reply, in reply RAI this, we think we've answered this specific question, that would allow us to reply back, no, here's the specifics of what is missing in that. And that's a perfectly - I mean that's all part of the process.

Believe me, you flooded us with so much information, could we have missed something? Yes. And that's okay.

MR. GALLAGHER: We wouldn't have talked

about that disclaimer.

Pete, did you have something?

MR. TAMBURRO: Yes, I just wanted to make sure I understood a point you made. You would like a description of how we started with the 49 points and came up with a representative value for those 49 points?

MR. GILLESPIE: I believe that's the point that Hans and I - Hans, why don't you.

MR. ASHAR: Let me explain.

I think some of the readings that you have taken are based on the grid. Some of the measurements you might have taken isolated away from the grid, or may not have used the grid. I'm not sure what was done where.

But that doesn't matter. The important thing is how you really used this data in coming out with the final thicknesses at those points, that is important.

MR. GALLAGHER: For the grids.

MR. ASHAR: For the grids, yes.

MR. GILLESPIE: So what we're seeing is a layering in this calculational process, where you start with raw data and then you do one thing to that, and then you do the next thing.

And we're down at the real fine tuned question here at the bottom. And it's that detail that we're not sure that we have.

Now it might have been submitted in 1990; I give you that. Could you repackage it and get it back to us?

It may be easier for you to do that than for us to do it again.

MR. ASHAR: I might say that you might have even provided some description as a result of the audit.

MR. GALLAGHER: Yes, that's what I was just referring to.

MR. ASHAR: I understand. I did not have a chance to see everything that they have acquired and have responded to.

MR. GALLAGHER: Oh, okay.

MR. ASHAR: Not all. I am aware of it, most of them, the basic things. But I did not see anything related to this one. But if it is there, just give an answer.

MR. GALLAGHER: That would be helpful, because we can pinpoint it, and then we can go from there.

MR. ASHAR: But to me, it looked like at least in 1990 it appears that this particular report was used, and to what extent it was used is not quite clear. How does it relate to what you did, and responded to as a part of the AMP questions, I don't know.

MR. GALLAGHER: Right, okay.

Now, Pete, Ahmed, you guys okay with understanding that, Howie?

MR. OUAOU: I understand the question. This is Ahmed again with Exelon. Part of that response was provided in the RAI and in the questions. So we'll go back and take a look specifically and look at that concern.

But we're not providing a response to you.

MR. GILLESPIE: No, no, again, it's perfectly acceptable for you to say, go back, go back

to New Jersey and say, you know what, we understand your concern, and we think we addressed this is in these RAIs, and the RAIs we have completed reviewed, in fact with multiple people. And if it makes sense that we're looking at how these 49 points - and there may be points that weren't grid points, that weren't 49 points, that were individual measurements, or maybe smaller samples. It's not clear that they were all uniformly 49 points, they were all uniform grids. That level of detail was not necessarily seen.

And I will say that we are trying to get you this information as we're putting our draft SE together so we can get these issues closed out.

MR. OUAOU: Again, this is Ahmed again, the reason I was kind of, I guess, thinking a little bit, it's such a straightforward question, we can answer that today.

MR. GILLESPIE: Again, my promise was, we have a second meeting scheduled, and we'd really like to get it in writing before that meeting so we can have a substantive meeting.

It was important for me, because of the detailed nature of our concerns, to get them to you and make sure you understood them. And I didn't say they were hard to answer. So just because we have a concern doesn't mean it's difficult to answer. What we wanted to do was get this kind of detail to you so you could answer it, and that was the important aspect.

MR. GALLAGHER: I think we understand that.

USE OF ASME CODE SECTION 3 SECTION NE-3213.10 FOR LOCALIZED CORROSION AREAS

MR. GILLESPIE: The next point was use of ASME Code Section III, Section NE-3213.10 - now you know why I say we'll publish the meeting minutes to this early - was used for localized corrosion areas. And this is a comment that is also going to come up later.

And by the way, this is all dealing with the 1991 GE report. So it's not that you used it; it's that it was used in the 1991 GE report. In general that code was written for and applicable to new containment shells. And the methodology for the buckling calculation, it's not clear its applicability to a shell that's actually older and has corrosion.

And I'm going to get Hans to amplify that, but in my simplistic terms - I get to be the non-engineering interpreter, and he gets to put the details on it - if things corrode in a manner that's pitting or discontinuous, and you have a shape that is much different than the discontinuity from two different sized plates.

And so this code was specifically developed for one purpose. That doesn't mean it's wrong to use it for this purpose; what it means is, the transition to using it for this purpose wasn't included in the 1991 GE report.

Now with that I'm going to turn it over to Hans.

MR. ASHAR: Let me just narrate the way I formulated the question.

For the localized thin areas, the applicant is using the provision of Section 3213.10 of the subsection NE of Section III of the ASME Code. This provision, though not directly applicable to the

randomly thin areas caused by corrosion, if used with care and adequate conservatism, may provide some idea about the primary stress levels at the junction of the thin and thick areas. The applicant is requested to provide a summary of the process used and to address this issue.

MR. GALLAGHER: In this particular analysis, I note that that particular question was looked at earlier when the analysis was originally reviewed and approved.

And I think, did we have discussion about that in the Q&As?

MR. OUAOU: This is Ahmed Ouaou again with Exelon. There was a discussion in the Q&As on the issue - on the concern. We spent a lot of time with the audit team talking about the calculation in particular, and it was reviewed by the audit team.

This same question that you have a concern was asked - again, I have to go back a little bit, because I spent a lot of time looking at the history on this - the same exact question came back in `91, and we - there was a formal report that was generated and submitted to address the question. It was done by Teledyne; it's not the GE report. It's in response to an RAI.

Our understanding is that after review of the calculation at the site that it appeared the approach was reasonable that it should not be a concern from a stress concentration perspective.

MR. GALLAGHER: And this review was done when the 1991 account was generated?

MR. OUAOU: That's correct.

MR. GALLAGHER: So what we were looking at,

we didn't see how there was any aging management related effect on the differences between the way it was evaluated before and when it was evaluated now.

MR. ASHAR: Let me again restate.

The question is, this particular provision in the ASME code is not written for the localized corroded areas. It has been used here between thin and thicker parts to justify the use of, you know, in a particular way.

Now I can see that there is no other way you can do that except to use this type of provisions. But I want to understand what kind of conservatism you have used.

Because there are a number of items related to this provision that are in the ASME code. For example, for primary membrane stress there is one particular areas where you go up to the square root of RT; for the secondary stress, you go to the 2.5 square root RT, and figure it out as to, now, I want to make sure that you have considered representation of the thin areas in this particular process.

MR. GALLAGHER: I think that's helpful, Hans. Because we didn't identify any other specific method to use, other than use this. And then there were some I guess checks that was done for, like, one thing Frank mentioned was about the plate changes; that was one check. Another check was done as far as a one-by-one depression, a one-by-one-foot depression in the shell; and then another would be a fairly localized 2-1/2 inch depression.

So they were kind of checks that said, they didn't look like there was any significant impact on the analysis.

The roughness looked like to us it'd be more of a - maybe it related to a fatigue concern, which really isn't an issue for the drywell.

So that's why that kind of a review, I think, was done in the 1991 review and analysis, and the staff had accepted that at that point.

And I don't think there's any methods that's changed since.

MR. ASHAR: This is for the license renewal we are talking about. So I understand that the staff will issue a report based on certain things.

But we are looking at this in more depth. And we want to understand the mechanism before we go and say, hey, this is the reasonable assurance that something would happen.

So you might see this as duplicative or something, in your mind, but for us that information is necessary to make that reasonableness estimate.

So even if you might have done something, you might have responded to this type of question in past, in 1992, 1993, I think we would like you to tell us more about it. If you done it during the audit team, please let us know about it. We can go and check it out in the AMP's responses. There is nothing - but I just want for you to understand that you understand the question.

MR. GILLESPIE: Yeah, this is not to say you haven't done it before, and it's part of everything that happened from the mid-`80s through `91. It wasn't reviewed by the staff for the purposes of the current existing license. But this is a question as part of the renewal review.

And if we're requesting you to repackage

something and send it in as part of this, then that's our request, because we're a second time dealing with what I said was the uncertainties. We're not saying anything negative about the GE calculation. What we're saying is, we have a set of reviews reviewing this for another 20 years on your license beyond, and so this is an aging issue.

I mean we met with ACRS on this yesterday. We're not saying you didn't do it 20 years ago. What we're saying is, it's not really readily available to the staff to be able to include it in their more global judgment on the liner today.

So if pulling it out of your records and getting the Teledyne report, if that's easy - I didn't say we were asking anything that was hard. I said we were going to try to give you our specific concerns.

MR. OUAOU: The Teledyne report was not in QA. But we can provide the Teledyne report and several correspondences to that address the question.

MR. GILLESPIE: That would be appreciated. Remember our goal here is to answer the questions. This is a bit collaborative in nature.

The other thing I have to ask your forbearance in part of our idea of trying to stay on a certain schedule is that things get done in parallel. And the audit team is in the process of writing a report, and the last I heard they were on page 700. And they have to look at it in an integrative way also. And that is one input to the SE.

But that's input eventually to Hans. Because Hans is the guy who on the line has to really make the safety judgment on behalf of the agency.

So I'm asking for your assistance. If it's a bit of repackaging, or a resubmittal, this is what's going to get the job done.

MR. GALLAGHER: Okay, so if we describe this analysis, and what - how we think it was put together to conservatively address some of these issues, then we could do that and talk about the Teledyne work. And I guess, I want to make sure, Hans, do you have any other methodology that we should be looking at?

MR. ASHAR: Well, yes, I think I'd refer to one report which Sandia developed for big area of containments. But I don't know to the extent to this particular aspect, it addresses that area.

What it does is, it models certain enclosures and certain degradation in containments of various types. It's a Mark I, Mark II, all containments have been considered in those.

MR. GALLAGHER: Okay, that report is available? We hadn't found that report, had we?

MR. ASHAR: I know. I'll try to get it.

MR. GALLAGHER: Can we get that today? Because that would be real important to us.

MR. GILLESPIE: Yes, if we get the ML number, since we're adjourning at lunch.

MR. ASHAR: Yes, we'll put it in ADAMS.

MR. GALLAGHER: That would be helpful, because we can review that report.

MR. GILLESPIE: And it may be as easy as saying, here's what we're done. Here's this other report that's a little newer. And here's why we're consistent with it, and why this makes sense.

But that's your judgment to do. We're

trying to give you our concern, and Hans is trying to give you at least one reference that's available to kind of the NRC sponsor which is kind of a benchmark.

And again, we're dealing with the uncertainty of the information at a very fine level, so.

MR. OUAOU: Again, this is Ahmed Ouaou. I just want to ask a question.

Do I understand you to say that that report, the Sandia report, has a benchmark we should be measuring against?

MR. ASHAR: I don't think so. The reason I don't recommend that is because it is meant only for internal reference.

MR. OUAOU: This is information?

MR. ASHAR: To the extent you can use it. It is not something that is endorsed for use for anybody.

MR. OUAOU: Do you know of any other methodology that would take surface corrosion areas that you're concerned with?

MR. ASHAR: No, I'm not aware of any.

MR. OUAOU: You're not aware of any? Okay, thank you.

MR. GALLAGHER: And we had looked at it, that stress ride issue looked like it was more of a fatigue issue, and the containment fatigue really isn't a concern.

MR. ASHAR: Well, containment for the ease of concern in the area of events, right.

MR. GALLAGHER: Right.

MR. ASHAR: But away from there, you don't have that concern.

MR. GALLAGHER: That's correct.

MR. GILLESPIE: But again, this is not saying you don't have the information on site. It's only saying we don't have it in a form which we can identify that it specifically addresses this question.

And so if you can help put that information in a form that specifically addresses the question - this is why I didn't want to get - this is why I said, let's have a meeting, versus writing RAIs where we didn't - have a total misinterpretation of the RAIs.

MR. GALLAGHER: Yes, right.

MR. GILLESPIE: So again if you get back to the site, and you want to email us, because emails are on the record, and we try to keep everything on the record, to get further amplification, that's perfectly. And you know if you have thoughts when you go back, just say - you know.

MR. GALLAGHER: Okay, that's helpful, thank you.

MR. GILLESPIE: We finished with - this was really the assumptions in the 1991 GE report section. And so there were really two bullets that we had in summary. And that was, the first was the uncertainties in ultrasonic testing results, and this was the grid thing we talked about, and then the next one.

And the first one was just for you to know that we're going to do something of an independent nature to verify the calculation. And that's not an action on you, that's an action on us.

VALIDATION OF UT MEASUREMENTS AND BUCKLING ANALYSIS

The next major topic - and major doesn't

mean important; major just means it's the next heading on my notes - is validation of UT measurements and buckling analysis.

In this I have three principal notes, and let me just go through them. And the first note is, UT results indicating increase in shell thickness. And there was this anomalous point.

And the anomalous point raises questions that are probably unanswerable. So let me say in retrospect, looking back, the answer to the specific question might be unanswerable going back, but the actions to be taken in the future might be very doable. And that's questions on the accuracy of measurements, the appropriateness of calibration, the one point was significantly above the curve.

So with that, let me turn that one over to Hans, so he can go into details of that concern.

MR. ASHAR: Okay, I'm going to narrate that again.

In the sand pocket region of a drywell shell, the most susceptible base are incorporated into assembly. However, there are a number of issues that need to be addressed to ensure that the readings are taken at the vulnerable locations and techniques used are reliable.

I'm talking about the technique right now first, and then I'm going to talk about the other points. That will come with discussion of the other bullets.

Review of table two indicates that the UT measurements taken from inside the drywell after 1992 shows a general increase in the measurement taken from inside the metal thickness. In some cases it

increases as much as 50 mils in a two-year time frame.

MR. GALLAGHER: What was that number?

MR. ASHAR: Fifty mils.

MR. GALLAGHER: Fifteen?

MR. ASHAR: Fifty, 5-0.

MR. GALLAGHER: Oh, 50.

MR. ASHAR: Fifty mils within a time frame of two inspections, 1994 and 1996, I think.

In general it appears that the UT measurements taken after 1992 requires proper calibration considering the coatings on both sides of the drywell shell.

The applicant is requested to address this issue.

MR. GILLESPIE: Now, again, as I said, you can't go back and fix what is.

MR. ASHAR: Well, Frank, I don't agree. I think if the tests done outside on an epoxy-coated and galvanized inside, and you've calibrated that, the readings taken earlier can be reduced to this.

It's possible to do it too to the existing - but I don't know what you want to do.

MR. GILLESPIE: What you're saying is, if they did some calibration samples, that had the proper codings on either side, there may be the data available in their records to go back and -

MR. ASHAR: Yes, compare what they have done earlier with or without coatings, you know, that kind of thing.

MR. OUAOU: Again, this is Ahmed with Exelon. I was surprised, too, that those points were as high as they are. We expected some variation because of surface roughness, of the shell itself.

Although we use a template, and we use a probe. If you just happen to move the probe just a little bit you would get a different reading.

But in that particular `92, it appears that one set of readings were consistently higher than the rest. And we spent a lot of time trying to find the cause that caused that, and talked to Rich Morante at the site there during the audit review. And frankly, what they came up with I'm not sure that's satisfactory.

We just couldn't. Qualified people were doing the testing, same methodology that was used before. We haven't looked at the potential, because there is a grease where you do UT measurements, potentially, that might not have been removed. We looked at all that, but really couldn't come up with a specific answer why those values were higher.

MR. TAMBURRO: Going forward, the potential items that we've looked at, we're going to reduce or eliminate them. For example the grease will be removed prior to the inspections. We will do calibrations, both on the external coating and the internal coating, to get an understanding of how they affect the measurements.

So we intend on reducing all those potential variants out of the future inspections.

MR. GILLESPIE: The importance of this issue may be one, the narrow technical issue itself. And it's a good response. Didn't really need it, but it was a good response.

But it does contribute to the general thought we have which we'll get to later when we talk about some of the commitments you made already on the

level of uncertainty. And these things just contribute to the level of uncertainty of the measurement.

And I would use - maybe it's not invalidating the measurement, but it's the uncertainty involved with any individual measurement, and the trend.

And uncertainty, like I said in the beginning, is kind of what we're trying to reduce or understand through all of these points.

And so I think the idea that you can only make these measurements just so certain, and just - let's just keep it - there's only so much you can do with these kind of UT measurements.

But this seemed to be a very large uncertainty, in fact much in exceedance of some of the things you've actually measured in other areas. relative to thickness changes.

So as long as you understand our concern, this - minimize the contribution of these to uncertainty, and if you can't do anything about the past one, you can't; you did this examination then.

But this contributes to some of the thoughts we have relative to the 10-year commitment that we'll talk about later.

MR. ASHAR: I feel that you will have to do some kind of a comparative testing in order to, at least for the future readings that you take is going to influence that.

If that was the cause, because of a coatings on two sides, this thing we have normal readings that showed more thickness than the other thicknesses, then I think it is something that you

ought to look into it and come to grips with it.

MR. GALLAGHER: How many points did you have a concern with, Hans, do you remember?

MR. ASHAR: Well, I just think in general. Just like Ahmed said before, in general you can see when you look at the readings that they are increasing in 1996 compared to 1994. 1992 and 1994 are almost same; they are not changing too much in general. But there are a few places where it is about 30 mils higher or 50 mils higher, like that, you know.

So there's an anomaly here, and that has to be resolved.

MR. OUAOU: If I may just add, that we're benchmarking other people doing the UT measurements in the past, but that was before 1996. For instance, GE - GPO brought in GE to do some UT measurements. And I don't believe the methodology has changed in the way we did it.

Whatever, we couldn't explain it. We couldn't explain why these particular points were that much different than the previous UT measurements.

MR. GILLESPIE: Just keep the word uncertainty in mind, and let's move on. We live with uncertainty; we're not asking for absolutes.

The next item is sensitivity studies for localized corroded areas. And I'm going to turn this one over to Hans, because my notes are that we basically have - we've only reviewed the results in the application on these reference sensitivity studies. And that we really weren't provided with an expansion of what was - how was the sensitivity study done, how were uncertainties considered in it; that there's kind of an absence of detail at the next level

down.

And because we didn't get the detail, I can't give you a specific question on what's missing. So let me ask Hans on that one, because I think he's at the same loss I am on that one.

MR. ASHAR: Yes, that is true.

I think I did point out about sensitiveness, that they have to be correct enough that we have confidence that the metal thickness is what it's measuring. That is all I can say at this time.

MR. GALLAGHER: What sensitivity studies are we talking about?

MR. ASHAR: What we are talking about, as I explained earlier, that you take a plate, similar plate, and take the UT measurements outside, without any coatings inside. And then you take the measurements with zinc oxide, whatever coating you have applied inside, and outside epoxy coating, and see - the measurements - and see if there is any - I mean you have to take enough sample to make sure that you have got confidence in what you are doing, even for the tests. This is what we are thinking.

It's up to you.

MR. OUAOU: This is Ahmed with Exelon. Inside, we don't have a coated -

MR. TAMBURRO: No, we have a protective grease. They're supposed to clean off that in the grid area, clean it off and then do the -

MR. GILLESPIE: Then I think you're exactly where I think Hans is at, is, there was no evidence in the submission, I think it talked about doing the representativeness, but there was no description that

would say, okay, we do it with the grease steam blasted off and we do it actually under conditions that are in containment where they may wipe it down with acetone or something else to get it clean, just to get a handle on the uncertainty involved in the measurement itself.

Remember, all the topics we're talking about now are really uncertainties involved in the UT measurements. And we're trying to get an understanding of, how do you think about them, and what have you don't to make sure you have a handle on the uncertainties.

And in this case, it wasn't really - the description, you've already said more here than we've had in the application dealing with the uncertainty. We have an organic grease; we clean it off. So what we're looking for is some understanding so Hans can say, you know what, that's a pretty credible way to understand the uncertainty involved with the measurement technique being applied.

MR. TAMBURRO: This is Pete Tamburro again. So when you said sensitivity, you're really talking about sensitivity testing of how we do our ultrasonic tests.

MR. GILLESPIE: You might say, what you're doing to assure yourselves that you've got a handle that the reading coming out - and I know that every utility has a program that does this kind of qualification thing. It just wasn't described in there. And the sensitivity here is a large component very much of interest, and that information just wasn't there.

On the other hand, we didn't ask you for

it.

MR. GALLAGHER: Okay, thank you.

MR. GILLESPIE: So it wasn't your fault it wasn't there; we didn't ask you for it. So we're asking this. That's why we're putting it on the table right now.

And again, I think you probably have a program there.

MR. OUAOU: No, this was not in the QA. In the QA we said that we're going to take the UT measurements through the epoxy coating on the outside, because it was qualified previously; and we're going to use the most up-to-date techniques to do that.

MR. GILLESPIE: What is the most up-to-date techniques for Oyster Creek?

MR. GALLAGHER: So we'll give you a description.

MR. GILLESPIE: Again, I didn't say any of this was hard; I just said we don't feel we have it.

MR. GALLAGHER: Right.

USE OF ASME CODE CASE 284-1

MR. GILLESPIE: One last one - any questions? One more under UT measurements, that is going to be the use of ASME Code Case 284-1. And I want to temper this a little bit, because there is already a 284-2, as best I've been told, out. Neither one have been endorsed by the NRC, but not being endorsed by the NRC actually does not invalidate them.

But it does put a burden on you into having to convince us on the applicability. And these deal with buckling of the shell.

And the validation of the underlying assumptions, you can't depend on ASME, because you're

using it, and they haven't - we haven't really looked at it on their behalf yet. And that's kind of how I understand the issue.

But now I want to turn to Hans for the details on this one.

MR. ASHAR: Yes, this Code Case has been within the agency for a number of years now, since it was, the first one was proposed by Dr. Miller, who had done the testing, and committed to all the results.

Now we did not endorse it during review of reactors for the buckling analysis, 284-1. We did take a Branch Position during that time. And in addition to what they have done in 284-1, we require them to do more in the bifurcation analysis, and reduce the plasticity index, and those kind of stuff.

284-2, which ASME still is struggling with, has a number of changes made in this area, and that is - and with the typographical corrections that they are making right now, put into the equations. Because that makes a lot of difference in the research you have.

So I think that looks to be something acceptable you might accept in the future. Until now there is uncertainty regarding the use of 284-1.

Now, if it is used only the way I saw it being used is in one particular provision that is quoted in response to the TLAA is that you have assumed that the stresses are uniform along the thickness of the metal.

Now in the case of a localized corroded area, that may not be the case. Because when you start from a corroded area to an uncorroded area, you lose metal thickness. But it might have a lower

strength than the strength than you go up above at the end of the plate.

Okay, if it's conservative, that's fine, use it. But I believe it may not be conservative. Because there will be a decreasing strength as you go near the corroded area. And it might show you as the metal thickness, but the strength may be different.

MR. GILLESPIE: Basically you've got that oxide layer on the outside. And we're not saying it's right or wrong. As I said, endorsement or not endorsement doesn't affect the applicability, but it puts the burden on you, because we have not accepted it in this application to give us the explanation of why you still think it remains conservative enough.

And this is in addition to the RAI. It's kind of the next level of detail down on that RAI.

MR. OUAOU: And again, Ahmed with Exelon, we did, spent a lot of time at the site review on this particular item. And the calculations that were based on 284-1 were reviewed. And the conclusion is that the impact of 284 for what we're using it for is not significant.

There are a number of questions that deal with those provided in response to these questions, as well as the previous discussion, back in `91 or whatever, that came up when this was used.

But one of the things -

MR. GALLAGHER: Just one question I have here, isn't this really the same issue as item two, the `91 GE document.

MR. ASHAR: Well, they have different implications. One thing is about the area considered for discontinuity analysis, and one is about the

buckling analysis itself. So those are two different aspects there.

MR. GILLESPIE: In principle you could say it's ASME code and (garbled) code. In principle and philosophically even. One is dealing with some of the assumptions in the GE calculation, and this one is really dealing -

MR. ASHAR: The buckling analysis.

MR. GILLESPIE: -- with the buckling analysis.

MR. GALLAGHER: The other one was related to the buckling analysis also, right?

MR. ASHAR: Well, not necessarily.

MR. OUAOU: The difference with 284 is, that's what's actually again the capacity factor.

MR. ASHAR: Capacity factor. That is where -

MR. OUAOU: -- factors that you use to correct your allowable stress to come up with a stress at the end.

MR. GALLAGHER: So did we provide a description of the use of the Code Case 284?

MR. OUAOU: It was not in the RAI; it was in questions. Yes.

MR. GILLESPIE: So again, we have two processes going on. And the audit guys are still writing their piece up.

But if you feel you've answered it, but you need to understand Hans' specific concern is still lingering in his parallel collection process is the application of this code.

And we put this under UT measurement and buckling analysis, because it's how you take the

measurement itself, as I understand it, and then incorporate that into the calculation, which is a little different than the translation we talked about in the calculation, the other ASME code piece.

What I'm trying to do is, we'll get it on the table here. The audit process is going on in parallel. And if you feel, if you can point to the Q&A that it's answered, and just for convenience, you'll be helping us out, for Hans. We're not trying to make you recreate a whole new report if you've already given us the information.

We'll internally check with the audit team on the Q&As on this, but if you want to hold our feet to the fire, because we've already asked it to you, and email it in, that would be appreciated too, and we'll make sure we get the point covered.

But you need to know right now in the overall evaluation, this is right now kind of an unanswered issue.

MR. ASHAR: The main thing is that in the response that you provided to the TLAA you say you made use of a particular provision 1700, which is - allows you to use it as the same test level throughout the thickness. Now the point that I am trying to make, it may not be true. So there might be a possible distribution of the strength, and you might have a different output from that pint. The analysis is based on this type of assumption.

So I want to make sure that you are doing the right thing.

MR. GALLAGHER: Is there a different code case or assumption we should be using?

MR. ASHAR: No, I think it would be -

because this is very specific to the characterization of the various containments. You have to make a certain judgment as to how the strength near the core area would be as compared to away from the core area, and make a - if you have done the average strength analysis, it will not be conservative, and you might have to pull your neutral axis up, and it might change the character of you compressive stresses. That's what I'm thinking about.

MR. GILLESPIE: Mike, it's plant specific, and ASME, as I understand it, doesn't really have a lot of code cases that go out to 60 year lives, and deal with longer term corrosion issues, and the specific effects, and how they may modify codes that were actually there for design codes.

And so we have to look to you to now explain the application. And we're not saying the application is wrong; we're only saying, you need to explain this piece to us on the application.

So we're not telling you to do it different. We're only saying, again, this contributes to the uncertainty of the application of it. And if you've answered this in the RAI database and you can point that out to us, and we'll check internally, that's fine.

But this as of this morning is kind of an uncertainty in the engineering case.

MR. GALLAGHER: Okay, you guys have any other questions related to that.

MR. OUAOU: No, understood.

MR. GALLAGHER: Good, because when he starts going into moving the axes on compressive stresses, that's why he has to sit here.

MR. GILLESPIE: Okay, next topic, and in fact, the last topic, and again, we're trying to be as fine tuned and as crisp as we can, because if we sent you some general RAI to try to get where I hope we're getting at this meeting, it would not have the specifics that just transpired right here in it, so that we can nail this thing down.

ULTRASONIC TESTING ISSUES

Ultrasonic testing issues: And now we're shifting not to the technique, and not to the 1981 report, but sample size and sample locations.

And again, we have - I'm going to say - three areas of clarification that are needed.

And this one is junctions between plates of different thicknesses. The generalization that I'm understanding is, the reason for which points are being selected where. And now we're really talking about the upper parts, and the representativeness, bad word, how representative the points you're using are to the whole, which if it was demonstrated 20 years ago, it's not clear that there has been a redemonstration, as we're trying to add yet another 20 years on to the license.

And so with that, let me turn this one again over to Hans for some detail.

MR. ASHAR: I'm going to go through three areas here, okay. The cylindrical portion of the sample size and the spherical portion of the sample size and the sanbed area.

The samples taken at this time in the upper portion of the cylindrical portion it is taken I think at one elevation of 87 foot 5 inch. Represent a cylindrical portion of a drywell, and then it is our

suggestion at least for the future UT results to add one more elevation for taking the samples, which is 71.6 inches.

And what the significance of that particular elevation is that is where the lower thickness meets the knuckle (phonetic) area. And the question here is that if the water even in a small conduit is passing through there, it is going to stagnate in the area there, because the ledges form in that area on the upside. And that is where the water is going to accumulate, or it might be absorbed into the insulation itself, wouldn't know what would happen.

But that is a sensitive area which could be subject to more corrosion than the straight portion of the cylindrical area.

So our suggestion for the future is to have you include that area near the junction of the -- to get a confidence that you are good enough, your sample size, enough locations taken.

MR. GALLAGHER: So this is elevation 71.6?

MR. ASHAR: 71.6, that is the suggestion. You might not have platform there, you might have do something else. So you may change a little bit here and there. But the point is that the dissimilar thickness, wherever you go to the joint between the courses, you know, thickness courses.

MR. GALLAGHER: Just where the knuckle is.

MR. ASHAR: Just before the knuckle.

MR. TAMBURRO: This is Pete Tamburro.

So are you asking to take a representative sample of one plate, and then the weld, and then another plate?

MR. ASHAR: Yeah, I think if you use the 6X6 grate in the grated area you can cover the whole, including weld and everything, in one grid.

MR. GILLESPIE: Remember, the underlying question is, because we're not telling you what to do. What Hans has done is very nicely given you a specific example of where he feels the physical configuration forms an area which could be conducive to higher corrosion rates than potentially your sample that you're taking.

So the real question is the representativeness of your current sample as we go forward for even another 20 years. And it's not that we're asking you to do this everytime; what we're asking you to do is reinforce the assertion that your current sample is in fact representative. But we've noted that you haven't been looking at this area which by physical configuration could be picked out as maybe a high corrosion area.

So it's kind of the validation of what you're doing, and so it - I guess what we're asking is, remove this uncertainty in your sampling process somehow. And the only way we can think to do it is to pick a high corrosion area that's not being sampled and ensure it actually is - continues to be enveloped if you would by the current area.

MR. GALLAGHER: And I guess I'm - I mean we actually did some exploratory on the knuckle area, didn't we, Pete?

MR. TAMBURRO: Yes, we did.

MR. GALLAGHER: In the past. So we have -

MR. GILLESPIE: Sometimes you only have to document what you did if you did a good job.

MR. GALLAGHER: Yeah, this drywell has been very thoroughly looked at over the years. So the chances are, we have that data, and I think we talked about that earlier.

MR. ASHAR: Yes, I would have relied on the thousand UTs you have done before. But because of the continuing water -

MR. GILLESPIE: Yeah, there's an operating history there that gives us a concern in operations. And again, we're updating - you know, in always sampling a measurement, what you're really trying to do is bring the applicability of that calculation up to date, and that's really -- and the only way to do that sometimes is a positive measurement.

And so yes, you might have done it 15 years ago, but there's been an operating history and an experience base since then which has affected the environment in that gap.

And so it's your option. You can either explain why 15 years ago applies to today, given all of that operating history, or positive knowledge on both of our parts, versus arguing words and pencil notes, well, take a measurement.

MR. GALLAGHER: No, I think it's a good idea.

MR. GILLESPIE: You know what I mean? It eliminates all the bias, and to a degree the uncertainty, and gives you a new point to project. Because you're asking for a license for an additional 20 years.

And so we had confidence in that assertion for the remaining portion of your current license, which is 2009, and now we need something a little more

to project that past 2009 for an additional half a life.

MR. GALLAGHER: Yeah, I think that's a good idea. I just wanted to make sure you knew we'd looked at that.

MR. GILLESPIE: I didn't know you had looked at that area, because it wasn't part of the application.

But again, you have to understand our concern. It's not just isolated to that area; it's that area combined with operating history subsequent to those measurements being taken.

Again, to revalidate the trends, revalidate the calculations. So we're kind of looking at a revalidation process given the operating history.

MR. GALLAGHER: Okay, so any other questions on that, guys?

MR. ASHAR: A similar request in the area where the thickness of I think .622 missed the 1.548 thick area. There is the area likely to be - there is some accumulation of water if anything is going on. Similar to the cylindrical portion. The junction of the thickness change.

MR. OUAOU: This is aside that region -

MR. ASHAR: No, above the same region.

MR. OUAOU: So from 1.154 to .77.

MR. ASHAR: Exactly.

MR. OUAOU: Okay.

MR. GILLESPIE: So the plate above the -

MR. OUAOU: Right.

MR. GILLESPIE: That joint right there.

MR. OUAOU: Yeah.

MR. OUAOU: This is Ahmed again. One

thing I'm not totally sure on yet, I understand the differences in the thicknesses. But typically you grind that so you wouldn't have that. We have to go back to confirm that. So I just wanted to mention, typically you wouldn't leave a discontinuity like that going from one thickness to the other without grinding it.

MR. ASHAR: Well, if they use a groove weld to weld those two courses, I think you are going to have a ledge. There won't be a transition there.

MR. GILLESPIE: Again, the big question is, the representativeness of the current sampling program for areas that when another engineer looks at it says you could have a ledge there.

Again, we are not here to give you the answer; we're giving you our concerns. And there are two ways you can do it, and there are a combination of two ways you can explain it.

MR. OUAOU: The only thing I may add is that when the investigative work was going on to come up with the very 1,000 UT measurements to find the thin areas, we didn't stay away - I don't think we stayed away from the areas where we transitioned from one plate to the other, especially when you do that from the outside.

You move the template along the elevation to see where you have a corrosion, and you don't specifically say I'm going to exclude this area because it's not -

MR. GILLESPIE: Again, that was for the life of the current license. And really what you're asking for in renewal space in your application, fundamentally, is to take that projection and now move

it forward now almost 17 years or 20 years to the end of the license, and you're asking the NRC to make another 20-year judgment.

We're fundamentally remaking the 20-year judgment we made before. And so it's the same technical issues, are still the same technical issues, and again, it's your choice. But what we're looking for is the least uncertainty on the measurement of making this projection forward 20 years that's also rational. And it's your judgment.

So you understand, we still have this uncertainty. We're not negating the finding from 1991, but you're asking us to take that and now move it forward, and all Hans is saying is, actually no new positive measure which now we're not arguing calculations or philosophy, there is no new positive measure in this area of potential. We're not saying it is a high area, but there is a potential, normal industry practices grind down welds and make them smooth. We're also not disagreeing with that.

But it seems that you need to understand our concern is, in just looking at the physical arrangement, this is an area of potentially higher corrosion, and we're asking why is your current sample set still representative of that area?

If the explanation is, we were 1,000 percent sure that this was ground down, and that there are no crevices or anything in that grinding that could catch water, that's one way of doing it.

There are two approaches to everything.

MR. GALLAGHER: And I think what you're saying, Frank, is that some of these areas that helps to narrow the uncertainty. So I think we -

MR. GILLESPIE: Remember, we're trying to be as clear as possible to you.

MR. ASHAR: In the pocket region of the drywell shell, the most susceptible bays are incorporated in the sampling, the present sampling is fine.

However, there are a number of issues that need to be addressed to ensure that readings are taken at whatever locations, and techniques used are reliable.

It is not clear if the junction between the 1.154 inch plate and the .676 inch plate, which I think I had explained to Ahmed when I was there in audit on April 28th.

That area - we do have a concern in that area. Because you took out the sand from the sand pocket area, before you put the ceiling in the junction between the steel and the concrete, quite a bit of amount of water might have seeped through in those areas, and might have caused corrosion in those areas.

And the way we are writing is, we'd prefer that you try to find out some technique to measure the thicknesses in those areas and alleviate any doubt about there is no corrosion. Or if there is corrosion, then you know about it, how much it is. Or justify why this area should not be included in the sand pocket areas.

You understand what junction I'm talking about?

MR. GILLESPIE: Let me give you a little more amplification on this, because Oyster Creek is not alone on this. We had an ACRS meeting yesterday

where this area between the concrete steel concrete sandwich, in there, were addressed.

And as best I understand it right now, there really is likely - while we have some research going on in this area, and a research letter from Oak Ridge available, this is not an area where I think - and I think we recognize this - that there is a lot of commercial activity. It's accurately being able to measure through concrete, through steel, and into concrete in that environment, without chipping concrete out, and we have to be, at ACRS, talking to a licensee that actually chipped concrete out yesterday.

But some of the discussion went on, with ACRS. And again Hans' second comment was, provide us at least with a rationale that is coherent and makes sense. And some of the points that ACRS raised in challenging the staff on our interim staff guidance, where we had to kind of make a rationale for such aspects of the fact that the inside containment temperature is like 130 degrees. And therefore it's going to drive moisture out. The lack of oxygen in the area.

Once it's been sealed, the initial oxidation is going to consume the available free oxygen, and therefore, there is some severe limitations on corrosion.

These are the kinds of things we discussed with ACRS in a broad sense of applicability of how we'd see an applicant trying to address the rationale portion of this, if chipping up the concrete was really not rational.

That explanation I don't believe was in

the RAIs or the application. You have to make it for us. I know what we did as staff to help support our interim staff guidance on why it wasn't more demanding if you would in this area. And these are the kinds of things that were going through our mind. And I want you go away understanding that that's the same thing that was on the record at the ACRS meeting was the kind of rationale the staff had in mind as to why this actually should be. And looking at the chemistry of it, an area of fairly low concern.

But you have to tell us why for your plant it's a fairly low concern with your operating history. And so then there's timing elements about when the seal went on, when various leakages might have occurred, when water could have accumulated, groundwater levels, and the ACRS asked about, what about concrete, it's porous, it contains water. Then an ACRS member said, yeah, but there is no oxygen left.

So it's that rationale, or advanced measurement techniques that might or might not be available. That's not my area; I don't know. As you know we have an Oakridge report, and I think we've already supplied you with our ADAMS number.

MR. ASHAR: ADAMS number.

MR. GALLAGHER: Do we have that report?

MR. GILLESPIE: But let me be careful, I do have to be rational, we're not asking you to be in advance of the state of the art of applicable commercial techniques, and again, in RAIs I couldn't say that, but we're trying to keep this in context. But we do need a signed understanding from you, in your words, as to why this should be a low susceptible

area.

And that's your choice on how to do that, and we've supplied you with the one letter report, and since it's a letter report on a NUREG, that tells you right there, it's very advanced information.

And so you have to digest the information. Just understand our concern, and the rationale we're looking for.

Does that make sense?

MR. OUAOU: I understand. This is Ahmed with Exelon. We understand the question.

We did not provide all that detail you're talking about in the application. We specifically used a NUREG-1001 as a basis why that area is not susceptible to accelerated corrosion.

Basically the idea is, if it's embedded in the concrete, you don't have an adverse environment, chlorides and sulfates, you should not - you know, you have an alkaline environment that is not conducive to corrosion of the shell.

And all those items that you mentioned contribute to why that area is not -

MR. GALLAGHER: So we did not provide that.

MR. OUAOU: We have.

MR. GALLAGHER: Where is that, in the application?

MR. OUAOU: It's in the application; it's in the questions, Q&A. We did not provide, we did not state that it's totally sealed; the oxygen is limited. We didn't get into that detail.

MR. GILLESPIE: Yes, and again we didn't ask for it. Again, we're at a level of detail,

because you did supply us a lot of information in the RAIs, we're really now fine tuning and focusing in on these real specifics.

MR. ASHAR: We did mention about the inaccessible areas, and we did provide certain guidance to if the concrete is like this or that. Then you may not have to do much in that area. But Oyster Creek is a little different animal here, because it has a history of contaminated water going into the sanbed area. It might have seeped through in the area with the thinnest part of the steel is there. Though it is bearing on concrete, still, it is very thin. And if it is rusting, there are problems with it, and with the analysis, too.

MR. GALLAGHER: And as far as the techniques for looking at this, we had looked into that, and we hadn't really found anything.

Did you see anything, Hans?

MR. ASHAR: Yeah, in this Oak Ridge report that Frank talked about does have three separate matters came in. Each will have a different applicability. I don't know which is more suitable. I cannot recommend to you that.

But there is a potential for use of one of those methods. We requested Research to have Oak Ridge National Laboratory conduct a study. They are state of the art kind of report. They give a contract with three separate independent people to develop some kind of techniques to have the metal thickness results being given when the metal is embedded in concrete on both sides; that was the main purpose of it.

So there is some applicable review.

MR. GALLAGHER: And we have that Oak Ridge

report?

MR. OUAOU: We have the - John you have the - yeah, right.

MR. GILLESPIE: But again, I really went out of my way to try to keep that in perspective.

MR. GALLAGHER: Right, so we'll take a look at it.

MR. GILLESPIE: Sometimes people say, the NRC asked me a question, and that's telling them to do something. I'm not. I'm asking, just reevaluate the data. I'm not insisting on people to do the impossible. But it's the rationale and the details underlying it. You didn't give it to us; we didn't ask for it. And that's why we're here saying, this is that little piece that's missing under here.

And as we told ACRS yesterday, although we kind of have a generic position, our generic position is really applicable to facilities that have had no history at all of leakage. And then you step off from that, and when we reviewed Brown's Ferry, they were a little different. You were a little different. Your operating histories are slightly different.

And so the generic applicability strictly of the new reg what we're saying is, there is some customization you have to do specific to your operating history.

MR. GALLAGHER: Okay.

MR. GILLESPIE: Ready for the next one?

MR. GALLAGHER: Yes.

MR. GILLESPIE: Okay.

INSPECTION INCREMENTS WITH UT COMMITMENT

Sanbed region inspection increments associated with UT commitment in letter dated April

4th, 2006, page 3, item two.

This - actually I'm going to get your commitment - don't throw it out. It was a good commitment. Let me try to articulate this one.

And our thinking is, we're trying to be very consistent with the previous thinking back in the `80s. And also with concepts that we kind of have in the maintenance rule and other things. And the idea is, the intent here is to bring all of this technical information that was developed in the early `90s forward, and essentially revalidate for today.

I do understand, in the press clippings, although I don't think you've written it to us, that you were going to do some measurements in 2006.

I read that in the paper. But we probably would - it would be beneficial to have that on the record. And I assume that's your commitment actually to do it, that that's the one you're going to do prior to entering the period.

MR. GALLAGHER: That's correct.

MR. GILLESPIE: Well, I'm making that leap of faith assumption. So the measurement you are going to do prior to entering the period is really the first measurement that's been done since 1996, and there's been a significant amount of history since 1996.

And I'm going to simplify this down to my kind of thinking. It takes two points to have a line in order to have a slope. And there's been some operating history between `96 and now that one point validates to some degree I'm going to say current thickness for the last 15 years.

But then you're asking in your commitment to jump to not do anything for 10 years, okay. Now

I'm going to invoke the concept that we have in the maintenance rule, which is kind of more of an OR gate (phonetic) if you would for any measurement which says, if we do the measurement in `06, and we see some level of degradation which is inconsistent with what you would have predicted, then you're going to do something.

Then if I go to the maintenance rule, it says, I'm going to increase my surveillance frequency.

And then if you increase your surveillance frequency and see with the second measurement that it's stable, then you decrease your surveillance frequency.

What we'd ask is it's - there is no criteria for what happens, what you're going to find in `06. It still leads in our mind to a degree of uncertainty. And we'd like to ask consideration in terms of what's the basis for 10 years? If you say you're going to do something in `06, and if that's part of some criteria, then we're going to do something within four years after that again.

Now you are really consistent with our previous judgments from last time, in which you committed to do several I think measurements I think in a row at four-year intervals.

But then if you come up with a second measurement, and it's better, then there should be an opportunity to extend it past that.

So what we're suggesting is, in our minds, we're looking for some sense of commitment to what happens, what's your criteria if you find something, thinner, thicker. What happens if this measurement comes out like the `96 measurement, and comes out as

growing more?

Then there is a calibration issue I hope.

And so what we're looking for is I'm going to say a bit of a more disciplined reliability approach to the sampling plan maybe as opposed to the rigidity of 10 years.

And there's a sense on our part right now that given our current knowledge base, and the uncertainties in operating history, the uncertainties in the `96 measurement itself, which may not be - you might not be able to do anything - it's 10 years ago. I'm just being realistic.

The coatings are getting older. Yet you aren't going to do the inspections. We're not questioning your inspection regimes, your commitment, that's very good, to do 100 percent in 30 years of commitments. But it is getting older, so there is these degree of uncertainties that more progressive sampling - the broad RAI would be, what is the justification for 10 years?

Because 10 years is independent of what you find in `06?

MR. GALLAGHER: I think one of the things we tried to do, Frank, was, if you look at all those commitments, they're kind of like an integrated package, you know what I mean? Because the agent-management program is an integrated package on that.

And I guess what we were trying to say and maybe it didn't come across, we take the readings before the end of the period and we did have some - and our expectation is that the corrosion has been arrested, and has been arrested since 1996. So our expectation is, we would have similar measurements.

And then we said, we had the criterion, and I think it was plus or minus 21 mils? And it was based on the uncertainties of measuring and equipment.

And then if we were outside of that we would notify the NRC within 48 hours. And we made a commitment to that effect. And that we would have specific actions.

And those specific actions relate to doing the projection, increase the frequency of the testing, and things like that.

We didn't put the decision tree in there, but that's our intent.

MR. GILLESPIE: Okay, and on this aspect - as I said, don't throw out the commitment. The commitment, it was a very good commitment.

Our question really is the decision tree, and we've had this same discussion actually with Nine Mile Island on could you give us the acceptance criteria.

Because while you can assume that everything will be correct, as the regulator, we cannot assume everything will be correct.

And so it's a decision tree that affects inspection frequency. You're reporting to us, all of that was fine. What we're doing is, saying that the specific commitment that says, we're going to do a measurement before we hit the period, and then, really, reading it word for word literal, the next measure is at 10 years.

We're absent that decision logic that you have internally that would make perfect sense. And so on the frequency thing, we're asking, could you give us a relook at that in 10 years, and either

rationalize why 10 years as an absolute is okay, or provide the commitment of what your decision tree is, relative to frequency of remeasuring versus which goals.

Again, you're assuming it won't. And we're regulators, so we have to assume it will. And we need to address both sides.

And quite honestly, I think, in the public's view, they need to have a certain assurance that if this becomes a commitment, or whatever, within the license itself as we reissue it, then it becomes real solid, it's inspectable, and what I'm saying it has all the bells and whistles on it that go with the regulatory process.

So we'd ask you to relook at the 10-year, and you've just described an internal logic that is not visible to people on the outside who read the literal words of that commitment.

So the request is, could you look at the commitment on the 10 years. Because we're reading it like an absolute. Yeah, you report to us, you'll do all those things, but gee, they never said they'd go in and remeasure.

MR. HUFNAGEL: Frank, this is John Hufnagel from Exelon. Just a clarification. Because when I was listening to you, I believe you may have said that even if we went in and found essentially the same result with the ultrasound testing, the 10-year frequency may not be enough.

So I think what Mike described was if we would go in, we would find some degradation, we would consider corrective actions including things such as more frequent inspections.

MR. GILLESPIE: Okay, now we get to the uncertainty issue on that. And that's why I can't give you a specific answer. That's why I said it kind of nebulously.

The uncertainty issue is, if you go in and you do the measurements, and let me say you have the same issues that you had in `96 that were kind of inexplicable but why it grew, then 10 years is probably too much.

And so what I'm dealing with, and I can't do it for you, I'm dealing with, there is an operating history there. There are these uncertainties that in fact you may be within - if it's an asymmetrical 21 mil objective, then you still have the same regulatory question, well, it grew again. They don't have to do anything.

MR. GALLAGHER: Right, and we would take corrective action. So I guess maybe related to the question John just asked, so I guess the corollary would maybe be, if we were within that plus or minus 21 mils, is 10 years okay?

MR. GILLESPIE: There is no absolute on 10 years. Okay? That was what was in your application. There is an uncertainty connected with these measurements. There is a specific uncertainty demonstrated in measurements at Oyster Creek specifically over time.

If you really are trying to bring that forward, you have to make the judgment, is once at the beginning of the period, and doing a second one at four years, and then not doing any more for 16 years, is the right answer.

Because remember, what you're trying to do

is take this calculation and all this body of information from the `80s and `90s and reapply it to a new 20-year period. And if you're going to do two measurements, should that second commitment for all of these questions actually be way out there at 10 years? Or if you're going to do two measurements anyway, should it be at four years or six years? Because that's giving us assurance on the projection of all this body of data forward.

And by the 10th year it's not really contributing to the projection doing forward.

And now I'm going to make a leap of faith to a new topic -

MR. GALLAGHER: Before you go there, Frank?

MR. GILLESPIE: It'll make sense though if you let me do it.

MR. GALLAGHER: All right.

MR. GILLESPIE: Because it'll make sense to why I just said what I'm saying. In the interim staff guidance there is an event aspect to it, which says, if you ever see water, you have to go do a measurement.

And so it's not mutually exclusive. And so if you're committed to two measurements on a frequency that allows us to translate this body of information forward for most of the period, we would still ask you, you have not committed to the ISG relative to that event aspect to it, which says, if you see water, you have to measure again.

And so I'm saying this measurement thing is kind of an integral case. And if you're really good and you never get a leak again, you've still only done two measurements, but you're adding to the

principle of moving the body of knowledge forward.

But if you ever see water again, you are committed to a third measurement.

And so it's a package. I'm agreeing with you; it's a package. And that's not in the commitment. And it's kind of the event based aspect of that ISG which then says, you need to redo your rate calculation and project it forward it forward if you see moisture.

And that's the package I wanted to get out, because it's not like I'm - we've kind of done something thinking on this, and what are we really trying to achieve relative to the staff's approval of your application, and we're trying to approve is that projection forward for the next 20 years.

We're not actually trying to specifically find the thin spot at any given year; we're trying to have enough comfort if you would or faith. And it's faith in that calculation we're trying to get, not just a random measurement at a 10-year point of a vessel.

So it depends on how you look at - what is your objective of doing those measurements. If the objective is a random point in time, to make everyone feel comfortable with something you've already approved, the first thing is, get the piece already approved.

MR. GALLAGHER: We'll definitely look at that, Frank, because again, I think that was our intent, outside this region, we would change the frequency.

But one thing I just want to clarify because even sometimes we fall into this trap, and we

talk about the individual components of the aging management program.

Like people would say, hey, the last management we took was `96, and that's a long time ago. You know we have the advantage at Oyster Creek where that area is accessible now, because we made these modifications. So we've had eyes on on the coding ever since then, that the coding is put on in `92.

So that was our look, ongoing look, to make sure that corrosion was arrested, and was gone. Except so we see that as a real good advantage for us, because we have that area to be accessible.

So when you look at the package of UTs and visuals, it's a pretty good one.

MR. GILLESPIE: But that's why I just - and Hans, you can jump in, because I might say something wrong here. But you notice coatings wasn't on our list, and you're answer and your commitments in that does reinforce what you just said.

So again it reinforces if the codings are being expected reasonably vigorously at one time 100 percent, and then it'll go to 30 each outage, that's confirming the underlying assumption that moisture isn't present and therefore corrosion doesn't occur, which makes the usefulness of a 10-year out measurement potentially less useful than one that might be in more like a four-year duration that allows us to do what we did in the `80s, to say, okay, you've got enough information to project this forward, and now depend on your commitment on the coatings examination.

And so at least and I'm going to ask Hans,

because I - and so there is a thought process there that is different than just picking 10 years because it's in the middle.

Hans.

MR. ASHAR: Yeah, I think programmatically, I think the way you have committed to coating inspections, if during the inspection of coatings, you see seepage of water that you have seen earlier in 2004, 2006 time frames, then there is always a question as to what is going on.

And that's why what Frank is trying to explain is that you've got to have a program based on what you find rather than straightforward to 10 years.

And I think Frank did describe it very vividly, but I'm trying to simplify it. That's what we are looking at here. Programmatically.

MR. GALLAGHER: And I think that was our intent, but we can clarify that.

MR. GILLESPIE: So the summary is, could you relook at the purpose of the 10 years, and is the 10 years really serving the purpose of bringing this data point forward so that we can make the same decision now for the next 20 years we made before for the last 20 years.

MR. GALLAGHER: You guys have some questions?

MR. OUAOU: Well, the only thing I really want to add - this is Ahmed with Exelon - is the UT measurements we're using in the sanbed region is to confirm that in fact corrosion is not undergone, which is stated, it's arrested.

But you've got to remember, on a forty-year basis, we're still doing UT measurements on the

upper region of the drywell, which is not coated, and it really should bound the other areas.

MR. GILLESPIE: Again, you're making my case why 10 years may be a random point that is just out there that was picked because it's in the middle, as opposed to being a point that in a real early part of a period contributes to reinforcing the fact that the body of knowledge in the inspection techniques for both how you apply that corrosion rate you're finding at the top which is uncoated, and how you look at the coatings, is doing.

All the reasons you're giving me are reasons why you want to reinforce your technical bases early as opposed to late. That's all I'm saying. I'm just asking you to think about it.

MR. OUAOU: The only thing I want to point out is, the basis for the 10 years we used for was certainly not random. It's based on the ISI interval.

MR. GILLESPIE: Okay, the ISI period is also 10 years.

MR. OUAOU: That was the basis for it.

MR. GILLESPIE: We've actually had some discussions with people that the whole ASME code issue, which is not yours, is given us great pain in aging management as you know with relief, because the code is written to cycles, et cetera, et cetera, that are really based on a 40-year life.

And so we're, again, that may be the code, but that is not - I'm trying to say, it could be a technical rationale, other than it's convenient with the code for doing it. And because of your answer and commitments in the coatings, because of the reinforcing measurements at the top in the uncoated

areas, we're looking for as much definitive information early in the period that there will be success during the period as we can, relative to projections.

And again, the kicker in here is, we'd be looking at the event part of the ISG which then applies to future - because you got a 16-year period I just suggested in there. But the ISG would say, if water shows up, you're doing UTs again. I mean that's what the ISG says.

But if you're real good and you never have a leak, because of the inspections and the projections and that, and then the validity of your projections are doubly reinforced early in the period.

So I'm asking you to look at the rationale for the 10 years, and what I'm suggesting is, in light of how we thought about the maintenance rule when we were writing that, and what we were doing and what was happening in the maintenance area; I'm applying those same principles.

Remove the uncertainty early, and that allows you to have a justification and a rationale for the extension, and why a more minimal surveillance program is unsatisfactory.

MR. GALLAGHER: And Frank, do you have any thought in mind for what an early interval would be?

MR. GILLESPIE: No. If you can rationalize 10 years as being early in providing the moving forward into the entire period of that -

MR. ASHAR: We'll look at it.

MR. GILLESPIE: -- we'll look at it. But the uncertainties involved - and I will admit, this is - there is some subjectivity to this. I mean this is

not an algorithm that we can put into a spreadsheet and do a calculation on.

But there are a number of uncertainties, the residual ones we went over today, which we're looking for clarity in. And I think what you as an applicant are trying to do is reduce or minimize those uncertainties to the degree possible for the maximum period of operation.

And what we're suggesting is, 10 years leaves a great deal of uncertainty in our minds relative to the sample selections, and projecting this vast body of data and this calculation forward.

Again, we're dealing with taking a vast amount of information which was reviewed now almost 15, 16 years ago, it was probably developed close to 18 years ago, and bringing that forward for a new 20-year period.

And yes, that was satisfactory for the last 20 years of the license, but now we're making a new finding that it's satisfactory for yet even another 20 years.

MR. GALLAGHER: Okay, I think we understand it. Okay.

MR. GILLESPIE: With that, I've got one other issue, and this - to close out containment, and to let people know that what we've talked about here is only a small piece of the whole.

And this has no action for you. But actually in looking at the whole thing, we were really trying to look holistically as a staff at the entire containment structure. And we did note that your last appendix J integrated leak rate test was in 2000, which means your next one is due in 2010, which is

really close to the beginning of the period.

And while that is not a design test, there are other things going on as part of our body of rules that do affect the integral look that we take at things like the containment shell.

And so I didn't want people to think that we only looked at what we talked about at this meeting, which I'm hoping was very focused and quite narrow to our residual concerns.

But that we do see that kind of under the rules you have to pick a date, 2008 or 2010 plus or minus a year under 10 years, and that's probably either one within six months of the renewal period.

So there are other things going on to give us increased assurance of the operability of the shell. And because this isn't just a meeting between you and us, I want people - and this is an example of other things that we're considering. So we're not just narrow people. We're not just looking at the 10 years and asking about that. We actually found some really satisfactory things, and just in compliance with the regular body of rules that was going on.

And with that, I'm down to my topic called general discussion, but Im' about worn out.

GENERAL DISCUSSION

I would ask you and then I'll ask - or perhaps I should ask Hans if he has anything else he would like?

MR. ASHAR: No, I don't think I have anything more than what you described, no.

MR. GILLESPIE: I would like to ask you as an applicant - I mean we're trying to be real crisp here, because we want to get on with the job.

MR. GALLAGHER: John, do you think we have succinctly what the issues are we need to respond back on would be?

MR. HUFNAGEL: I have a lot of notes, Mike. It would take me more than a couple of minutes to go through these notes. So I'm not sure I can go and summarize all that right now. But I think between us I'm sure we have enough notes and understanding.

MR. GILLESPIE: And we're going to do our best, by the way, John, to get what Hans was reading. We went through a lot of effort to try to really narrow this down. But we do have the audit process you know kind of going on in parallel. And we'll try to get these meeting notes out in a timely way for us, and timely for us, given our secretarial situation, can be long.

But in this case we're going to push this to kind of the front of the list, and try to maybe - I need to get these notes out in a public forum.

And again, if there is a follow on email needed to clarify the issue, that's fine.

The other question that came up, because normally we would have probably followed this meeting with a formal set of RAIs. When I saw what Hans had written in coordination with the bullets we wanted to covered, the RAIs are really embedded in his detailed words. And these, I think, are more - are better words than we generally send in kind of our whitewashed versions of RAIs that require phone calls for clarity on.

So we will try to get the meeting notice, the meeting minutes out, with basically Hans' comments and the bullets, as quickly as possible.

Now, if we do that, then my intention would be not to issue a separate document of RAIs in prep for your opportunity to come back and talk to us.

And the other thing is, we'd like to ask that you send something in in writing before that meeting so that we can really be kind of at the end of the road at that meeting. And the question I have of you is, when we were setting this up, we scheduled it so we could talk to you, and scheduled the next meeting so you could talk to us. But that is actually your option.

If we don't need a meeting, and you'd rather answer these in writing, I would just ask that you get back to us in a timely enough way so that we can cancel the meeting at least a week before.

And it's really your option, but we were trying to set this whole thing up to make sure that we had all the vehicles for communications. And since we have a 10-day noticing period for public meetings, and it takes a couple of extra days - it really takes about 15 days to do it - then we had to in a positive way set up both meetings at once just to have a process put in place.

But it's your application and it's your answers and it's your choice. So right now we do have it scheduled. Donnie was going to put a notice out, but I would ask for the other people in the public who might want to participate, a timely notification of them is an obligation we have.

And so let me leave that to you and not even ask you to answer that question today. But you can get back to us on how you want to do th at.

MR. GALLAGHER: I think what we're going to

do, Frank, is we'll meet and go over what issues we think we have. Maybe John and Donnie can communicate to ensure that these are the things we're going to be providing in a written format, and we would want to get that to you a few days before the 22nd, and whether we meet or not, we can determine that at a later date. And talk with Donnie about that.

MR. GILLESPIE: I'll leave that to Donnie and John, then,

MR. GALLAGHER: And then so that would be our - the things that we talked about providing, we would provide that in writing; that's what you're looking for.

MR. GILLESPIE: Hans and I are going to try to get everything that we have in writing out as part of the meeting minutes with Donnie. I think it's going to be a more fruitful meeting if everyone, all the participants, has it in black and white. And then you leave that with either a markup or a nonmarkup, and everyone knows where we stand on these issues. Because I think we've really narrowed some things down here.

MR. GALLAGHER: That's what I was going to say. Like the issues, like the thank you for getting clear with us on what these issues are. Because I think they are very pinpointed, and I think that will help us really see what information you need to close the issues.

Like you said, we provided a ton of information, and we have it down to just a handful right now to really get you just the information you need.

MR. GILLESPIE: By the way, we're not

looking for another ton. We're really trying to see - if these answers end up coming in 57 pages long, then we've miscommunicated what we think our residual concern.

MR. GALLAGHER: Okay.

MR. GILLESPIE: So really, as you're doing it, keep it in perspective. And if that requires calling Donnie, say, you know what, Frank said he didn't expect the Encyclopedia Britannica for every question. We think these concerns are very focused.

MR. GALLAGHER: Right, right.

MR. ASHLEY: In addition - this is Donnie Ashley - in addition, John, to your notes and the rest of our notes, we're going to try to get a quick turnaround on the transcript so that you can have that available to you as well. And we'll have that in ADAMS just as quickly as we can.

MR. GILLESPIE: Final part of this meeting I'll turn over to Donnie, and that's I believe requests from any members of the public, or anyone else, to ask questions -

MR. GALLAGHER: Wait, Frank, did you have a question?

MR. HUFNAGEL: Just a brief, if I may - John Hufnagel here - just a brief comment that it goes without saying, but I'll be working with Donnie to try to coordinate the next three weeks such that as he's working on pulling together the notes from this meeting, and we're working on providing the information as we understand it, that there will hopefully be a brief period where we can check what we've done against the meeting notes prior to us sending it in.

So we'll obviously need to coordinate to do that.

MR. GILLESPIE: That's why we're going to do everything we can to get these notes out pretty quickly for everybody whose participated in listening in on the meeting.

MR. HUFNAGEL: Thank you.

MR. GALLAGHER: Thanks.

MR. GILLESPIE: And Donnie, now I think it's time to ask -

MR. ASHLEY: I would like to continue on because we only have the phone for a short period of time, and I don't want to lose the people that are on the bridge.

Can I go ahead, Frank?

MR. GILLESPIE: Go ahead.

MR. ASHLEY: We've got a little bit of housekeeping for the purposes of the transcript that I need to take care of. I need to verify the spelling of your names for the people who are on the telephone bridge. And in particular order, Ron Zak with the New Jersey DEP, would you spell your name for me, please?

MR. ZAK: Z-a-k.

MR. ASHLEY: Tom Quintenz from Oyster Creek?

MR. QUINTENZ: Q-u-i-n-t-e-n-z.

MR. ASHLEY: Thank you.

Nick Clunn with the Astbury Park Press, would you spell your name please for the reporter?

MR. CLUNN: C-l-u-n-n.

MR. ASHLEY: Thank you.

Mr. Webster?

MR. WEBSTER: Richard, R-i-c-h-a-r-d

Webster W-e-b-s-t-e-r.

MR. ASHLEY: And your organization, sir?

MR. WEBSTER: Directors Environmental Law.

MR. ASHLEY: Thank you.

Mr. Brown, Jeff Brown?

MR. BROWN: B-r-o-w-n.

MR. ASHLEY: And your organization, Mr. Brown?

MR. BROWN: Is G-r-a-m-m-e-n.

MR. ASHLEY: Thank you.

Ms. Gotsch?

MS. GOTSCH: G-o-t-s-c-h, same organization.

MR. ASHLEY: Thank you.

Mr. Atherton?

MR. ATHERTON: A-t-h-e-r-t-o-n.

MR. ASHLEY: And you represent?

MR. ATHERTON: I'm working with Jersey Shore Nuclear Watch.

MR. ASHLEY: Thank you, sir.

Ms. Gbur.

MS. GBUR: G-b-u-r, Jersey Shore Nuclear Watch.

MR. ASHLEY: Thank you.

Mr. Warren?

MR. WARREN: W-a-r-r-e-n, and I'm also with Jersey Shore Nuclear Watch.

MR. ASHLEY: Thank you very much.

Is there anyone that came on the line that I didn't mention your name?

MR. LAIRD: Name is Jim L-a-i-r-d, Exelon.

MR. ASHLEY: Thank you, Mr. Laird.

MR. PINNEY: My name is Richard Pinney. P

as in Paul -i-n-n-e-y, New Jersey DED.

MR. ASHLEY: Anyone else that we didn't recognize?

In the interest of having an opportunity for the people that are on the phone bridge, is there anyone who would like to ask the staff a question, or to make a statement at this time?

MR. ATHERTON: My name is Atherton. I have a technical background in technical and nuclear engineering. And the first complaint I have is, half the conversation I heard was inaudible. And I didn't know whether it was bad technology in the electronics that you have for transmitting this, or some other cause. And I did phone the public affairs office to complain about that, and I was hoping you got the message.

But toward the end of the conversation you were slightly more audible. So I missed out on a lot. And I do have a couple of questions I'd like to ask or get clarification for. Is that possible?

MR. ASHLEY: Go ahead, Mr. Atherton.

MR. ATHERTON: I'm going to back up to the specifics concerning the issue of uncertainty and sensitivity analysis and the like.

The basic question would be, is there the potential, since I didn't catch all the information that was taking place back and forth, is the potential for harm to the shell or the liner significant enough with the uncertainties involved so that it would be better not to use uncertainty as a sole means of analyzing the situation, but to approach it from the worst case analysis perspective; and if so, why?

MR. GILLESPIE: Yeah, this is Frank

Gillespie.

MR. ATHERTON: You're barely audible. I heard the Frank.

MR. GILLESPIE: This is probably because we're using 20-year-old technology for our phone system here.

MR. ATHERTON: And how did you spell your last name, sir?

MR. GILLESPIE: Gillespie, G-i-l-l-e-s-p-i-e.

MR. ATHERTON: Okay.

MR. GILLESPIE: The context of this meeting was very incremental, in addition to a lot of information that we've already gotten in the request for additional information.

And in some ways, if you - have you read all the additional information that's been sent in to us that's been made available?

MR. ATHERTON: Unfortunately I haven't had the opportunity to do that yet. I just received a disk a couple of days ago, and I haven't had the opportunity to go through that yet.

The general question concerned, I doubt the information that I'm seeking is going to be on the disk, because I'm questioning whether you should use uncertainty analysis versus worst case analysis.

MR. GILLESPIE: Well, to some degree, I think you'll find in the applicant's information, and this is a little beyond the narrow scope of this meeting, but in general, in the applicant's information, there are discussions about measurements taken in the upper portion of this light bulb shell, which is uncoated, which presents a - any application

it would make a case, it presents a case that is far less conservative than the bottom section of the shell which is uncoated.

And so there are some assumptions on rates where projections are made where exactly what you're saying I think has been taken into consideration.

Now what could be up for discussion is different people's view of what worst case is. And you have to go through the material and give me a specific, but it's really kind of a blend of, we basically have an estimate line, and the estimate comes from various data sources that get combined to make the estimate.

And we're trying to have the highest possible confidence in the estimate and the calculated projections. And the projections have been made; the measurements have been made. And that's why the focus of a lot of the discussion here was the residual questions on the part of the staff to ensure that we understand the uncertainties involved in that projection.

But that projection involves some assumptions on corrosion rates which some people would say in their minds is worst case of the situation in the environment of the facility.

So I think both in different viewers, different readers' views, have probably been done, and we're wrestling with that total decision right now.

So it's not uncertainty is everything or nothing; it just happens to be our residual concern.

(Telephone operator voice interrupts)

MR. ASHLEY: Mr. Atherton, are you still with us?

MR. GILLESPIE: Anyway, for whoever was listening.

MR. ASHLEY: Just a second, Frank? Is anyone still on the line?

(Loud telephone noise)

MR. ASHLEY: They cut us off.

MR. GILLESPIE: We had inadequate safety margin in our bridge.

(Technical interruption)

MR. ASHLEY: We'll try to pick up Mr. Atherton as he comes back on.

Did anyone else have a comment so we can continue on?

MR. ATHERTON: Hello.

MR. ASHLEY: Yes.

MR. ATHERTON: This is Peter Atherton. I don't want what happened. But I suddenly got disconnected during Mr. Gillespie's part.

MR. ASHLEY: We did to. We're glad to have you back again.

MR. GILLESPIE: Go ahead.

MR. ATHERTON: Well, Mr. Gillespie was talking about the use of a version of the worst case analysis for a bottom uncoated part of the containment structure or the shell.

MR. GILLESPIE: The bottom part -

MR. ATHERTON: And that's where I lost you.

MR. GILLESPIE: The bottom part - and this is difficult, because what we've got is a staff here that's gone through literally thousands of pages of documentation to come down to these residual comments.

And in going through that there are estimates made with corrosion rates that are believed

by the applicant - and this is a finding we're trying to make - is believed by the applicant to be reasonably conservative in nature.

And there is a coating on the bottom portion of this light bulb fixture containment, and they have measurements from the top part of the containment, which is uncoated, but in a similar environment on the inaccessible side.

And I believe the applicant has made some projections using this, and then making the case that the coating really provides this uncoated area measurements are in essence a worst case in their projection.

And therefore we've looked at that as a staff, and all their information. And this information was really focusing on the uncertainties that were connected to that projection.

It's not that we're making judgments on the uncertainties, but we're trying to make sure that we have the soundest possible number and a good understanding of what could be viewed by some as a worst case projection.

Now others could view this projection and the numbers used as not being the worst case, and so I'm very hesitant to use the word, worst case.

It's a projection that I think is generally believed, actually representing a measurement in an environment that is more harsh than the environment it's being applied on to a carbon steel piece of metal.

And that's what's in the application. And so this meeting is trying to deal with making sure that when we make whatever judgment we need to make,

that we understand what the pluses and minuses connected with that are.

And so the staff has actually read the application, and so we had that part done, and we really weren't questioning the rate. We were questioning the uncertainties around it to make sure we could make an appropriate finding.

MR. ASHLEY: Thanks a lot, Frank.

Mr. Atherton, you still with us?

MR. ATHERTON: Yes, can anybody hear me?

MR. ASHLEY: Yes, sir.

MR. ATHERTON: I'm having connection problems.

Let me back up just a little bit farther. On a very general or holistic view of the containment structure, the plant was approved originally to last 40 years. That essentially meant back in those days, the `60s and `70s, that the major components of the plant would not fail for a total of 40 years.

We're seeing the drywell apparently degrade prematurely which was not anticipated 40 years ago.

The projecting that type of discovery into the future for 20 more years, how are we to know as members of the public that you're going to have 20 good years left on the material that was supposed to last 40 years and hasn't?

MR. ASHLEY: Who's speaking?

MR. ATHERTON: My name is Atherton.

MR. ASHLEY: Okay, go ahead.

MR. GILLESPIE: Well, that's exactly the finding we're being asked to make as part of the license renewal.

And first I would refute your assertion that every component in the plant was designed to last 40 years.

In the basic underlying premise of operation is a large number of surveillances, tests and inspections. And the intent is that the structure and the license be safe for the term of the license, and that includes special tests and analysis, which would detect, prior to violating or causing a safety issue, the degradation of components.

And what we're really talking about is taking that same principle and pushing it forward another 20 years. In fact, many of the components in the plant have seen a less severe environment than they were projected in their original design.

And it's that baseline and moving it forward, that we're doing with renewal, which is why there are extra commitments in the overall renewal effort to extra special tests and analysis.

The intention is not to say it will last 20 years; that's an economic issue. It's to say that the licensee has processes and procedures in place that we can inspect and that they can follow that will detect and remediate anything that would cross a safety margin.

And that's a different statement than saying, we're saying it will last 20 years. In fact if they would do a test and do a projection in accordance with our interim staff guidance for the renewal period, see water, and do an event test and find out they were approaching minimum wall thickness, they have to do an operability analysis under the current requirements, which also project forward. And

they have a decision to make to either repair or shut down.

And instances of this we have in other cases in pressurized thermal shock where we're evaluating licenses for 20 years where the pressurized thermal shock analysis for other licensees will not make it to 20 years. But there is a requirement in the rules that if you don't make it you shut down, or you can replace your vessel.

And so it's not saying everything will last the period of the license; it's saying the plant will operate safely for the period of the license, and we have reasonable assurance of that.

MR. ASHLEY: Thanks, Frank, I appreciate that.

Mr. Brown or Ms. Gotsch, do you have a question or comment?

Ms. Gubr, are you on the line? Did you have a question or comment?

MS. GUBR: I have a question. In the 1996 inspection report --

MR. GILLESPIE: The 1996 inspection report? All the -- that's actually beyond the scope of this meeting, and our general counsel is here. And I understand that that is tied up in the litigation issues right now.

All of the NRC's information that we have from 1996 in the NRC inspection reports are public information. The licensee's information, which the NRC at this time does not and has not possessed, is actually tied up in the litigation right now, and we're really not in a position to comment on that.

MR. ASHLEY: Go ahead, Mr. Webster.

MR. WEBSTER: Okay, great.

With regard to the drywell liner and the UT measurements, I guess I'm somewhat surprised that the licensee had already known that the `96 results weren't good, but nonetheless based predictions forward on those `96 results. It seems to me, though, that the QAQC for those results should have identified the level a long time ago, so I'd just like a clarification of why the rejecting wasn't treated closer to the time.

MR. GILLESPIE: This is Frank Gillespie with the NRC. And since this is really an opportunity for people to ask the NRC for clarification on what we said, I will answer from the NRC's perspective that right now the people sitting in this room were generally not involved in the details of what happened in 1996.

But in looking at that anomaly, I think it would be unfair to say that that was - I forget what your word was - but I'll use an irrelevant measurement. It was a measurement, as we heard from the licensee at this meeting, they looked into it and examined it. They saw it as anomalous. But there was really no reason probably at the time to either exclude it or not include it.

MR. WEBSTER: There were three measurements taken, and that `96 result was one of those three. If you take that `96 result out of the analysis the uncertainties become huge.

MR. GILLESPIE: And what I'm going to suggest is, that's the exact question that staff has just asked the licensee on uncertainties.

MR. WEBSTER: Absolutely, that's why I --

MR. GILLESPIE: And so I'm just saying, I'm not in a position, and I'm not trying to put anyone in a position to defend what was done over 10 years ago. But because of the anomalous look at the results, we're really focusing on removing that uncertainty that we specifically pointed out as we project forward.

So we fundamentally have just asked the licensee to respond to that question. And we've, by design at this meeting, asked the licensee not to feel obligated to respond today to the staff's concerns.

So I guess we're in agreement.

One of our concerns you heard from Hans Ashar and I were on the calibration techniques. And I think the licensee responded, they recognize that there are certain coatings and stuff that they have to really be very careful of when they're doing these, and so we have to see what they answer.

You're asking for the answer we've asked for, and it's just not the right time for the answer yet.

MR. WEBSTER: Now the second issue that I think also relates to the questions you're asking is about how the actual raw measurements get incorporated. One of our concerns is that the uncertainties in these measurements become hidden in the way they're presented, because you take the measurements, get an average and put into one measurement, which is then put on a scatter graph. And then when you look at the scatter graph you don't actually see the underlying uncertainty. All you see is some scatter of averages, which is much less than the actual scatter and the underlying results.

Now one of the concerns I have, and we've reviewed these documents from the licensee, and it seems that they're editing the data, that they omit. They actually omit an outlier from the analysis. And again I think this is another way where the uncertainty is made to appear lower than it really is.

MR. GILLESPIE: Let me try to answer that. Now this is going to be dangerous. Because I was an engineer 35 years ago, but I'm going to - Hans has been training me for three weeks, Hans Ashar, who is our expert. So let me take a shot at the answer.

One, you have to understand, we've basically asked the same question that we need to have a good understanding about how that lower level combination of numbers was done.

That was a concern we had, and that's a question we asked.

Two, you also have to differentiate; there's two phenomena of interest here. One is pressure during an accident, and the other is buckling.

And the interest in the buckling sense, which is really the sandbed region interest, is buckling down at the lower level, is one of general area corrosion, a very broad degradation, and not one of pitting.

In fact in any structural member you can actually drill holes in it, and you do not significantly reduce its structural strength.

And so knowing that principle I would not want to draw a conclusion on information we don't know. And that's why we've asked for information on how they've done the statistical combination; what was

their basis for whatever, throwing out outliers, in a 95 percent confidence interval.

But for the purposes of buckling, a localized thinning spot is not a principal concern.

MR. WEBSTER: Well, I told you, I understand that. But my point is that if you permit that as part of the uncertainty analysis, then you tend to regard the measurement --

MR. GILLESPIE: Again, I don't know how they've been included or how they've been admitted, or has it followed standard practice. We've asked that question, and I hope within the next month we'll have a little more amplifying information, and I could give you a more satisfactory answer.

We're sharing the same concern.

MR. WEBSTER: Absolutely. I understand. I'm very pleased to see that we do share the same question.

My present issue -

MR. ASHLEY: Mr. Webster, this is Donnie Ashley. You said you had two.

Hold the third one, and let me get through, make sure we can touch base with everyone. If we have time we'll come back to you. I have some uncertainty about all four here.

Let me leave this -

MR. GILLESPIE: Just in case we get cut off from everybody, email Donnie Ashley and we will get back to you by email on any questions that we don't get to, because our phone system doesn't seem to be working as good as I'd like it to.

MR. ASHLEY: Thanks, Frank.

Mr. Clunn from the Astbury Park Press, do

you have any questions or comments? Nick Clunn? I guess we lost him a few minutes ago.

Ronzak (phonetic) or Ridgepenny (phonetic) with New Jersey DEP, any questions or comments from you?

MR. PINNEY: No, we have no questions here.

MR. ASHLEY: Okay. Dennis Zannoni, would you like to come down to the podium? I would like for you to go ahead so they can hear your comments as well.

Mr. Warner, if you'd wait just one second.

MR. ZANNONI: Dennis Zannoni, Z-a-n-n-o-n-I.

I'd also like to thank the Nuclear Regulatory Commission for having this meeting. I think it's obviously necessary.

So having the next meeting if it's conducted in the afternoon would also help me, since I have to drive up, since we're facing a very substantial budget deficit in New Jersey as you probably heard.

First, I want to mention that - and this is mostly for Frank's edification, because he is coming to our office I guess within two weeks with some of his staff, to give you a little bit of the flavor of what we're going to talk about, and it does relate to what we're covering here, and that is, there is a little bit of confusion on the ruling made by ASLB and its staff's attorneys, and it's mostly a question directed at the attorney, that we would like the NRC to clear up the fact that we are not a party or involved with the contention on the liner or

drywell shell in any way.

And I guess ASLB made that clear, but some kind of communication has come down the path, and it's affecting our ability to do work, that we're somehow tied up with that.

It would be nice if you could clarify that here today, but I know you're not.

We're going to pick that up when we talk too, because it is affecting what we're doing. We go to meetings, and people are confused about what our role is.

We do have three appeals to the Commission, but they have nothing to do with the liner.

And we have a good reason for that, because we have our own staff that have made their own conclusions, and I have to tell you, quite frankly, I was at a meeting here discussing the same drywell line issue when the company was going for a conversion from the full term operating license to the - or from the provisional operating license to the full term operating license, and it was only at the insistence of New Jersey that they took very aggressive protective corrective actions. I don't know if even anybody here at the AmerGen table was here. But removing the sand and all of that was very, very positive, and we view that in a way that we thought at the time was good for until April, 2009.

So our position right now, and Ron is online, and he's our expert actually on the drywell shell - he keeps telling me to call it a shell, not a liner - is right now positive. And the rigor that I see addressed here for that one issue, I wonder if

that's going to spill into many, many other issues that we feel an equal amount of rigor is needed.

Because you guys are going into some depth here that we are going to talk about again to see if it applies in maybe some other areas that could benefit from that, more so than the liner.

Anyway, that said, we also need to have some kind of - we don't know when the commission is bound. If not, I understand it's not to make decisions on the appeals that we submitted. Again, it has bearing, because the more they wait, the less we can interact with NRC staff on those specific issues.

And if they made a decision one way or the other, then we could get on with it. So we'll probably submit that in writing, but I'm just giving you a flavor of some of the topics that we're going to talk about.

Now specific to this meeting. Frank, you said earlier in the meeting you said you may - the NRC may recalculate something. And then later you said they will recalculate something.

I just need to know, you are going to recalculate something. What are you going to recalculate?

MR. GILLESPIE: Our intention right now is to do a comparative calculation to the GE calculation of 1991.

MR. ZANNONI: The one with the disclaimer?

MR. GILLESPIE: The one with - well, that was a piece of it. That report fed into the data that went into that calculation, and our intention would be to do kind of a comparative calculation.

Ours doesn't need to be as rigorous as

theirs, because we're doing it as a confirmatory measure, not as a decision tool on their part. So we're likely going to do that to get a perspective ourselves on the conservatisms that have been assumed in that calculation.

And so it's just an independent look. And we do this in thermal hydraulics. We do it in a seismic area. We do it in a lot of different areas occasionally.

The other piece is, we have six more Mark-1s coming in, and so for the renewal group, we're kind of setting a precedent. Because all of those same questions exist on all of those same containments.

And so part of this calculation will be giving us knowledge to a specific operating history and a specific calculation that GE did.

MR. ZANNONI: Is it going to be done in house or contracted?

MR. GILLESPIE: Part of this meeting is not discussing how the NRC will do this piece of the review.

MR. ZANNONI: I'll ask it at some point in the future. It tells what kind of depth you're going to do which is pretty - if it's in house it's one thing -

MR. GILLESPIE: Well, we're going to have outside experts helping us. And any report that's done will be public.

MR. ZANNONI: You mentioned, I guess for my own information and information concerning New Jersey, are there other - the rigor that you - the depth and the rigor that I send that you're requesting from AmerGen for Oyster Creek, have there been other plants

that have similar drywells gone through similar rigor? Or is this something new that you are going to ask plants to take a closer look at that have already gotten license renewal?

MR. GILLESPIE: There's two questions. The answer is yes, everyone else is going through a virtually similar process. But everyone has different operating histories.

I'll give you a specific one. We're going to ACRS, Nine Mile Point. Nine Mile Point has an operating history with no visual leakage. They also have welds around their seals. And so seals, for example, at bellows, are not an issue.

They have actual electronic alarm systems on their drains. They actually have a float alarm on -- there is a ledge in there that goes under the seal. And they put bore scopes up there and looked in with TV cameras and saw dust.

And so it's a form of rigor, but it's a different operating situation, and a slightly different design. So I would suggest that in essence all the licensees with this kind of containment are going through the same process, and the same level of detail, and trying to be just as certain about their projections, and the projections being used there, they're taking them from the torus at the water level where they do UTs, and it's a very aggressive area.

MR. ZANNONI: Plants that have already been approved?

MR. GILLESPIE: No, this one is in house. Brown's Ferry we did a similar rigorous review. And they had some unknown leakages, and they committed to an inspection regime. And theirs was the 10-year kind

of one. And that's through, and that license has been issued.

Brunswick does not have a shell; it has a liner. And the design difference there is, the structural elements, the concrete, is not the steel; the steel is basically a seal.

And so the answer is yes. Now the difference here is, the visibility of Oyster Creek is different than the others. And so a lot of what we do with these other facilities is closer - you know what I mean -- it's not quite as visible.

So every one is going through, you could say, an equal type of review, customized to their operating history, the operating conditions and the past events.

MR. ZANNONI: I know Donnie is going to cut me off. But just one last comment for the public that's listening, I know Peter Atherton did mention about confidence that the public is looking for, not only in this issue but all of license renewal.

I'll just throw out, and I always mention this, that in addition to AmerGen's huge workload to meet all the requirements - they got the NRC looking at it - we also as a state have a group of about 15 to 20 professionals, I already mentioned that we have a very sound expert in structural stuff on staff who has worked with Oyster Creek for awhile. And this hearing if anything comes out of it, hopefully it will be positive.

So the net result here, and I don't want anybody to miss this, and it's too bad the press wasn't here, is that this is getting a lot of eyes and a lot of attention. So that has to give the public

some sense of, they're not alone in this process.

So that's why I exist just to put it bluntly, so thanks.

MR. ASHLEY: Thank you, Mr. Zannoni.

MR. ASHAR: This is Hans ASHAR, NRC.

Let me say that for the general analysis purpose, the applicant has taken an approach where they are taking an average, but in addition to that, they also do the discontinuity analysis for the thin areas. Thin areas are where there are small sparks which might have been missed in averaging they might have counted as thin areas, but they have taken a number of places which are thin, and they have analyzed separately to understand the discontinuity stresses and their ability to withstand the loads they're supposed to withstand.

MR. GILLESPIE: Okay, this is Frank Gillespie. Let me amplify a little more. Because now I'm going to take what Hans just said and say, that's also part of the actual sample of the smaller area that's scanned.

This is a very, very, very large vessel, and the representative nature of the sample that was earlier worked on with literally thousands of measurement points by the applicant to ensure that even those areas that are scanned, and the 49 points that are averaged, are the right areas to be scanned.

And that's why we did ask an additional question here to reconfirm right now the representative nature of those areas, exactly so you couldn't get a substantial elongation or a major flaw.

So there's two things. One is the 49 points, which is a smaller, very small area, and the

other is the location of those small areas through the vessel itself.

And if you would look at the much earlier data of all the thousands of points that were done and reviewed by the NRC, it's that representative nature that actually covers your large perforation kind of question. It's not the 49 measurement points which were averaged, for maybe a 6 by 6 inch kind of area.

MR. ASHLEY: Thanks, Frank.

In closing I appreciate everyone's participation. I appreciate -- I'm sorry, we're going to be out of time, and the phone is going to shut you off in about two minutes.

But we do appreciate everyone's coming out to participate in this meeting. And again, if you need additional information, or if you have questions, send me email. My email address is on the website.

And once again, thanks to everyone, and we'll adjourn at this point.

MR. GILLESPIE: Thank you.

(Whereupon at 11:58 p.m. the proceeding the above-entitled matter went off the record to return on the record at 11:58 a.m.)

MR. GUNTER: That's all right. This is Paul Gunter, G-u-n-t-e-r.

I'm with Nuclear Information Resource Service.

There's a whole lot of questions, and I'm sorry that Richard Wester wasn't able to complete, but we'll go ahead and supplement the record by email. And I guess that could be incorporated into the transcript as well? Can we have email questions incorporated into the transcript?

MR. ASHLEY: I don't think we can have email questions in the transcript. But we can include it in the summary. We'll put it in the meeting summary.

MR. GUNTER: Okay, that's fine, that's fair enough.

MR. GILLESPIE: And our meeting summaries are all put on our website.

MR. GUNTER: You know for the sake of time I'm just going to ask one question here, and it gels back earlier to a comment that Frank made with regard to the 1990 GE report, and the assumptions that went into the corrosion and degradation.

I thought I heard you say that the NRC has - they've identified a degradation uncertainties within that GE report. Was that correct? Was I correct in hearing that?

And I think that was the basis of your going back and doing the recalculations; right?

So I'm asking first of all for clarification on what you've identified in the GE report that raised degradation uncertainties. And if you could identify those for us right now.

MR. GILLESPIE: Okay, I'm not sure how much detail Hans is in a position to go into. It was an accumulation fo fundamentally the underlying assumptions that went into it. And they appear to be conservative, but one of the only ways to test the overall conservatism of the assumptions is just to do a calculation with an independent person making an independent view of it.

But Hans, you did that?

MR. ASHAR: Yes, if you heard us on the

first or second questions that we had for the applicant, you might have heard that we requested the applicant to at least clarify as to what has been said in their statistical inference report that is attached to the GE report by the way they interpreted the measurements, and how they statistically put together, both that particular report findings were used, or some other metrics were used. That was our question to them before, and I'm looking for those answers.

MR. GUNTER: Right. So it's not so much that you're questioning the degradation mechanism itself?

MR. ASHAR: No.

MR. GUNTER: So one of our concerns is that, for example, I think it's been referenced here a number of times that there was - in order for the sandbed region to be - for the UT to resume at the sandbed, there was the event trigger for the presence of water.

But it's always been our concern that - there was I believe a `95 exemption that provides for a 12-gallon-per-minute leak rate, and that constitutes what we believe to be a significant event.

So during the refueling outages, there is this `95 exemption that provides, to reiterate, 12 gallons a minute leak rate.

So it's been a question for us why we've not seen this reevaluation with UT at the sandbed, and more particularly for the embedded region, so I think it's been raised here this morning that there needs to be a closer look at a number of areas for the reevaluation with UT. Crevice corrosion should be one of these areas, we believe. And I don't know what

level of confidence we have on the seals around - between the steel liner and the concrete. But I think that it's reasonable that we shouldn't be relying upon - that these seals are necessarily going to be high confidence seals.

So as you are looking at the ledges that were raised here today, we would strongly advise that the UTs be resumed at the levels below the sandbed region.

Hans, do you think that that is a reasonable request?

MR. ASHAR: Well, because this area is not accessible from any side, there is a state of the art, which is not being used by so many people. And we recommended its use if they can do that.

So we are trying to understand from them what they are going to do to gain the confidence that that area is being considered in a sample size.

MR. GILLESPIE: I'd also like to say, we have a broader level of operating experience than just Oyster Creek. And so we do have some sense, and a generic idea of - there are some licensees who actually went in and chipped concrete up and did some measurements. Not all of them. They did that in a response to the generic letter in 1987 we put out.

The other element is, we do kind of have an understanding of the environment. But we need the applicant to tell us what that environment is, and why it's okay.

They're going in and looking at the coatings in those areas. Basically you've committed to verifying those 100 percent, and a third, as you've been doing each time, for the three bays each time, or

something.

I don't know the details of that, and when the little person goes in this gap and does this inspection, whether they can eyeball the seals or not.

MR. GUNTER: Again, I've not seen a commitment to the seals.

MR. GILLESPIE: Okay. I'm going to leave it to Hans, as the expert, to say whether we need a commitment to that.

The other thing is, at least in the prints I saw, when we looked at the drain arrangement without the sand, it looked like the low points is where the drains were located in the sandbed area.

So there are some actual physical limitations on the accumulation it appears of water that actually could accumulate by those seals.

We're asking the licensee to come in and put all of these things together in this integral discussion of this area that is sandwiched with concrete.

It's more than just the chemistry that I mentioned we talked to ACRS about. And so that's on their plate to explain it.

It may not be everything that someone else may want, but we're charged with making an adequate protection or reasonable assurance finding, and we do have like I said other operating experience from other plants, so we're not totally isolated here.

Yes.

MR. ZANNONI: I think someone in the room knows the answer to this question, but is water an intrusion on this vessel part of license renewal space? I was told it wasn't. I mean it could leak,

it could flow, but it doesn't have a basis in license renewal space.

MR. GILLESPIE: Let me say it this way.

MR. ZANNONI: I was told that it did.

MR. GILLESPIE: The component is large, the component corrodes, and the component has a safety function.

That means the component is part of license renewal and has to be addressed. In fact that means it has to have an aging management program.

And if the water is allowed then the aging management program has to be such that it ensures the component's safety function will not be compromised with the water there.

And so the water leakage is not part of renewal.

But the environment, which is a high corrosive environment that the water creates, is part of license renewal. And so that's really why we're talking. Because part of the general solution for most licensees - and I'll get off Oyster Creek now - most licensees are using is a combination fo coatings - we just did Monticello with ACRS - they have a primer coating on the external surface. So it's a combination of coatings, leak control and leakage monitoring.

Both leak control and leakage monitoring, which put their seals in scope, because they said, okay, part of our aging management program for this environment is the seals, and we're not going to have leakage in the seals, so we'll have highly reliable - and so no.

But certainly the absence of water makes

aging management far easier.

MR. ZANNONI: That's a helpful clarification.

MR. GILLESPIE: Thank you, Mr. Zannoni.

Let me not make this mistake again. Is there anyone else who has a question or a comment in the room?

Mr. Recorder, you can turn it off.

(Whereupon at 12:08 p.m. the proceeding in the above-entitled matter was adjourned)

Citizen's Exhibit NC5

GPU Nuclear

Calculation Sheet

Subject	STATISTICAL ANALYSIS OF DRYWELL THICKNESS DATA THRU NOVEMBER 1991	Calc No. C-1302-187-5300-019		Rev. No. 0	Sheet No. 1 of 39
Originator	J. P. Moore, Jr.	Date 12/20/91	Reviewed by		Date 4/15/92

Verification: V-1302-187-005 Rev. 6 4-20-92

1.0 **PROBLEM STATEMENT**

The basic purpose of this calculation is to update the thickness measurement analyses documented in References 3.7, 3.8, 3.11, 3.12, 3.13 and 3.14 by incorporating the measurements taken in November 1991. Since no measurements were taken at the 87'-5" elevation in November 1991 due to high temperatures at that elevation, the results for the May 1991 measurements at 87'-5" (Ref. 3.14) are included for completeness.

Specific objectives of this calculation are:

(1) Determine the mean thickness at each of the monitored locations.

(2) Statistically analyze the thickness measurements to determine the corrosion rate at each of the monitored locations.

2.0 **SUMMARY OF RESULTS**

The results of the calculation are summarized in the following tables. The terms used are defined below.

(1) **Best Estimate Corrosion Rate**

- With three or more data points, this is the slope of the regression line.
- For only two data points, this is the slope of the steepest line which can be drawn within the ± one-sigma tolerance interval about the mean.

(2) **95% Upper Bound Corrosion Rate**

The corrosion rate for which we have 95% confidence that it is not being exceeded. At least four data sets are required to make a meaningful estimate of this value.

(3) **Best Estimate Mean Thickness**

- When the regression is statistically significant (F-Ratio is 1.0 or greater), this is the predicted value ± standard error from the regression for the date of the last measurement.

- When the regression is not statistically significant (F-Ratio less than 1.0), this is the grand mean of all the data ± standard error.

(4) **Measured Mean Thickness**

The mean ± standard error of the valid data points from the most recent set of measurements.

(5) **F-Ratio**

- An F-Ratio less than 1.0 occurs when the amount of corrosion which has occurred since the initial measurement is less than the random variations in the measurements and/or fewer than four measurements have been taken. In these cases, the computed corrosion rate does not necessarily reflect the actual corrosion rate, and it may be zero. However, the confidence interval about the computed corrosion rate does accurately reflect the range within which the actual corrosion rate lies at the specified confidence level.

- An F-Ratio of 1.0 or greater occurs when the amount of corrosion which has occurred since the initial measurement is significant compared to the random variations, and four or more measurements have been taken. In these cases, the computed corrosion rate more accurately reflects the actual corrosion rate, and there is a very low probability that the actual corrosion rate is zero. The higher the F-Ratio, the lower the uncertainty in the corrosion rate.

- Whereas an F-Ratio of 1.0 or greater provides confidence in the historical corrosion rate, the F-Ratio should be 4 to 5 if the corrosion rate is to be used to predict the thickness in the future. To have a high degree of confidence in the predicted thickness, the ratio should be at least 8 or 9.

(6) N

The number of data sets used in the analysis.

(7) Years

The time span between the first and last of the analyzed data sets.

2.1 Sand Bed Region Using Data Thru November 1991

Bay & Area	Corrosion Rate, mpy		Mean Thickness, Mils		F-Ratio(5)	N(6)	Data Span, YRS(7)
	Best Est.(1)	95% (2)	Best Est. (3)	Measured (4)			
9D	- 11.3 ±2.2	- 15.8	894.4 ±3.6	892.4 ±10.2	4.0	7	2.9
11A	- 16.2 ±1.7	- 21.2	837.3 ±5.0	832.6 ±8.4	23.4	13	4.5
11C Top	- 24.7 ±4.7	- 33.2	959.5 ±13.0	964.3 ±24.1	5.6	12	4.5
11C Bot	- 17.9 ±2.5	- 22.4	846.8 ±6.8	856.3 ±4.5	10.3	12	4.5
13A	- 17.6 ±4.1	- 25.4	839.9 ±7.1	849.6 ±7.7	3.4	8	2.9
13D Top	+ 1.2 ±13.7	--	1053.6 ±8.2	1047.8 ±13.3	--	4	1.6
13D Bot	+ 2.8 ±6.0	--	901.5 ±2.9	899.6 ±7.8	--	4	1.6
15D	- 4.3 ±2.2	- 8.6	1054.3 ±2.4	1041.7 ±10.1	0.7	8	2.9
17A Top	- 1.8 ±1.6	- 5.0	1128.1 ±1.6	1122.6 ±6.9	0.2	8	2.9
17A Bot	- 8.6 ±2.8	- 13.1	931.5 ±4.8	932.8 ±9.7	1.9	8	2.9
17D	- 19.7 ±1.8	- 22.9	810.4 ±5.2	822.2 ±9.2	26.0	13	4.7
17/19 Top	- 11.6 ±3.4	- 18.2	961.4 ±5.9	954.2 ±4.8	2.0	8	2.8
17/19 Bot	- 14.7 ±3.3	- 21.2	974.5 ±6.7	971.1 ±5.4	3.3	8	2.8
19A	- 16.3 ±1.8	- 19.1	793.6 ±4.7	803.2 ±8.9	22.0	13	4.7
19B	- 11.5 ±2.1	- 15.4	833.8 ±5.9	846.3 ±10.0	5.8	12	4.5
19C	- 17.0 ±2.1	- 20.8	813.2 ±5.9	822.3 ±10.8	13.0	12	4.5

2.2 Elevation 50'-2" Using Data Thru November 1991

Bay & Area	Corrosion Rate, mpy		Mean Thickness, Mils		F-Ratio(5)	N(6)	Data Span, YRS(7)
	Best Est.(1)	95% (2)	Best Est. (3)	Measured (4)			
5/D-12	- 3.5 ±1.1	- 5.4	742.7 ±2.4	748.1 ±2.0	2.0	11	4.0
5/5 >Mean	- 1.7 ±2.1	- 6.5	758.9 ±1.2	760.4 ±1.6	<0.1	5	1.6
5/5 ≤Mean	- 4.5 ±5.6	- 17.7	707.6 ±3.3	707.8 ±5.9	<0.1	5	1.6
13/31 >Mean	- 4.7 ±5.1	- 16.7	767.0 ±3.1	767.4 ±1.5	<0.1	5	1.6
13/31 ≤Mean	- 4.0 ±8.0	- 22.9	693.9 ±4.5	696.1 ±9.6	<0.1	5	1.6
15/23 >Mean	+ 3.0 ±2.5	- 2.8	764.1 ±1.6	768.2 ±1.0	0.1	5	1.6
15/23 ≤Mean	+ 3.8 ±2.2	- 1.5	735.7 ±1.7	739.3 ±4.2	0.3	5	1.6

2.3 Elevation 51'-10" Using Data Thru November 1991

Bay & Area	Corrosion Rate, mpy		Mean Thickness, Mils		F-Ratio(5)	N(6)	Data Span, YRS(7)
	Best Est.(1)	95% (2)	Best Est. (3)	Measured (4)			
13/32 >705	+ 1.6 ±2.1	- 4.5	718.9 ±1.1	720.0 ±0.9	<0.1	4	1.5
13/32 ≤705	- 1.7 ±1.2	- 5.2	682.8 ±0.8	682.1 ±4.5	0.1	4	1.5

2.4 Elevation 87'-5" Using Data Thru May 1991

Bay & Area	Corrosion Rate, mpy		Mean Thickness, Mils		F-Ratio(5)	N(6)	Data Span, YRS(7)
	Best Est.(1)	95% (2)	Best Est. (3)	Measured (4)			
9/20	- 2.1 ±0.7	- 3.5	614.3 ±1.5	612.2 ±1.8	1.4	7	3.5
13/28	- 3.1 ±1.2	- 5.6	634.1 ±2.7	628.9 ±3.4	0.95	7	3.5
15/31	- 2.6 ±1.4	- 5.4	634.6 ±2.1	626.8 ±1.9	0.5	7	3.5

2.5 Evaluation of Individual Measurements Exceeding 99%/99% Tolerance Interval

The following data points fell outside the 99%/99% tolerance interval and thus are statistically different from the mean thickness.

Bay	Elev	Area	Point	Mils	Dev.	Sigmas
5	51	D-1 2	9	689	-60.8	-2.9
15	51	23	26	650	-104.3	-3.7
15	51	23	27	638	-116.3	-4.1
13	52	32	23	601	-101.6	-2.9
13	52	32	28	563	-139.6	-4.0
13	86	28	32	549	-79.6	-3.8
15	86	31	34	556	-69.3	-4.2

Evaluation of the data for each of these points indicate that none of them is corroding more rapidly than the overall grid.

NOTE: Since no data was taken at the 86′ elevation in November 1991, the results of the analyses of the May 1991 data at this elevation are listed above. (Ref. 3.14)

2.6 Mean Thickness of All Points in the Grid

The following table lists the mean thickness ± 1-sigma for all the valid points in each 6"x6" grid.

Bay	Elev	Area	Date	Mean Thk
9D	Sand Bed		11/91	887.7 ±11.1
11A	Sand Bed		11/91	832.6 ±8.4
11C	Sand Bed		11/91	802.6 ±13.0
13A	Sand Bed		11/91	848.6 ±7.7
13D	Sand Bed		11/91	866.2 ±12.9
15D	Sand Bed		11/91	1041.7 ±10.1
17A	Sand Bed		11/91	1014.1 ±14.9
17D	Sand Bed		11/91	822.2 ±9.2
17/19	Frame		11/91	863.9 ±3.9
19A	Sand Bed		11/91	803.2 ±6.9
19B	Sand Bed		11/91	846.3 ±10.0
19C	Sand Bed		11/91	822.3 ±10.8
5	51'	D-1 2	11/91	749.8 ±3.3
5	51'	5	11/91	742.4 ±4.3
13	51'	31	11/91	742.9 ±5.5
15	51'	23	11/91	754.3 ±4.0
13	52'	32	11/91	702.6 ±5.0

3.0 REFERENCES

3.1 GPUN Safety Evaluation SE-000243-002, Rev. 0, "Drywell Steel Shell Plate Thickness Reduction at the Base Sand Cushion Entrenchment Region"

3.2 GPUN TDR 854, Rev. 0, "Drywell Corrosion Assessment"

3.3 GPUN TDR 851, Rev. 0, "Assessment of Oyster Creek Drywell Shell"

3.4 GPUN Installation Specification IS-328227-004, Rev. 3, "Functional Requirements for Drywell Containment Vessel Thickness Examination"

3.5 Applied Regression Analysis, 2nd Edition, N.R. Draper & H. Smith, John Wiley & Sons, 1981

3.6 Statistical Concepts and Methods, G.K. Bhattacharyya & R.A. Johnson, John Wiley & sons, 1977

3.7 GPUN Calculation C-1302-187-5300-005, Rev. 0, "Statistical Analysis of Drywell Thickness Data Thru 12-31-88"

3.8 GPUN TDR 948, Rev. 1, "Statistical Analysis of Drywell Thickness Data"

3.9 Experimental Statistics, Mary Gibbons Natrella, John Wiley & Sons, 1966 Reprint. (National Bureau of Standards Handbook 91)

3.10 Fundamental Concepts in the Design of Experiments, Charles C. Hicks, Saunders College Publishing, Fort Worth, 1982

3.11 GPUN Calculation C-1302-187-5300-008, Rev. 0, "Statistical Analysis of Drywell Thickness Data thru 2-8-90"

3.12 GPUN Calculation C-1302-187-5300-011, Rev. 1, "Statistical Analysis of Drywell Thickness Data Thru 4-24-90"

3.13 GPUN Calculation C-1302-187-5300-015, Rev. 0, "Statistical Analysis of Drywell Thickness Data Thru March 1991"

3.14 GPUN Calculation C-1302-187-5300-017, Rev. 0, "Statistical Analysis of Drywell Thickness Data Thru May 1991"

4.0 ASSUMPTIONS & BASIC DATA

4.1 Background

The design of the carbon steel drywell includes a sand bed which is located around the outside circumference between elevations 8'-11-1/4" and 12'-3". Leakage was observed from the sand bed drains during the 1980, 1983 and 1986 refueling outages indicating that water had intruded into the annular region between the drywell shell and the concrete shield wall.

The drywell shell was inspected in 1986 during the 10R outage to determine if corrosion was occurring. The inspection methods, results and conclusions are documented in Ref. 3.1, 3.2, and 3.3. As a result of these inspections it was concluded that a long term monitoring program would be established. This program includes repetitive Ultrasonic Thickness (UT) measurements in the sand bed region at a nominal elevation of 11'-3" in bays 11A, 11C, 17D, 19A, 19B, and 19C.

The continued presence of water in the sand bed raised concerns of potential corrosion at higher elevations. Therefore, UT measurements were taken at the 50'-2" and 87'-5" elevations in November 1987 during the 11R outage. As a result of these inspections, repetitive measurements in Bay 5 at elevation 50'-2" and in Bays 9, 13 and 15 at the 87'-5" elevation were added to the long term monitoring program to confirm that corrosion is not occurring at these higher elevations.

A cathodic protection system was installed in selected regions of the sand bed during the 12R outage to minimize corrosion of the drywell. The cathodic protection system was placed in service on January 31, 1989. The long term monitoring program was also expanded during the 12R outage to include measurements in the sand bed region of Bays 1D, 3D, 5D, 7D, 9A, 13A, 13C, 13D, 15A, 15D and 17A which are not covered by the cathodic protection system. It also includes measurements in the sand bed region between Bays 17 and 19 which is covered by the cathodic protection system, but does not have a reference electrode to monitor its effectiveness in this region.

The high corrosion rate computed for Bay 13A in the sand bed region through February 1990 (Ref. 3.11) raised concerns about the corrosion rate in the sand bed region of Bay 13D. Therefore, the monitoring of this location using a 6"x6" grid was added to the long term monitoring program. In addition, a 2-inch core sample was removed in March 1990 from a location adjacent to the 6"x6" monitored grid in Bay 13A.

Measurements taken in Bay 5 Area D-12 at elevation 50'-2" through March 1990 indicated that corrosion is occurring at his location. Therefore, survey measurements were taken to determine the thinnest locations at elevation 50'-2". As a result, three new locations were added to the long term monitoring program (Bay 5 Area 5, Bay 13 Area 31, and Bay 15 Area 23).

The indication of ongoing corrosion at elevation 50'-2" raised concerns about potential corrosion of the plates immediately above which have a smaller nominal thickness. Therefore, survey measurements were taken in April 1990 at the 51'-10" elevation in all bays to determine the thinnest locations. As a result of this survey, one new location was added to the long term monitoring plan at elevation 51'-10" (Bay 13 Area 32).

Some measurements in the long term monitoring program are to be taken at each outage of opportunity, while others are taken during each refueling outage. The functional requirements for these inspections are documented in Ref. 3.4. The purpose of the UT measurements is to determine the corrosion rate and monitor it over time, and to monitor the effectiveness of the cathodic protection system.

4.2 Selection of Areas to be Monitored

A program was initiated during the 11R outage to characterize the corrosion and to determine its extent. The details of this inspection program are documented in Ref. 3.3. The greatest corrosion was found via UT measurements in the sand bed region at the lowest accessible locations. Where thinning was detected, additional measurements were made in a cross pattern at the thinnest section to determine the extent in the vertical and horizontal directions. Having found the thinnest locations, measurements were made over a 6"x6" grid.

To determine the vertical profile of the thinning, a trench was excavated into the floor in Bay 17 and Bay 5. Bay 17 was selected since the extent of thinning at the floor level was greatest in that area. It was determined that the thinning below the top of the curb was no more severe than above the curb, and became less severe at the lower portions of the sand cushion. Bay 5 was excavated to determine if the thinning line was lower than the floor level in areas where no thinning was detected above the floor. There were no significant indications of thinning in Bay 5.

It was on the basis of these findings that the 6"x6" grids in Bays 11A, 11C, 17D, 19A, 19B and 19C were selected as representative locations for longer term monitoring. The initial measurements at these locations were taken in December 1986 without a template or markings to identify the location of each measurement. Subsequently, the location of the 6"x6" grids were permanently marked on the drywell shell and a template is used in conjunction with these markings to locate the UT probe for successive measurements. Analyses have shown that including the non-template data in the data base creates a significant variability in the thickness data. Therefore, to minimize the effects of probe location, only those data sets taken with the template are included in the analyses.

The presence of water in the sand bed also raised concern of potential corrosion at higher elevations. Therefore, UT measurements were taken at the 50'-2" and 87'-5" elevations in 1987 during the 11M outage. The measurements were taken in a band on 6-inch centers at all accessible regions at these elevations. Where these measurements indicated potential corrosion, the measurements spacing was reduced to 1-inch on centers. If these additional readings indicated potential corrosion, measurements were taken on a 6"x6" grid using the template. It was on the basis of these inspections that the 6"x6" grids in Bay 5 at elevation 50'-2" and in bays 9, 13 and 15 at the 87'-5" elevation were selected as representative locations for long term monitoring.

A cathodic protection system was installed in the sand bed region of Bays 11A, 11C, 17D, 19A, 19B, 19C, and at the frame between Bays 17 and 19 during the 12R outage. The system was placed in service on January 31, 1989.

The long term monitoring program was expanded as follows during the 12R outage:

(1) Measurements on 6"x6" grids in the sand bed region of Bays 9D, 13A, 15D and 17A. The basis for selecting these locations is that they were originally considered for cathodic protection but are not included in the system being installed.

(2) Measurements on 1-inch centers along a 6-inch horizontal strip in the sand bed region of Bays 1D, 3D, 5D, 7D, 9A, 13C, and 15A. These locations were selected on the basis that they are representative of regions which have experienced nominal corrosion and are not within the scope of the cathodic protection system.

(3) A 6"x6" grid in the curb cutout between Bays 17 and 19. The purpose of these measurements is to monitor corrosion in this region which is covered by the cathodic protection system but does not have a reference electrode to monitor its performance.

The long term monitoring program was expanded in March 1990 as follows:

(1) Measurements in the sand bed region of Bay 13D: This location was added due to the high indicated corrosion rate in the sand bed region of Bay 13A. The measurements taken in March 1990 were taken on a 1"x6" grid. All subsequent measurements are to be taken on a 6"x6" grid.

(2) Measurements on 6"x6" grids at the following locations at elevation 50'-2": Bay 5 Area 5, Bay 13 Area 31, and Bay 15 Area 2/3. These locations were added due to the indication of ongoing corrosion at elevation 50'-2", Bay 5 Area D-1.

The long term monitoring program was expanded in April 1990 by adding Bay 13 Area 32 at elevation 51'-10". This location was added due to the indication of ongoing corrosion at elevation 50'-2" and the fact that the nominal plate thickness at elevation 51'-10" is less than at elevation 50'-2".

4.3 UT Measurements

The UT measurements within the scope of the long term monitoring program are performed in accordance with Ref. 3.4. This involves taking UT measurements using a template with 49 holes laid out on a 6"x6" grid with 1" between centers on both axes. The center row is used in those bays where only 7 measurements are made along a 6-inch horizontal strip.

The first set of measurements were made in December 1986 without the use of a template. Ref. 3.4 specifies that for all subsequent readings, QA shall verify that locations of UT measurements performed are within ± 1/4" of the location of the 1986 UT measurements. It also specifies that all subsequent measurements are to be within ± 1/8" of the designated locations.

4.4 Data at Plug Locations

Seven core samples, each approximately two inches in diameter were removed from the drywell vessel shell. These samples were evaluated in Ref. 3.2. Five of these samples were removed within the 6"x6" grids for Bays 11A, 17D, 19A, 19C and Bay 5 at elevation 50'-2". These locations were repaired by welding a plug in each hole. Since these plugs are not representative of the drywell shell, UT measurements at these locations on the 6"x6" grid must be dropped from each data set.

The following specific grid points have been deleted:

Bay Area	Points
11A	23, 24, 30, 31
17D	15, 16, 22, 23
19A	24, 25, 31, 32
19C	20, 26, 27, 33,
5 EL 50'-2"	13, 20, 25, 26, 27, 28, 33, 34, 35

The core sample removed in the sand bed region of Bay 13A was not within the monitored 6"x6" grid.

4.5 Bases for Statistical Analysis of 6"x6" Grid Data

4.5.1 Assumptions

The statistical evaluation of the UT measurement data to determine the corrosion rate at each location is based on the following assumptions:

(1) Characterization of the scattering of data over each 6"x6" grid is such that the thickness measurements are normally distributed. If the data are not normally distributed, the grid is subdivided into normally distributed subdivisions.

(2) Once the distribution of data is found to be normal, the mean value of the thickness is the appropriate representation of the average condition.

(3) A decrease in the mean value of the thickness with time is representative of the corrosion occurring within the 6"x6" grid.

(4) If corrosion has ceased, the mean value of the thickness will not vary with time except for random errors in the UT measurements.

(5) If corrosion is continuing at a constant rate, the mean thickness will decrease linearly with time. In this case, linear regression analysis can be used to fit the mean thickness values for a given zone to a straight line as a function of time. The corrosion rate is equal to the slope of the line.

The validity of these assumptions is assured by:

(a) Using more than 30 data points per 6"x6" grid

(b) Testing the data for normality at each 6"x6" grid location.

(c) Testing the regression equation as an appropriate model to describe the corrosion rate.

These tests are discussed in the following section. In cases where one or more of these assumptions proves to be invalid, non-parametric analytical techniques can be used to evaluate the data.

4.5.2 Statistical Approach

The following steps are performed to test and evaluate the UT measurement data for those locations where 6"x6" grid data has been taken at least three times:

(1) Edit each 49-point data set by setting all invalid points to "missing." Invalid points are those which are declared invalid by the UT operator or are at a plug location. (The computer programs used in the following steps ignore all "missing" thickness data points.)

(2) Perform a Univariate Analysis of each 49 point data set to ensure that the assumption of normality is valid.

(3) Calculate the mean thickness and variance of each 49 point data set.

(4) Perform an Analysis of Variance (ANOVA) F-test to determine if there is a significant difference between the means of the data sets.

(5) Using the mean thickness values for each 6"x6" grid, perform linear regression analysis over time at each location.

   (a) Perform F-test for significance of regression at the 5% level of significance. The result of this test indicates whether or not the regression model is more appropriate than the mean model. In other words, it tests to see if the variation due to corrosion is statistically significant compared to the random variations.

   (b) Calculate the ratio of the observed F value to the critical F value at 5% level of significance. For data sets where the Residual Degress of Freedom in ANOVA is 4 to 9, this F-Ratio should be at least 8 for the regression to be considered "reliable" as opposed to simply "significant." (See paragraph 4.10.2)

   (c) Calculate the coefficient of determination (R^2) to assess how well the regression model explains the percentage of total error and thus how useful the regression line will be as a predictor.

   (d) Determine if the residual values for the regression equations are normally distributed.

(e) Calculate the y-intercept, the slope and their respective standard errors. The y-intercept represents the fitted mean thickness at time zero, the slope represents the corrosion rate, and the standard errors represent the uncertainty or random error of these two parameters. Calculate the upper bound of the 95% one-sided confidence interval about the computed slope to provide an estimate of the maximum probable corrosion rate at 95% confidence. This is explained in greater detail in paragraph 4.10.2.

(f) When the corrosion rate is not statistically significant compared to random variations in the mean thickness, the slope and confidence interval slope computed in the regression analysis still provides an estimate of the corrosion rate which could be masked by the random variations. This is explained in greater detail in paragraph 4.10.1.

(6) Use the chi-square goodness of fit test results to determine if low thickness measurements are significant pits. If the measurement deviates from the mean thickness by three standard deviations, it is considered to be a significant pit.

4.6 Analysis of Two 6"x6" Grid Data Sets

Regression analysis is inappropriate when data is available at only two points in time. However, the Analysis of Variance F-test can be used to determine if the means of the two data sets are statistically different.

4.6.1 Assumptions

This analysis is based upon the following assumptions:

(1) The data in each data set is normally distributed.

(2) The variances of the two data sets are equal.

4.6.2 Statistical Approach

The evaluation takes place in three steps:

(1) Perform a univariate test of each data set to ensure that the assumption of normality is valid.

(2) Perform an F-test at 5% level of significance of the two data sets being compared to ensure that the assumption of equal variances is valid.

(3) Perform an Analysis of Variance F-test at the 5% level of significance to determine if the means of the two data sets are statistically different.

A conclusion that the means are <u>not</u> statistically different is interpreted to mean that significant corrosion did not occur over the time period represented by the data. However, if equality of the means is rejected, this implies that the difference is statistically significant and could be due to corrosion.

The range of potential corrosion rates is estimated by computing the slope of the steepest line which can be drawn within the ± 1 sigma confidence interval about the mean thickness for the duration between the two measurements.

4.7 Analysis of Single 6"x6" Grid Data Set

In those cases where a 6"x6" data set is taken at a given location for the first time during the current outage, the only other data to which they can be compared are the UT survey measurements taken at an earlier time. For the most part, these are single point measurements which were taken in the vicinity of the 49-point data set, but not at the exact location. Therefore, rigorous statistical analysis of these single data sets is impossible. However, by making certain assumptions, they can be compared with the previous data points. If more extensive data is available at the location of the 49-point data set, the Analysis of Variance F-test can be used to compare the means of the two data sets as described in paragraph 4.5.

When additional measurements are made at these exact locations during future outages, more rigorous statistical analyses can be employed.

4.7.1 Assumptions

The comparison of a single 49-point data sets with previous data from the same vicinity is based on the following assumptions:

(1) Characterization of the scattering of data over the 6"x6" grid is such that the thickness measurements are normally distributed.

(2) Once the distribution of data for the 6"x6" grid is found to be normal, then the mean value of the thickness is the appropriate representation of the average condition.

(3) The prior data is representative of the condition at this location at the earlier date.

4.7.2 Statistical Approach

The evaluation takes place in four steps:

(1) Perform a univariate analysis of each data set to ensure that the assumption of normality is valid.

(2) Calculate the mean and the standard error of the mean of the 49-point data set.

(3) Determine the two-tailed t value from a t distribution table at levels of significance of 0.05 for n-1 degrees of freedom.

(4) Use the t value and the standard error of the mean to calculate the 95% confidence interval about the mean of the 49-point data set.

(5) Compare the prior data point(s) with these confidence intervals about the mean of the 49-point data sets.

If the prior data falls within the 95% confidence intervals, it provides some assurance that significant corrosion has not occurred in this region in the period of time covered by the data.

If the prior data falls above the upper 95% confidence limit, it could mean either of two things: (1) significant corrosion has occurred over the time period covered by the data, or (2) the prior data point was not representative of the condition of the location of the 49-point data set in 1986. There is no way to differentiate between the two.

If the prior data falls below the lower 95% confidence limit, it means that it is not representative of the condition at this location at the earlier date.

4.8 Analysis of Single 7-Point Data Set

In those cases where a 7-point data set is taken at a given location for the first time during the current outage, the only other data to which they can be compared are the UT survey measurements taken at an earlier time to identify the thinnest regions of the drywell shell in the sand bed region. For the most part, these are single point measurements which were taken in the vicinity of the 7-point data sets, but not at the exact locations. However, by making certain assumptions, they can be compared with the previous data points. If more extensive data is available at the location of the 7-point data set, the Analysis of Variance F-test can be used to compare the means of the two data sets as described in paragraph 4.5.

When additional measurements are made at these exact locations during future outages, more rigorous statistical analyses can be employed.

4.8.1 Assumptions

The comparison of a single 7-point data sets with previous data from the same vicinity is based on the following assumptions:

(1) The corrosion in the region of each 7-point data set is normally distributed.

(2) The prior data is representative of the condition at this location at the earlier date.

The validity of these assumptions cannot be verified.

4.8.2 Statistical Approach

Perform the Analysis of Variance and F-test

If the prior data falls within the 95% confidence interval, it provides some assurance that significant corrosion has not occurred in this region in the period of time covered by the data.

If the prior data falls above the upper 95% confidence interval, it could mean either of two things: (1) significant corrosion has occurred over the time period covered by the data, or (2) the prior data point was not representative of the condition of the location of the 7-point data set in 1986. There is no way to differentiate between the two.

If the prior data falls below the lower 99% confidence limit, it means that it is not representative of the condition at this location at the earlier date. In this case, the corrosion rate will be interpreted to be "Indeterminable".

4.9 Evaluation of Drywell Mean Thickness

This section defines the methods used to evaluate the drywell thickness at each location within the scope of the long term monitoring program.

4.9.1 Evaluation of Mean Thickness Using Regression Analysis

The following procedure is used to evaluate the drywell mean thickness at those locations where regression analysis has been deemed to be significant (F-Ratio is 1.0 or greater).

(1) The best estimate of the mean thickness at these locations is the point on the regression line corresponding to the time when the most recent set of measurements was taken. In the SAS Regression Analysis output (App. 6.2), this is the last value in the column labeled "PREDICT VALUE".

(2) The best estimate of the standard error of the mean thickness is the standard error of the predicted value used above. In the SAS Regression Analysis output, this is the last value in the column labeled "STD ERR PREDICT".

(3) The two-sided 95% confidence interval about the mean thickness is equal to the mean thickness plus or minus t times the estimated standard error of the mean. This is the interval for which we have 95% confidence that the true mean thickness will fall within. The value of t is obtained from a t distribution table for equal tails at n-2 degrees of freedom and 0.05 level of significance, where n is the number of sets of measurements used in the regression analysis. The degrees of freedom is equal to n-2 because two parameters (the y-intercept and the slope) are calculated in the regression analysis with n mean thicknesses as input.

(4) The one-sided 95% lower limit of the mean thickness is equal to the estimated mean thickness minus t times the estimated standard error of the mean. This is the mean thickness for which we have 95% confidence that the true mean thickness does not fall below. In this case, the value of t is obtained from a t distribution table for one tail at n-2 degrees of freedom and 0.05 level of significance.

4.9.2 Evaluation of Mean Thickness Using Mean Model

The following procedure is used to evaluate the drywell mean thickness at those locations where the regression analysis is not significant (F-Ratio is less than 1.0). This method is consistent with that used to evaluate the mean thickness using the regression model.

(1) Calculate the mean of each set of UT thickness measurements.

(2) Sum the means of the sets and divide by the number of sets to calculate the grand mean. This is the best estimate of the mean thickness. In the SAS Regression Analysis output, this is the value labelled "DEP MEAN".

(3) Using the means of the sets from (1) as input, calculate the standard error about the mean. This is the best estimate of the standard error of the mean thickness.

(4) The two-sided 95% confidence interval about the mean thickness is equal to the mean thickness plus or minus t times the estimated standard error of the mean. This is the interval for which we have 95% confidence that the true mean thickness will fall within. The value of t is obtained from a t distribution table for equal tails at n-1 degrees of freedom and 0.05 level of significance.

(5) The one-sided 95% lower limit of the mean thickness is equal to the estimated mean thickness minus t times the estimated standard error of the mean. This is the mean thickness for which we have 95% confidence that the true mean thickness does not fall below. In this case, the value of t is obtained from a t distribution table for one tail at n-1 degrees of freedom and 0.05 level of significance.

4.9.3 Evaluation of Mean Thickness Using Single Data Set

The following procedure is used to evaluate the drywell thickness at those locations where only one set of measurements is available.

(1) Calculate the mean of the set of UT thickness measurements. This is the best estimate of the mean thickness.

(2) Calculate the standard error of the mean for the set of UT measurements. This is the best estimate of the standard error of the mean thickness.

Confidence intervals about the mean thickness cannot be calculated with only one data set available.

4.10 Evaluation of Drywell Corrosion Rate

4.10.1 Regression Not Significant

If the ratio of the observed F value to the critical F value is less than 1 for the F-test for the significance of regression, it indicates that the regression is not significant at the 5% level of significance. In other words, the variation in mean thickness with time can be explained solely by the random variations in the measurements. This means that the corrosion rate is not statistically significant compared to the random variations.

The possibility does exist that the variability in the data may be masking an actual corrosion rate. Although the regression is not the result of the regression analysis can be used to estimate the potentially masked corrosion rate. We can also state with 95% confidence that the corrosion rate does exceed the upper bound of the 95% one-sided confidence interval of the slope computed in the regression analysis. The 95% upper bound is equal to the computed slope plus the one-sided t-table value times the standard error of the slope. The value of t is determined for n-2 degrees of freedom.

4.10.2 Regression Significant

If the ratio of the observed F value to the critical F value is 1 or greater, it indicates that the regression model is more appropriate than the mean model at the 5% level of significance. In other words, the variation in mean thickness with time cannot be explained solely by the random variations in the measurements. This means that the corrosion rate is significant compared to the random variations.

Although a ratio of 1 or greater indicates that regression is significant, it does not mean that the slope of the regression line is an accurate prediction of the corrosion rate. The ratio should be at least 4 or 5 to consider the slope to be a useful predictor of the corrosion rate (Ref. 3.5, pp. 93, 129-133). A ratio of 4 or 5 means that the variation from the mean due to regression is approximately twice the standard deviation of the residuals of the regression. To have a high degree of confidence in the predicted corrosion rate, the ratio should be at least 8 or 9 (Ref. 3.5, pp. 129-133).

The upper bound of the 95% one-sided confidence interval about the computed slope is an estimate of the maximum probable corrosion rate at 95% confidence. The 95% upper bound is equal to the computed slope plus the one-sided t-table value times the standard error of the slope. The value of t is determined for n-2 degrees of freedom.

5.0 CALCULATIONS

5.1 6"x6" Grids in Sand Bed Region

5.1.1 Bay 9D 12/19/88 to 11/02/91

In the analysis of data thru May 1991, these data sets did not meet the acceptance criteria for either regression or difference between means. Examination of the analysis revealed two reasons for this: (1) the mean value of the 6/26/89 data set fell about 30 mils above the regression line, and (2) there was a pit at point 15 which deviated from the mean thickness by more than 3-sigma. The data was reanalyzed without the 6/26/89 data set and without point 15. The regression of these data sets met the acceptance criteria and the regression was statistically significant.

Eight 49-point data sets were available for the period through November 1991. With the November 1991 data, the data sets meet the acceptance criteria for regression with the 6/26/89 data set and point 15. However, the regression accounts for only 61% of the variability in the data. The regression without the 6/26/89 data set accounts for 85% of the variability in the data. The regression without the 6/26/89 data and without point 15 accounts for 84% of the variability in the data. The deviation of point 15 from the mean thickness is 2.89-sigma for the November 1991 data, and thus is close to the 3-sigma value for a deep pit. The regression without the 6/26/89 data is much stronger than the regression with it, and the regressions with and without point 15 are essentially identical. Therefore, to provide continuity with the prior analyses, the reported regression results are without the 6/26/89 data and without point 15. The regression of these data sets meet the acceptance criteria and is statistically significant.

5.1.2 Bay 11A: 4/29/87 to 11/02/91

The regression of thirteen data sets for this period meets the acceptance criteria and is statistically significant.

5.1.3 Bay 11C: 5/1/87 to 11/02/91

Twelve 49-point data sets were available for this period. Prior analysis have shown that there has been minimal corrosion in the top 3 rows of the 6" x 6" grid with more extensive corrosion in the bottom 4 rows. Therefore, these subsets are analyzed separately.

Top 3 Rows

The regression of these data sets meets the acceptance criteria and is statistically significant.

Bottom 4 Rows

The regression of these data sets meets the acceptance criteria and is statistically significant.

5.1.4 Bay 13A: 12/17/88 to 11/02/91

The regression of nine data sets for this period meets the acceptance criteria and is statistically significant.

5.1.5 Bay 13D: 3/28/90 to 11/02/91

One 7-point data set and four 49-point data sets were available for this period.

Prior evaluation showed that the 7-point data set of 3/28/90 and the 49-point data set of 4/25/90 were normally distributed. However, there was a line of demarcation separating a zone of minimal corrosion at the top from a corroded zone at the bottom. Thus, it was concluded that corrosion has occurred at this location.

The 49-point data set of 2/23/91 contains an invalid measurement at point #47. Therefore, this was input as a "missing" value to exclude it from the analyses. The data sets have a line of demarcation separating the upper and lower zones. Therefore, the grid was divided into two zones consisting of the following points:

Top Zone	Bottom Zone
1 - 16	17 - 18
19 - 22	23 - 26
27 - 28	29 - 49

Top Zone

This zone consists of 22 points.

(1) The data are normally distributed.

(2) The regression is not statistically significant and has a positive slope.

(3) Analysis of variance shows no significant difference between the means. Thus, there is no indication of statistically significant corrosion during this period.

Bottom Zone

This zone consists of 27 points.

(1) The data are normally distributed except for the 4/25/90 data which is skewed to the thin side.

(2) The regression is not statistically significant and has a positive slope.

(3) Analysis of variance shows no significant difference between the means. Thus, there is no indication of statistically significant corrosion during this period.

5.1.6 Bay 15D: 12/17/88 to 11/02/91

Eight 49-point data sets were available for this period.

(1) The regression is not statistically significant.

(2) The data are normally distributed.

(3) The Analysis of Variance shows that there is no significant difference in the means at 95% confidence. Thus, there is no indication of statistically significant corrosion during this time period.

5.1.7 Bay 17A: 12/17/88 to 11/02/91

Eight 49-point data sets were available for this period.

Prior analyses have shown a lack of normality due to minimal corrosion in the top 3 rows and more extensive corrosion in the bottom 4 rows. Therefore, these subsets are analyzed separately.

Top 3 Rows

(1) the regression is not statistically significant.

(2) the data are normally distributed.

(3) The Analysis of Variance shows that there is no significant difference in the means at 95% confidence. Thus, there is no indication of statistically significant corrosion during this time period.

Bottom 4 Rows

The regression of these data sets meets the acceptance criteria and is statistically significant.

5.1.8 Bay 17D: 2/17/87 to 11/02/91

The regression of thirteen data sets for this period meets the acceptance criteria and is statistically significant.

5.1.9 Bay 17/19 Frame Cutout: 12/30/88 to 11/02/91

Eight 49-point data sets were available for this period.

Prior analyses have shown a lack of normality due to more extensive loss of thickness in the top 3 rows than in the bottom 4 rows. Therefore, these subsets are analyzed separately.

Top 3 Rows

(1) Based on the Univariate Analysis, seven of the eight subsets are normally distributed. The other one (February 1990) contains two high readings and one low reading which cause the maldistribution.

(2) The Analysis of Variance shows that there is a significant difference amongst the means at 95% confidence. This indicates that there is significant ongoing corrosion.

(3) The regression of the eight data sets meets the acceptance criteria and is statistically significant.

Bottom 4 rows

(1) Based on the Univariate Analysis, three of the subsets are normally distributed. The other two (February 1990 and April 1990) each contain a data point which deviates significantly from the mean and causes the maldistribution.

(2) The regression of the eight data sets meets the acceptance criteria and is statistically significant.

5.1.10 Bay 19A: 2/17/87 to 11/02/91

Thirteen 49-point data sets were available for this period. Since a plug lies within this region, four of the points were voided in each data set. The regression of these data sets meets the acceptance criteria and is statistically significant.

5.1.11 Bay 19B: 5/1/87 to 11/02/91

The regression of twelve data sets for this period meets the acceptance criteria and is statistically significant.

5.1.12 Bay 19C: 5/1/87 to 11/02/91

Twelve 49-point data sets were available for this period. Since a plug lies within this region, four of the points were voided in each data set. The regression of these data sets meets the acceptance criteria and is statistically significant.

5.2 6" x 6" Grids at Elevation 50'-2"

5.2.1 Bay 5 Area D-12: 11/1/87 to 11/02/91

Ten 49-point data sets were available for this period. Since a plug lies within this region, seven of the points were voided in each data set.

The initial analysis of these data sets indicated that they are not normally distributed. The following adjustments were made to the data:

(1) Point 9 is a significant pit. Therefore, it was dropped from the overall analysis and is evaluated separately.

(2) Points 13 and 25 are extremely variable and are located adjacent to the plug which removed from this grid. They were dropped from the analysis.

(3) Point 43 in the 11/01/87 data set is much less than any succeeding measurement. Therefore, this data point was dropped from the analysis.

(4) Point 29 in the 9/13/89 data is much greater than the preceding or succeeding measurements. Therefore, this data point was dropped from the analysis.

(5) Points 1 and 37 in the 4/25/90 data set are much greater than the preceding or succeeding measurements. Therefore, these two data points were dropped from the analysis.

(6) Points 3 and 36 in the 11/02/91 data set are much greater than the preceding or succeeding measurements. Therefore, these two data points were dropped from the analysis.

With these adjustments, the Univariate Analyses indicate that all of the data sets are normally distributed at the 1% level of significance.

The regression of these data sets meets the acceptance criteria and is statistically significant.

Pit at Point 9

Analyses show that the high reading of 746 mils in July 1988 for the pit at point 9 is an outlier and must be dropped to obtain a meaningful least squares fit. Dropping this point, the mean thickness of the remaining points is 694.6 ±1.9 mils, and the standard deviation of the measurements is ±6.1 mils. The best estimate of the corrosion rate is -3.6 ±1.2 mils per year with an R^2=52%. It is concluded that the corrosion rate in the pit is essentially the same as the overall grid.

5.2.2 Bay 5 Area 5: 3/31/90 to 11/02/91

Three 49-point data sets were available for this period.

The data are not normally distributed due to a large corroded patch near the center of the grid and several smaller patches on the periphery.

The data was split into two subsets consisting of points whose mean value is less than or equal to the grand mean, and those greater than the grand mean.

Points With Mean Less than Grand Mean

(1) The regression is not statistically significant.

(2) These 15-point subsets are normally distributed.

(3) Analysis of variance shows that there is not a significant difference between the means of the subsets. Thus, there is no indication of statistically significant corrosion during this period.

Points with Mean Greater than Grand Mean

(1) The regression is not statistically significant.

(2) These 34-point subsets are normally distributed.

(3) Analysis of variance shows that there is a statistically significant difference between some of the means. However, the differences do not correlate with time and are not attributed to corrosion.

(4) Thus, there is no indication of statistically significant corrosion during this period.

5.2.3 Bay 13 Area 31: 3/31/90 to 11/2/91

Five 49-point data sets were available for this period.

The data are not normally distributed. This is due to a large corroded patch at the left edge of the grid.

The data was split into two subsets consisting of those points whose mean value is less than or equal to the grand mean, and those greater than the grand mean.

Points with Mean Less than Grand Mean

(1) The regression is not statistically significant.

(2) These 14-point subsets are normally distributed.

(3) Analysis of Variance shows that there is not a significant difference between the means of the subsets. Thus, there is no indication of statistically significant corrosion during this period.

Points with Mean Greater than Grand Mean

These 35-point subsets are not normally distributed. This is due to two points with low readings in March 1990, two points with high readings in April 1990, two points with low readings in February 1991, and one point with a low reading in November 1991. When these seven points are deleted, the subsets are normally distributed.

These subsets with the outliers deleted are evaluated below.

(1) The regression is not statistically significant.
(2) Analysis of variance shows that the second data set (April 1990) is statistically different from the other four. The November 1991 subset is greater than all except the April 1990 subset. Thus, there is no indication of statistically significant corrosion during this period.

5.2.4 Bay 15 Area 23: 3/31/90 to 11/2/91

Five 49-point data sets were available for this period.

The data are not normally distributed. This is due to a large corroded patch near the center of the grid and a significant pit at point 26. There are also some random readings over 780 mils which are outliers. Also, the measurement of 638 mils at point 27 in November 1991 is 118 mils less than the lowest prior measurement. This point is adjacent to the pit at point 26 and was therefore deleted.

The data was split into two subsets:

(1) Points whose mean value is less than or equal to the grand mean. The pit at point 26 was excluded.

(2) Points whose mean value is greater than the grand mean. Readings greater than 780 mils were set to "missing."

Points with Mean Less than Grand Mean

(1) The regression is not statistically significant and has a positive slope.

(2) The 16-point subsets are normally distributed.

(3) Analysis of Variance shows that there is not a significant difference between the means of the subsets.

(4) There is no indication of statistically significant corrosion during this period.

Points with Mean Greater than Grand Mean

(1) The regression is not statistically significant and has a positive slope.

(2) The subsets are all normally distributed except for the 2/23/91 data which has two measurements (points 22 and 29) which are significantly higher than prior or subsequent measurements.

(3) Analysis of Variance indicates that there is a significant difference between some of the means. However, this is not indicative of corrosion since the later means exceed the earlier means.

(4) There is no indication of statistically significant corrosion during this period.

Pit at Point 26

The five readings are normally distributed. The best estimate of the corrosion rate is +1.2 ±3.0 mils per year. There is no indication of significant corrosion during this period.

Point 27 had a low measurement of 638 mils in November 1991. All prior measurements fell between 756 and 763 mils. Since this point is adjacent to point 26, it is concluded that the November 1991 measurement is really the pit analyzed above.

5.3 <u>6" x 6" Grids at Elevation 51'-10"</u>

5.3.1 Bay 13 Area 32: 4/26/90 to 11/02/91

Four 49-point data sets were available for this period.

The data are not normally distributed. This is due to a "T" shaped corrosion patch along the right edge and across the center. Examination of the Normal Probability Plot from the Univariate Analysis reveals the following distinct populations:

(1) Four pits at points 20, 23, 25 and 28.

(2) A group of 13 to 14 readings less than 705 mils.

(3) A group of 31 to 32 readings greater than 705 mils.

(4) Two outliers with values of 732 mils (Point 34 on 4/26/90) and 736 mils (point 33 on 2/23/91).

(5) The 5/23/91 value at point 11 (660 mils) was 39 to 45 mils less than the other three values. If this point were included in the analysis, it would have a major impact on the calculated mean corrosion rate.

For subsets (2) and (3) above, all points consistently fell in the same group except for points 1, 5, 7, 14, and 49. For each of these points, three measurements fell in one subset and one measurement fell in the other subset.

Subsets (2) and (3) were used to analyze the corrosion rate.

Points Less than 705 Mils

(1) The regression is not statistically significant.

(2) These subsets are normally distributed.

(3) Analysis of Variance shows that there is not a significant difference between the means of the subsets.

(4) There is no indication of statistically significant corrosion during this period.

Points Greater than 705 Mils

(1) The subsets are normally distributed except for one exceptionally high reading in February 1991.

(2) Analysis of Variance shows that there is a significant difference between the mean of the November 1991 subset

and the means of the other three subsets. However, the mean of the November 1991 subset exceeds the others and thus is not indicative of corrosion.

(3) The regression is not statistically significant.

(4) Thus, there is no indication of significant corrosion during this period.

Pits at Points 20, 23, 25 and 28

The measurement at these locations are listed below.

	20	23	25	28
4/26/90	628	594	622	558
2/23/91	626	594	621	558
5/23/91	626	592	620	555
11/2/91	630	601	626	563

The standard deviation of November 1991 data for the points less than 705 mils is 14.3 mils. With 14 data points, the 99%/99% one-sided lower bound is 682-4.5 (14.3) = 617 mils. Thus points 23 and 28 are significant pits. However, the difference between readings is minimal, so there is no indication of significant corrosion in these pits.

Low Reading at Point 11

There have been several cases where there have been significant differences between readings at a given location. It usually occurs in grids with significant pitting such that a pit is observed one time but not another time. The large difference at point 11 is attributed to this.

5.4 6" x 6" Grids at 87'-5" Elevation

No measurements were taken at the 87'-5" Elevation during the November 1991 due to the high temperature. Therefore, the May 1991 evaluation of corrosion rates is given below to provide complete documentation of the latest analyses.

5.4.1 Bay 9 Area 20: 11/6/87 to 5/23/91

The regression of the seven 49-point data sets for this period meets the acceptance criteria and is statistically significant.

5.4.2 Bay 13 Area 28: 11/10/87 to 5/23/91

Seven 49-point data sets were available for this period.

The data sets are not normally distributed. Examination of the data shows that this is due to the seven thinnest points: 1, 2, 22, 25, 26, 36 and 48.

Analysis of Data Without 7 Thinnest Points

(1) The data are normally distributed.

(2) The regression is not statistically significant.

(3) Analysis of variance indicate that there is a significant difference between the means of the February and May 1991 data sets and the means of the other five data sets. This could be caused by actual corrosion, random variations in the data, or a slight bias in the measurements. More data is required to determine the true cause.

5.4.3 **Bay 15 Area 31: 11/10/87 to 5/23/91**

Seven 49-point data sets were available for this period.

(1) The data sets are normally distributed at 95% confidence except for the July 1988 data which is normally distributed at 99%.

(2) The regression is not statistically significant.

(3) Analysis of variance shows that there is a significant difference between the means of the February and May 1991 data sets and the means of the prior data sets. This could be caused by actual corrosion, random variations in the data, or a slight bias in the measurements. More data is required to determine the true cause.

(4) The pit at point 34 is behaving like the rest of the grid. The current reading of 556 mils at point 34 is 9 mils below the mean for this point. The current mean reading for the grid is 8 mils below the grand mean.

Citizen's Exhibit NC6

Citizen's Exhibit NC6

AmerGen
A PECO Energy/British Energy Company

CALCULATION COVER SHEET
(Ref. EP-006)

Subject: Statistical Analysis of Drywell Vessel Thickness Data Through September 2000	Calculation No. C-1302-187-E310-037	Rev. No. ~~0~~ 1	System Nos. 187	Sheet 1 of 36

1. Is this calculation within the scope of the GPUN Operational Quality Assurance Plan? (If YES, a verification is required unless the calculation is a non-substantive revision.) — X Yes ☐ No

2. Does this calculation contain assumptions / design inputs that require confirmation? (If YES, provide CAP or appropriate configuration control number(s)) (e.g., ECD, PFU, MD, PCR, etc.) ______ — ☐ Yes X No

3. Does this calculation require revision to any existing documents? (If yes, provide CAP or appropriate configuration control number(s)) ______ — ☐ Yes X No

4. Is this calculation performed as a design basis calculation? (If YES, identify design basis parameters.) (See Section 3.3) — ☐ Yes X No

Parameter: ______

Referenced Calculations and Safety Evaluations (See Section 4.3.1.3)	Rev. No.
1) Safety Evaluation SE-000243-002, "Drywell Steel Shell Plate Thickness Reduction at the Base Sand Cushion Entrenchment Region."	15
2) GPUN calculation C-1302-187-5300-005, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru 12-31-88"	0
3) GPUN Calculation C-1302-187-5300-028, Rev.0, "OCDW Statistical Analysis of Drywell Thickness Data Thru September 1994"	0
4) GPUN Calculation C-1302-187-5300-028, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru September 1996"	0

Comments: Rev.1 updates the Coversheet Referenced Calculation Section with three additional references. In addition reference 3.22 on page 11 was corrected from C-1302-187-5300-028 to C-1302-187-5300-030. These changes correct or update references and editorial and do not affect the calculation, the conclusions or results. Therefore the verification is unaffected.

APPROVALS

Originator Peter Tamburro [signature]	Date 12/23/00
Verification Engineer/Reviewer Steve Leshnoff S. Leshnoff	Date 12/28/00
Section Manager Tom Quintenz [signature]	Date 3-26-01
Other Verification Engineer/Reviewer	Date
Other Verification Engineer/Reviewer	Date

AG5870 (02/00)

AmerGen	CALCULATION VERIFICATION CHECKLIST (Ref. EP-006)			
Subject: Statistical Analysis of Drywell Vessel Thickness Data Through September 2000	Calculation No. C-1302-187-E310-037	Rev. No. 0	System Nos. 187	Sheet: 3 of 36

Place an "X" in the applicable box (Yes, No, N/A) for each item.

A "NO" response may indicate that the design or verification is incomplete and may require a CAP to be assigned by the responsible Section Manager. The Section Manager shall review each "NO" response to determine if the "NO" response requires further investigation.

A "N/A" (Not Applicable) response does not require any further action by the Verification Engineer.

The Verification Summary (Exhibit 7A) may be used to outline the Verification Engineer's work or to document comments that are deemed appropriate by the Verification Engineer.

ITEMS	Review Check / Design Compliance Yes	No	N/A
1. Design Input and Data – Were the inputs correctly selected, referenced (latest revision) and incorporated into the calculation?	☒	☐	☐
2. Assumptions – Are assumptions necessary to perform the calculation adequately described and reasonable?	☒	☐	☐
3. Regulatory Requirements – Are the applicable codes and standards and regulatory requirements, including issue and addenda, properly identified and their requirements met?	☐	☐	☒
4. Construction and Operating Experience – Has applicable construction and operating experience been considered?	☐	☐	☒
5. Interfaces – Have the design interface requirements been satisfied?	☐	☐	☒
6. Methods –Is the appropriate calculation method used?	☒	☐	☐
7. Output – Is the output reasonable compared to the inputs?	☒	☐	☐
8. Acceptance Criteria – Are the acceptance criteria incorporated in the calculation sufficient to allow verification that the design requirements have been satisfactorily accomplished?	☒	☐	☐
9. Radiation Exposure – Has the calculation properly considered radiation exposure to the public and plant personnel?	☐	☐	☒

Comments:

1. Purpose

The purpose of this calculation is to update the Drywell Thickness Analyses documented in reference 3.7, 3.8, and 3.11 through 3.22 by incorporating measurements taken in September 2000 (see Appendix 10). Results of this calculation will be used in to update reference 3.1

Specific objectives of this calculation are:

1) Determine the September 2000 mean thickness at each monitored location
2) Statistically analyze the thickness measurements to determine if a corrosion rate exists at each location,
3) If corrosion rate exists, provide a conservative projection to 2009 and 2029.

This calculation does not evaluate the sand bed region. The corrosion in the sand bed region was eradicated in 1992 by removing sand. The external side of the Drywell Vessel in these regions was then coated. Follow-up inspections after 1992 (including September 2000) shows that the coating is good condition. Therefore thickness measurements of the sandbed region are not required.

This calculation does not use the same software that was used in earlier calculations. Previous calculations utilized the GPUN main frame computer and the "SAS" main frame software. The Oyster Creek Plant has been sold to AmerGen in the year 2000. The GPUN Main Frame will not be available to AmerGen after the year 2002. Also the "SAS" software is mainframe based and difficult to learn and maintain. An alternative PC based software, "MATHCAD", has been chosen to perform this calculation.

Although software has been changed the overall methodology, with minor exceptions, is the same as in previous calculation. The minor exceptions are the statistical tests which determine whether the data is normally distributed.

Also, since the GPUN Maine Frame Computer stored all program data, this calculation documents all data sets since the beginning of the program for each inspection location above the sandbed elevation.

1. Purpose

The purpose of this calculation is to update the Drywell Thickness Analyses documented in reference 3.7, 3.8, and 3.11 through 3.22 by incorporating measurements taken in September 2000 (see Appendix 10). Results of this calculation will be used in to update reference 3.1

Specific objectives of this calculation are:

1) Determine the September 2000 mean thickness at each monitored location
2) Statistically analyze the thickness measurements to determine if a corrosion rate exists at each location,
3) If corrosion rate exists, provide a conservative projection to 2009 and 2029.

This calculation does not evaluate the sand bed region. The corrosion in the sand bed region was eradicated in 1992 by removing sand. The external side of the Drywell Vessel in these regions was then coated. Follow-up inspections after 1992 (including September 2000) shows that the coating is good condition. Therefore thickness measurements of the sandbed region are not required.

This calculation does not use the same software that was used in earlier calculations. Previous calculations utilized the GPUN main frame computer and the "SAS" main frame software. The Oyster Creek Plant has been sold to AmerGen in the year 2000. The GPUN Main Frame will not be available to AmerGen after the year 2002. Also the "SAS" software is mainframe based and difficult to learn and maintain. An alternative PC based software, "MATHCAD", has been chosen to perform this calculation.

Although software has been changed the overall methodology, with minor exceptions, is the same as in previous calculation. The minor exceptions are the statistical tests which determine whether the data is normally distributed.

Also, since the GPUN Maine Frame Computer stored all program data, this calculation documents all data sets since the beginning of the program for each inspection location above the sandbed elevation.

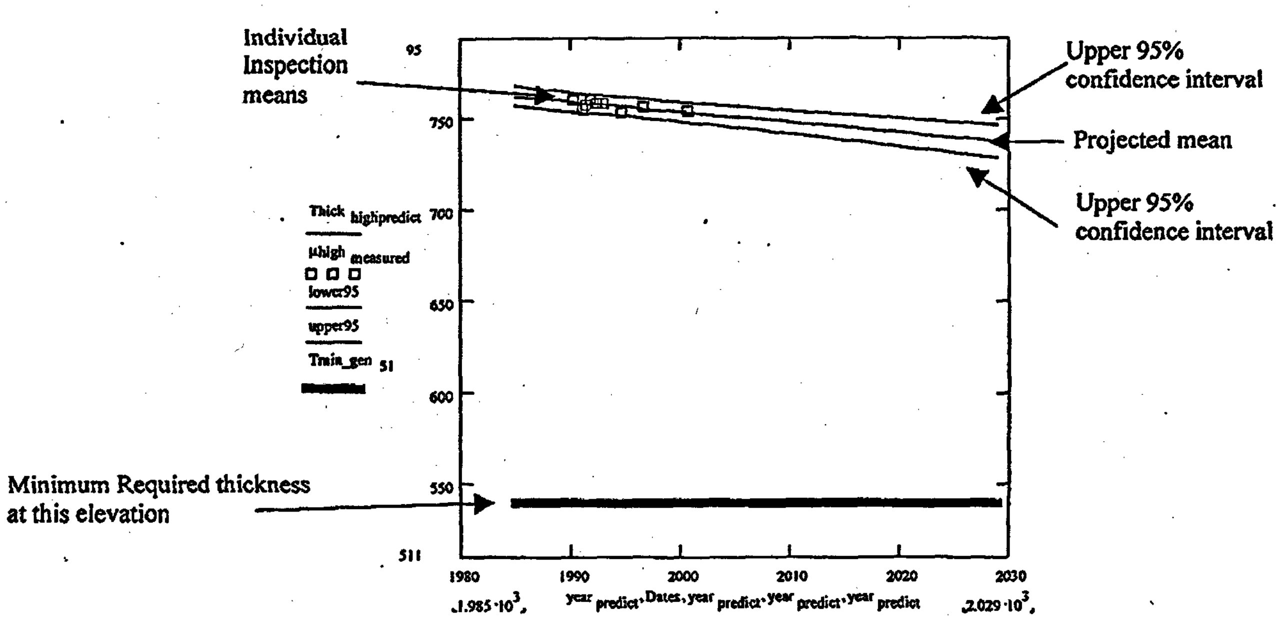
2.0 Summary of Results

2.1 Elevation 50' 2" Through September 2000.

Bay	Area/ Location	Sept. 2000 Mean +/- Standard Error (mils)	No of Insp.	F-ratio	Mean of all Inspections +/- Standard Error (mils)	Corrosion Rate (mils/ year)	Projected Lower 95% Confidence Thickness in 2009 (mils)	Min Required Thickness (mils)
5	D12	741.2 +/- 1.8	11	0.13	744.8 +/- 0.8	NA	NA	541
5	5 low	706.1 +/- 6.6	10	0.06	704.7 +/- 0.6	NA	NA	541
5	5 hi	754.1 +/- 1.9	10	1.23	NA	0.6	742.8	541
13	31 low	682.0 +/- 6.9	10	0.02	685.4 +/- 1.2	NA	NA	541
13	31 hi	762.4 +/- 2.0	10	0.06	764.0 +/- 1.8	NA	NA	541
15	23 low	729.4 +/- 3.6	10	0.51	726.5 +/- 0.6	NA	NA	541
15	23 hi	757.8 +/- 1.1	10	0.01	761.7 +/- 1.0	NA	NA	541

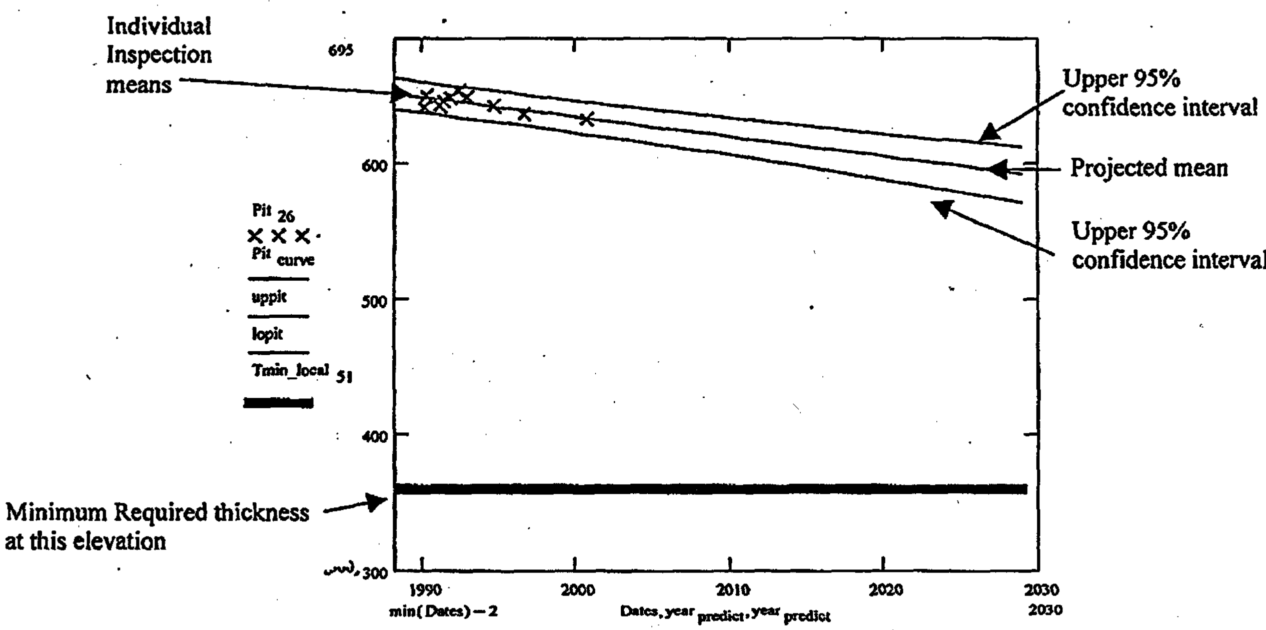
Since February 1990, ten or more inspections have been performed on each of the four locations at this elevation. Three of these four locations are not experiencing corrosion. A portion of the fourth location (Bay 5, area 5) may be experiencing a minor corrosion rate of approximately 0.6 mils per year. This corrosion rate is very small. Projection based on this corrosion rate using the 95% lower confidence interval shows that it will not corrode to less than the minimum required thickness by the year 2009 or 2029. There is substantial margin, even when considering plant life extension (see the plot below).

Bay 5 Area 5 Corrosion Projection



Analysis of individual points within these four locations shows no ongoing corrosion except for two points. Bay 5 Location D12, point 9 may be experiencing a corrosion rate of 1.3 mils per year. Bay 5 Location 23, point 26 may be experiencing a corrosion rate of 1.5 mils per year. These corrosion rates are very small. Projection based on these corrosion rates using the 95% lower confidence interval shows that these points will not corrode to less than the minimum required thickness by the years 2009 or 2029. There is substantial margin, even when considering plant life extension (see the plot below).

Bay 5 Area 23 Point 26 Corrosion Projection



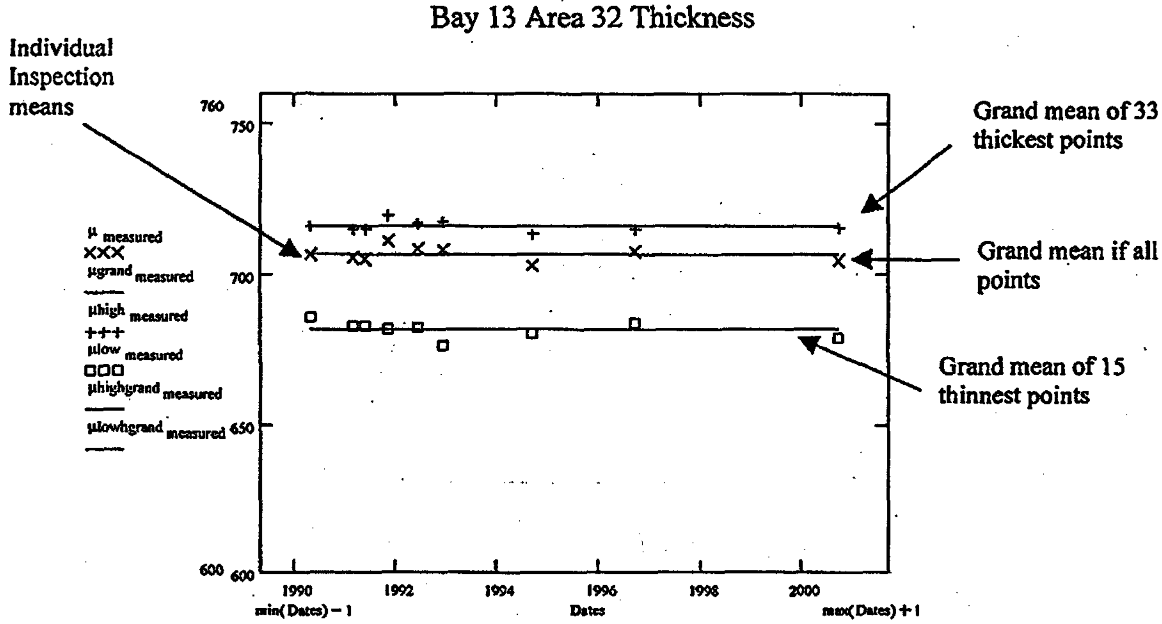
These results are not unexpected given the minor rates, the accuracy of UT technology, and the repeatability of data collection methodology. For example, in Bay 5 location 5 the Standard Error for September 2000 is 1.9 mils. This Standard Error is consistent for data from past inspections and for this location. Therefore it would take a substantial amount of time for a rate of 0.6 mils per year to be observed. It is therefore concluded that the program has finally performed enough inspections over a long enough time frame to observe these minor corrosion rates.

2.2 Elevation 51' 10" through September 2000.

Bay	Area/ Location	Sept. 2000 Mean +/- Standard Error (mils)	No of Insp.	F-ratio	Mean of all Inspections +/- Standard Error (mils)	Corrosi on Rate (mils/ year)	Projected Lower 95% Confidence Thickness in 2009 (mils)	Min Required Thickness (mils)
13	32 low	678.8 +/-5.2	9	0.30	681.8 +/- 0.9	NA	NA	541
13	32 hi	715.2 +/-0.8	9	0.17	716.0 +/- 0.6	NA	NA	541

Since April 1990, nine inspections have been performed on one location at this elevation. The data indicates that this location is not experiencing corrosion (see the pot below).

Bay 13 Area 32 Thickness



Analysis of local individual points within this location shows no ongoing corrosion.

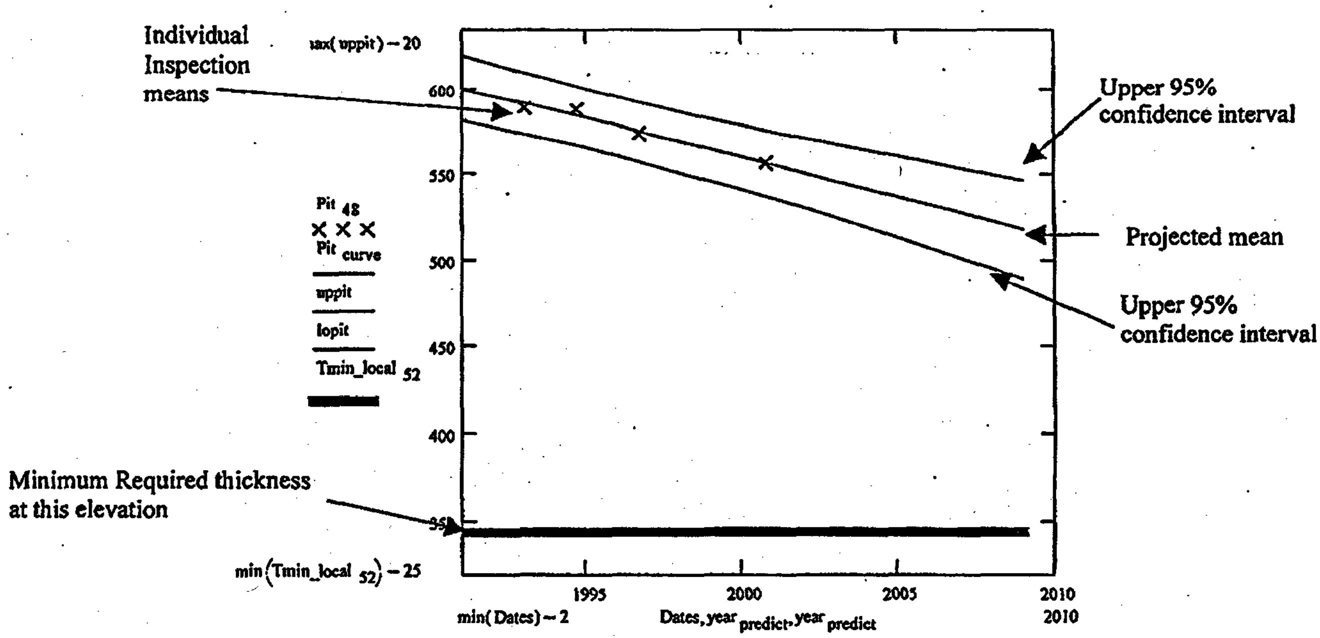
2.3 Elevation 60' 10" through September 2000.

Bay	Area/ Location	Sept. 2000 Mean +/- Standard Error (mils)	No of Insp.	F-ratio	Mean of all Inspections +/- Standard Error (mils)	Corrosion Rate (mils/ year)	Projected Lower 95% Confidence Thickness in 2009 (mils)	Min Required Thickness (mils)
1	5-22	688.5 +/- 4.2	4	0.04	696.5 +/- 5.0	NA	NA	518

Since December 1992, only four inspections have been performed on this one location. The data indicates that this location is not experiencing corrosion.

Analysis of local individual points within this location shows that there may be ongoing corrosion at one point. Bay 1 location 5-22, point 48 may be experiencing a corrosion rate of 4.5 mils per year. This calculated rate, which is greater than all other calculated rates may be due to the limited amount of inspections. The methodology and analysis results in greater rates and confidence levels with less inspection information. As shown for other locations, which have at least 9 inspections, the observed rates are less. Never-the-less projection based on this corrosion rates using the 95% lower confidence interval, which is significantly more conservative than at other locations show that this point will not corrode to less than the minimum required thickness by the year 2009. Additional inspections are required to successfully project to 2029.

Bay 1 Area 5-22 Point 48 Corrosion Projection

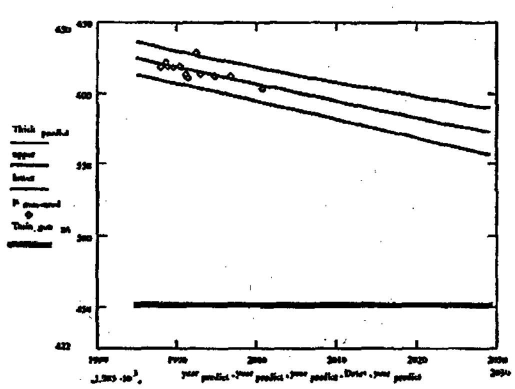


2.4 Elevation 87' 5" through September 2000.

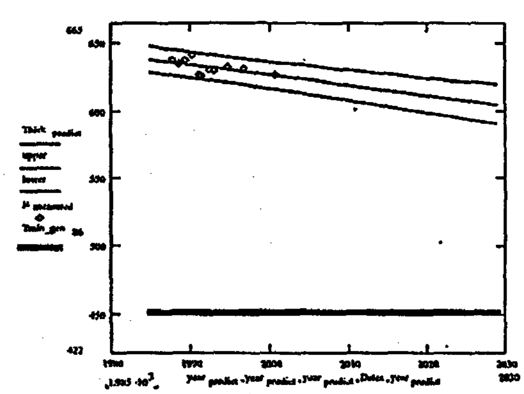
Bay	Area/ Location	Sept. 2000 Mean +/- Standard Error (mils)	No of Insp.	F-ratio	Mean of all Inspections +/- Standard Error (mils)	Corrosion Rate (mils/ year)	Projected Lower 95% Confidence Thickness in 2009 (mils)	Min Required Thickness (mils)
9	20	603.8 +/-2.1	12	1.84	NA	1.2	596.7	452
13	28	634.9 +/-1.9	12	0.62	638.8 +/- 1.3	NA	NA	452
15	31	627.5 +/-2.0	12	1.05	633.1 +/- 1.4	0.75	620.5	452

Since November 1987, twelve inspections have been performed on each of the three locations at this elevation. Two of the three locations may be experiencing corrosion. Bay 9, area 20 is experiencing minor a corrosion rate of approximately 1.2 mils per year. Bay 15 area 31 may be experiencing a corrosion rate of 0.75 mils per year. The F-ratio for this second location is 1.05, which is on the threshold as to whether or not a rate exists. These corrosion rates are very small. Projections based on these corrosion rates using the 95% lower confidence interval shows that they will not corrode to less than the minimum required thickness by the years 2009 or 2029. There is substantial margin, even when considering life extension.

Bay 9 Area 20 Corrosion Projection



Bay 15 Area 31 Corrosion Projection



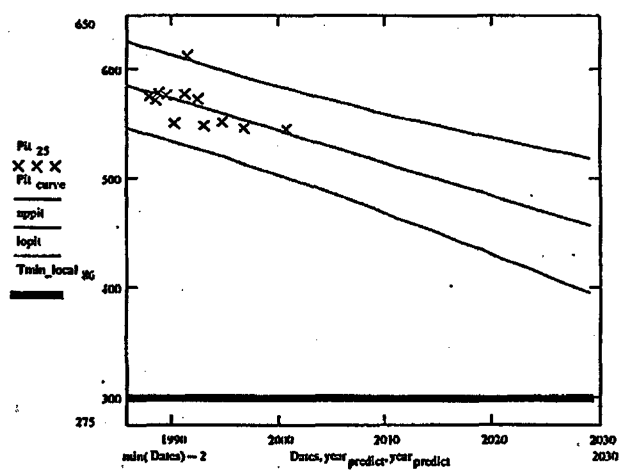
Analysis of local individual points within these three locations show no ongoing corrosion with the possible exception of point 25 in bay 13 area 28 which has an F-ratio of 0.96. Again this value is on the threshold as to whether or not a rate exists. This point may be experiencing a corrosion rate of 3.0 mils per year. Projection based on these corrosion rates using the 95% lower confidence interval shows that this point will not corrode to less than the minimum required thickness by the years 2009 or 2029. There is substantial margin, even when considering plant life extension.

AmerGen CALCULATION SHEET

Preparer: Pete Tamburro 2/13/01

Subject:	Calculation No.	Rev. No.	System Nos.	Sheet
Statistical Analysis of Drywell Vessel Thickness Data Through September 2000	C-1302-187-E310-037	0	187	

Bay 13 Area 28 Point 25 Corrosion Projection



These results are not unexpected given the minor rates, the accuracy of UT technology, and the repeatability of data collection methodology. For example, in Bay 9 location 20 the Standard Error for September 2000 is 2.1 mils. This Standard Error is consistent for data from past inspections and for this location. Therefore it would take a substantial amount of time for a rate of 1.2 mils per year to be observed. It is therefore concluded that the program has finally performed enough inspections over a long enough time frame to observe these minor corrosion rates.

3.1 References

3.1 GPUN Safety Evaluation SE-000243-002, Rev. 14 "Drywell Steel Shell Plate Thickness Reduction at the Base Sand Cushion Entrenchment Region."

3.2 GPUN TDR 854, Rev. 0 "Drywell Corrosion Assessment"

3.3 GPUN TDR 851, Rev. 0 "Assessment of Oyster Creek Drywell Shell"

3.4 GPUN Installation Specification, IS-328227-004, Rev XX, "Functional Requirements for Drywell Containment Vessel Thickness Examination"

3.5 Applied Regression Analysis, 2nd Edition, N. R. Draper & H. Smith, John Wiley and Sons 1981

3.6 Statistical Concepts and Methods, G.K. Bhattacharyya & R.A. Johnson, John Wiley and Sons 1977

3.7 GPUN calculation C-1302-187-5300-005, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru 12-31-88"

3.8 GPUN TDR 948, Rev. 1 "Statistical Analysis of Drywell Thickness Data"

3.9 Experimental Statistics, Mary Gobbons Natrella, John Wiley & Sons, 1966 Reprint (National Bureau of Standards Handbook 91)

3.10 Fundamental Concepts in the Design of Experiments, Charles C Hicks, Saunders College Publishing, Fort Worth, 1982

3.11 GPUN Calculation C-1302-187-5300-008, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru 2-8-90"

3.12 GPUN Calculation C-1302-187-5300-011, Rev.1, "Statistical Analysis of Drywell Thickness Data Thru 4-24-90"

3.13 GPUN Calculation C-1302-187-5300-015, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru March 1991"

3.14 GPUN Calculation C-1302-187-5300-017, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru May 1991"

3.15 GPUN Calculation C-1302-187-5300-019, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru November 1991"

3.16 GPUN Calculation C-1302-187-5300-020, Rev.0, "OCDW Projected Thickness Data Thru 11/02/91"

3.17 GPUN Calculation C-1302-187-5300-021, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru May 1992"

3.18 GPUN Calculation C-1302-187-5300-022, Rev.0, "OCDW Projected Thickness Data Thru 5/31/92"

3.19 GPUN Calculation C-1302-187-5300-025, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru December 1992"

3.20 GPUN Calculation C-1302-187-5300-024, Rev.0, "OCDW Projected Thickness Data Thru 12/8/92"

3.21 GPUN Calculation C-1302-187-5300-028, Rev.0, "OCDW Statistical Analysis of Drywell Thickness Data Thru September 1994"

3.22 GPUN Calculation C-1302-187-5300-030, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru September 1996" 1

3.23 Practical Statistics – "Mathcad Software Version 7.0 Reference Library, Published by Mathsoft, Inc. Cambridge

4.0 Assumptions

The statistical evaluation of the UT measurement data to determine the corrosion rate at each location is based on the following assumptions:

4.1 Characterization of the scattering of the data over each 6" by 6" grid is such that the thickness measurements are normally distributed. If the data is not normally distributed the grid is subdivide into normally distributed subdivisions.

4.2 Once the distribution of data is found to be close to normal, the mean value of the data points is the appropriate representation of the average condition.

4.3 A decrease in the mean value of the thickness over time is representative of the corrosion.

4.4 If corrosion does not exist, the mean value of the thickness will not vary with time except for random variations in the UT measurements

4.5 If corrosion is continuing at a constant rate, the mean thickness will decrease linearly with time. In this case, linear regression analysis can be used to fit the mean thickness values for a given zone to a straight line as a function of time. The corrosion rate is equal to the slope of the line.

5.0 Design Inputs:

5.1 The minimum required thickness for the three elevations in which the data was collected in September 2000 are documented below (reference 3.1).

Drywell Vessel Plate Elevations	Acceptable Mean Thickness	Local Acceptable Thickness
El. 23' to 50' 11-1/8"	0.541"	0.360"
El. 50' 11-1/8" to 65' 2-7/16"	0.518"	0.345"
El. 65' 2-7/16" to 94' 9"	0.452"	0.300"

5.2 Seven core sample approximately 2" in diameter were removed from the drywell vessel shell for analysis (reference 3.1). In these locations replacement plugs were installed. Five of these removed cores are in grid locations that are part of the monitoring program. Of these, 4 were in sandbed region, which are no longer monitored (reference 3.1). The remaining core was removed from the grid at elevation 50'2" bay 5 area D 12. The replacement plug is located over data points 13, 20, 25, 26, 27, 28, 33, 34, and 35. Therefore the UT data from these points are not included in the calculation.

5.3 Historical data sets were collected from previous calculations (references 3.7, and 3.11 through 3.22)

6.0 OVERALL APPROACH AND METHODOLOGY:

6.1 Definitions

6.1.1 A Normal Distribution has the following properties

- Characterized by a bell shaped curve centered on the mean.
- A value of that quantity is just as likely to lie above the mean as below it
- A value of that quantity is less likely to occur the farther it is from the mean
- Values to one side of the mean are of the same probability as values at the same distance on the other side of the mean

6.1.2 Mean thickness is the mean of valid points, which are normally, distributed from the most recent UT measurements at a location.

6.1.3 Variance is the mean of the square of the difference between each data point value and the mean of the population.

6.1.4 Standard Deviation is the square root of the variance.

6.1.5 Standard Error is the standard deviation divided by the square root of the number of data points. Used to measure the dispersion in the distribution.

6.1.6 Skewness measures the relative positions of the mean, medium and mode of a distribution. In general when the skewness is close to zero, the mean, medium and mode are centered on the distribution. The closer skewness is to zero the more symmetrical the distribution. Normal distributions have skewness, which approach zero.

6.1.7 Kurtosis measures the heaviness of a distribution tails. A normal distribution has a kurtosis, which approaches zero.

6.1.8 Linear Regression is a linear relationship between two variables. A line with a slope and an intercept with the vertical axis can characterize the linear relationship. In this case the linear relationship is between time (which is the independent variable) and corrosion (which is the dependent variable).

6.1.9 F-Ratio –

An F-Ratio less than 1.0 occurs when the amount of corrosion which has occurred since the initial measurement is less than the random variations in the measurements or fewer than four measurements have been taken. If the F ratio is less than 1.0, the computed corrosion rate does not reflect the actual corrosion rate but rather is provided to as a conservative projection (reference 2.22).

An "F" ratio of 1 or less indicates that the data trend is best explained by the grand mean of the data and the trend has no slope. The variability in the data is within the distribution profile for the data, which is normally distributed. Therefore a grand mean ($\mu grand_{actual}$) is best estimate of the thickness of the location.

An F-Ratio of greater than 1.0 occurs when the amount of corrosion that has occurred since the initial measurement is significant compared to the random variations, and four or more measurements have been taken. In these cases the computed corrosion rate more accurately reflects the actual corrosion rate, and there is a very low probability that the actual corrosion rate is zero. The greater the F-Ratio the lower the uncertainty in the corrosion rate (reference 2.22).

Where the F-Ratio of 1.0 or greater provides confidence in the historical corrosion rate, the F-Ratio should be 4 to 5 if the corrosion rate is to be used to predict the thickness in the future. To have a high degree of confidence in the predicted thickness, the ratio should be at least 8 or 9 (reference 3.22).

6.1.10 Grand mean - when the F-Ratio test is less than 1.0 and/or the slope is positive this is the grand mean of all data.

6.1.11 Corrosion Rate – With three or more data sets and the F-Ratio test greater than 1.0 this is the slope of the regression line.

6.1.12 Upper and Lower 95% Confidence Interval – The upper and lower corrosion rate range for which there is 95% confidence that the actual rate lies within.

6.2 The UT measurements within scope of this monitoring program are performed in accordance with ref. 3.4. This specification involves taking UT measurements using a template with 49 holes laid out on a 6" by 6" grid with 1" between centers on both axes. The first sets of measurements were made in 1987. All subsequent measurements are made in the same location within 1/8" (reference 3.4).

6.3 Each 49 point data set is evaluated for missing data. Invalid points are those that are declared invalid by the UT operator or are at plug locations.

6.3 Past calculations were reviewed to ensure that points that were considered pits are accurately trended and excluded from the calculation of the mean.

6.4 September 2000 data that are not normally distributed were compared to previous calculations to determine if past data was also not normally distributed. In such cases the new data is divided into subsets with the same points as in past calculations.

6.5 Methodology

6.5.1 Test Matrix

To demonstrate the methodology a 49 member array will be generated using the Mathcad "rnorm" function. This function returns an array with a probability density which is normally distributed, where the size of the array ($No_{DataCells}$), the target mean (μ_{input}), and the target standard deviation (σ_{input}) are input.

The following will build a matrix of 49 points

$No_{DataCells} := 49$ $\quad i := 0..\, No_{DataCells} - 1$ $\quad count := 7$

The array "Cells" is generated by Mathcad with the target mean (μ_{input}) and standard deviation (σ_{input})

$\mu_{input} := 775$ $\quad \sigma_{input} := 20$ $\quad Cells := rnorm(No_{DataCells}, \mu_{input}, \sigma_{input})$

"Cells" is shown as a 7 by 7 matrix

$$Show_{matrix}(Cells, 7) = \begin{bmatrix} 766 & 761 & 766 & 756 & 741 & 776 & 773 \\ 786 & 819 & 791 & 795 & 792 & 793 & 788 \\ 754 & 776 & 760 & 789 & 771 & 762 & 761 \\ 765 & 786 & 770 & 777 & 800 & 761 & 775 \\ 797 & 793 & 717 & 732 & 779 & 763 & 751 \\ 777 & 790 & 781 & 775 & 760 & 767 & 762 \\ 772 & 795 & 779 & 785 & 790 & 775 & 781 \end{bmatrix}$$

The above test matrix will be used in sections 6.5.2 through 6.5.8

6.5.2 Mean and Standard Deviation

The actual mean and standard deviation are calculated for the matrix "Cells" by the Mathcad functions "mean" and "Stdev".

Therefore for the matrix generated in section 6.5.1

$\mu_{actual} := mean(Cells)$ $\quad \sigma_{actual} := Stdev(Cells)$

$\mu_{actual} = 774.104$ $\quad \sigma_{actual} = 18.258$

Inspection shows that the actual mean and standard deviations are not the same as the target mean and target standard deviation which were input. This is expected since the "rnorm" function returns an array with a probability density which is normally distributed.

6.5.3 Standard Error

The Standard Error is calculated using the following equation (reference 3.23).
For the matrix generated in section 6.5.1

$$\text{Standard}_{\text{error}} := \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Standard}_{\text{error}} = 2.578$$

6.5.4 Skewness

Skewness is calculated using the following equation (reference 3.23).

For the matrix generated in section 6.5.1

$$\text{Skewness} := \frac{\left(\text{No}_{\text{DataCells}}\right)\cdot\sum\overrightarrow{\left(\text{Cells} - \mu_{\text{actual}}\right)^3}}{\left(\text{No}_{\text{DataCells}} - 1\right)\cdot\left(\text{No}_{\text{DataCells}} - 2\right)\cdot\left(\sigma_{\text{actual}}\right)^3} \qquad \text{Skewness} = 0.354$$

A skewness value close to zero is indicative of a normal distribution (reference 3.22 and 3.23

6.5 Kurtosis

Kurtosis is calculated using the following equation (reference 3.23).
For the matrix generated in section 6.5.1

$$\text{Kurtosis} := \frac{\text{No}_{\text{DataCells}}\cdot\left(\text{No}_{\text{DataCells}} + 1\right)\cdot\sum\overrightarrow{\left(\text{Cells} - \mu_{\text{actual}}\right)^4}}{\left(\text{No}_{\text{DataCells}} - 1\right)\cdot\left(\text{No}_{\text{DataCells}} - 2\right)\cdot\left(\text{No}_{\text{DataCells}} - 3\right)\cdot\left(\sigma_{\text{actual}}\right)^4} \dots + -\frac{3\cdot\left(\text{No}_{\text{DataCells}} - 1\right)^2}{\left(\text{No}_{\text{DataCells}} - 2\right)\cdot\left(\text{No}_{\text{DataCells}} - 3\right)}$$

$$\text{Kurtosis} = 0.262$$

A Kurtosis value close to zero is indicative of a normal distribution (reference 3.23)

6.5.6 Normal Probability Plot

An alternative method to determine whether a sample distribution approaches a normal distrib is by anormal probability plo(reference 3.22 and 3.23). In a normal plot, each data value is plot against what its value would be if it actually came from a normal distribThe expected normal values, callednormal scores and can be estimated by first calculating the rank scores of the sort data. The Mathcad function "sorts" sorts the "Cells" array

$j := 0 .. \mathrm{last}(Cells)$ $\quad\quad srt := \mathrm{sort}(Cells)$

Then each data point is ranked. The array "rank" captures these rankings

$$r_j := j + 1 \quad\quad rank_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt = srt_j}\right) \cdot r}}{\overrightarrow{\Sigma srt = srt_j}}$$

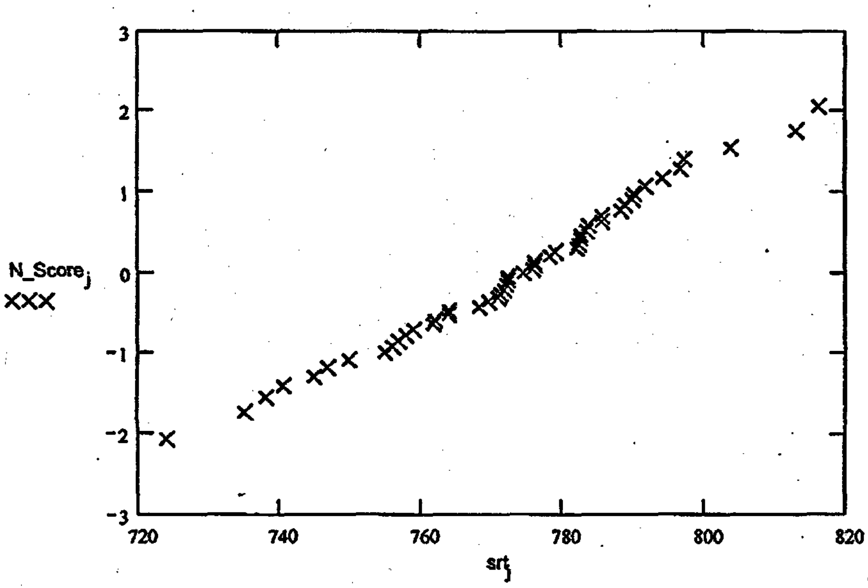
Each rank is proportioned into the "p" array. Then based on the portion an estimate for data point. TheVan der Waerden's formula is used

$$p_j := \frac{rank_j}{\mathrm{rows}(Cells) + 1}$$

The normal scores are the correspondingth percentile points from the standard normal distribution:

$x := 1 \quad\quad N\_Score_j := \mathrm{root}\left[\mathrm{cnorm}(x) - \left(p_j\right), x\right]$

If a sample is normally distributed, the points of the "Normal Plot" will seem to form a nearly straight line. The plot below shows the "Normal Plot" for the matrix generated in section 6.5.1



6.5.7 Upper and Lower Confidence Values

The Upper and Lower confidence values are calculated based on .05 degree of confidence α" (reference 3.23).

$$\alpha := .05 \qquad T\alpha := qt\left[\left(1-\frac{\alpha}{2}\right), 48\right] \qquad T\alpha = 2.011$$

Therefore for the matrix generated in section 6.1

$$Lower_{95\%Con} := \mu_{actual} - T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 767.726$$

$$Upper_{95\%Con} := \mu_{actual} + T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 778.094$$

These values represent a range on the calculated mean in which there is 95% confidence. In other words, if the 49 data points were collected 100 times the calculated mean in 95 of those 100 times would be within this range.

6.5.8 Graphical Representation

Below is the distribution of the "Cells" matrix generated in section 6.5.1 sorted in one half standard deviation increments (bins) within a range from minus 3 standard deviations to plus 3 standard deviations.

$$Bins := Make_{bins}\left(\mu_{actual}, \sigma_{actual}\right)$$

$$Distribution := hist(Bins, Cells)$$

Distribution =

	0
0	0
1	0
2	3
3	4
4	6
5	13
6	7
7	8
8	4
9	3
10	0
11	1

The mid points of the Bins are calculated

$$k := 0..11 \qquad Midpoints_k := \frac{\left(Bins_k + Bins_{k+1}\right)}{2}$$

The Mathcad function pnorm calculates the normal distribution curve based on a given mean and standard deviation. The actual mean and standard deviation generated in section 6.5.2 are input. The resulting plot will provide a representation of the normally distribution corresponding the the actual mean and standard deviation.

$$normal_{curve_0} := pnorm(Bins_1, \mu_{actual}, \sigma_{actual})$$

$$normal_{curve_k} := pnorm(Bins_{k+1}, \mu_{actual}, \sigma_{actual}) - pnorm(Bins_k, \mu_{actual}, \sigma_{actual})$$

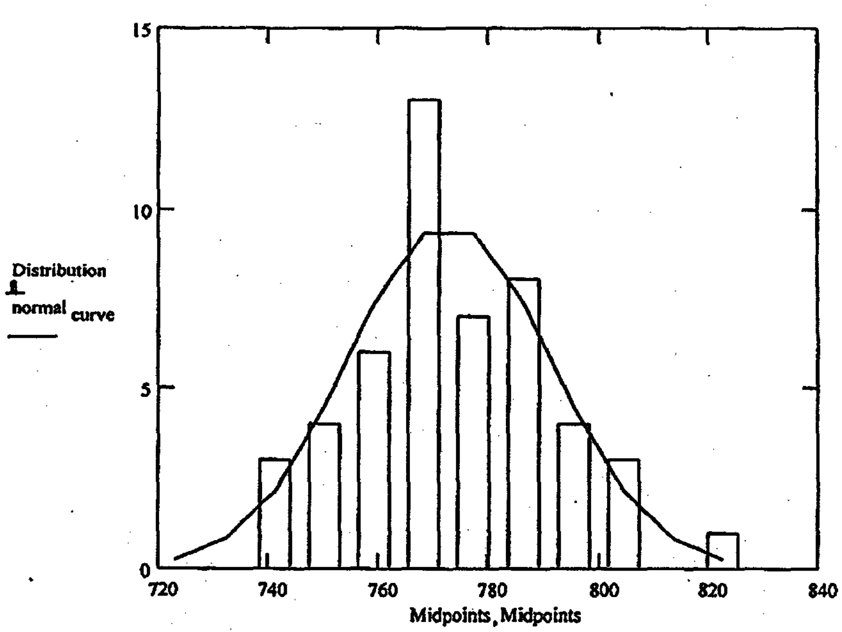
The normal curve is simply a proportion, which is multiplied by the number of "Cells" (49)

$$normal_{curve} := No_{DataCells} \cdot normal_{curve}$$

The following schematic shows: the actual distribution of the samples (the bars), the normal curve (solid line) based on the actual mean (μ_{actual}) and standard deviation σ_{actual}), the kurtosis ($Kurtosis$), the skewness ($Skewness$), the number of data points ($No_{DataCells}$), and the the lower and upper 95% confidence values $Lower_{95\%Con}$, $Upper_{95\%Con}$).

$\mu_{actual} = 772.91$ $\sigma_{actual} = 18.047$ $Standard_{error} = 2.578$

$Skewness = 0.354$ $Kurtosis = 0.262$ $No_{DataCells} = 49$



$Lower_{95\%Con} = 767.726$ $Upper_{95\%Con} = 778.094$

6.5.9 The "F" Test for Linear Regression

In order to determine whether the historical data for each location is indicative of corrosion, the means collected at each location over time are tested using the "F" Test for Linear Regression as follows (reference 3.22 and 3.23).

6.5.9.1 "F" Test Results Indicative of No Corrosion

For purposes of demonstration, five 49 point matrixes with the same input mean are generated. This will illustrate the case in which the means are indicative of a location which is not corroding.

$d := 0..4$ $\mu\ input_d := 775$ $\sigma\ input_d := 20$ $Cells_d := rnorm(No\ DataCells, \mu\ input_d, \sigma\ input_d)$

$\mu\ actual_d := mean(Cells_d)$ $\sigma\ actual_d := Stdev(Cells_d)$

The five means, standard deviations, and simulated dates are shown below

$$\mu\ actual = \begin{bmatrix} 769.638 \\ 775.647 \\ 771.334 \\ 779.326 \\ 773.555 \end{bmatrix} \qquad \sigma\ actual = \begin{bmatrix} 18.813 \\ 19.4 \\ 23.726 \\ 19.422 \\ 18.793 \end{bmatrix} \qquad Dates_i := \begin{array}{|c|} \hline 1993 + \frac{6}{365} \\ \hline 1994 + \frac{243+14}{365} \\ \hline 1996 + \frac{243+16}{365} \\ \hline 1997 + \frac{356}{365} \\ \hline 1999 + \frac{105}{365} \\ \hline \end{array}$$

The following function simply returns the number of means (No_of_{means}) which will be used later

$No\_of_{means} := rows(\mu\ actual)$ $No\_of_{means} = 5$

6.5.9 The "F" Test for Linear Regression
In order to determine whether the historical data for each location is indicative of corrosion, the means collected at each location over time are tested using the "F" Test for Linear Regression as follows (reference 3.22 and 3.23).

6.5.9.1 "F" Test Results Indicative of No Corrosion

For purposes of demonstration, five 49 point matrixes with the same input mean are generated. This will illustrate the case in which the means are indicative of a location which is not corroding.

$d := 0..4$ $\quad \mu_{input_d} := 775$ $\quad \sigma_{input_d} := 20$ $\quad Cells_d := rnorm\left(No_{DataCells}, \mu_{input_d}, \sigma_{input_d}\right)$

$\mu_{actual_d} := mean\left(Cells_d\right)$ $\quad \sigma_{actual_d} := Stdev\left(Cells_d\right)$

The five means, standard deviations, and simulated dates are shown below

$$\mu_{actual} = \begin{bmatrix} 769.638 \\ 775.647 \\ 771.334 \\ 779.326 \\ 773.555 \end{bmatrix} \qquad \sigma_{actual} = \begin{bmatrix} 18.813 \\ 19.4 \\ 23.726 \\ 19.422 \\ 18.793 \end{bmatrix} \qquad Dates_i := \begin{array}{|c|} \hline 1993 + \frac{6}{365} \\ \hline 1994 + \frac{243+14}{365} \\ \hline 1996 + \frac{243+16}{365} \\ \hline 1997 + \frac{356}{365} \\ \hline 1999 + \frac{105}{365} \\ \hline \end{array}$$

The following function simply returns the number of means (No_of_{means}) which will be used later

$No\_of_{means} := rows\left(\mu_{actual}\right)$ $\qquad No\_of_{means} = 5$

The curve fit equation in which the date t_{Dates} is the independent variable and the measured mean thickness of the location (μ_{actual}) is the dependent variable is then defined as the function "yhat". This function make use of Mathcad function "intercept" which returns the intercept value of the "Best Fit" curve fit and the Mathcad function "slope" which returns the slope value of the "Best Fit" curve fit.

$$yhat(x,y) := intercept(x,y) + slope(x,y) \cdot x$$

The Sum of Squared Error (SSE) is calculated as follows (reference 3.23)

$$SSE := \sum_{i=0}^{last(Dates)} \left(\mu_{actual_i} - yhat\left(Dates, \mu_{actual}\right)_i\right)^2 \qquad SSE = 44.202$$

The Sum of Squared Residuals (SSR) is then calculated as follows (reference 3.23)

$$SSR := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, \mu_{actual}\right)_i - mean\left(\mu_{actual}\right)\right)^2 \qquad SSR = 13.158$$

Degrees of freedom associated with the sum of squares for residual error is calculated (reference 3.23).

$$DegreeFree_{ss} := No\_of_{means} - 2$$

The degrees of freedom for the sum of squares due to regression is calculated (reference 3.22 and 3.23).

$$DegreeFree_{reg} := No\_of_{means}$$

Dividing a sum of squares by its degrees of freedom provides the variance estimate (reference 3.22 and 3.23).

$$MSE := \frac{SSE}{DegreeFree_{ss}} \qquad MSE = 14.734$$

An estimate of the error standard deviation which is also called the standard error of estimate is calculated (reference 3.23).

$Standard_{error} := \sqrt{MSE}$ $\qquad Standard_{error} = 3.838$

MSR, the population error variance is calculated (reference 3.23)

$MSR := \frac{SSR}{DegreeFree_{reg}}$ $\qquad MSR = 2.632$

The MSE is the variance estimate for the mean model. Similarly, the MSR is an estimate for the variance that is explained by the regression model. The ratio of regression variance (MSR) to mean variance MSE, gives measure of the regression relationship.

$$F_{actaul} := \frac{MSR}{MSE}$$

For 95% confidence level the "F" critical is calculated as follows (reference 3.22 and 3.23)

$\alpha := 0.05 \qquad F_{critical} := qF(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}) \qquad F_{critical} = 9.013$

The "F" ratio for 95% confidence is calculated:

$F_{ratio} := \frac{F_{actaul}}{F_{critical}}$ $\qquad F_{ratio} = 0.02$

An F-Ratio less than 1.0 occurs when the amount of corrosion which has occurred since the initial measurement is less than the random variations in the measurements or fewer than four measurements have been taken. If the F ratio is less than 1.0, the computer corrosion rate does not reflect the actual corrosion rate but rather is provided as a conservative projection(reference 3.22)

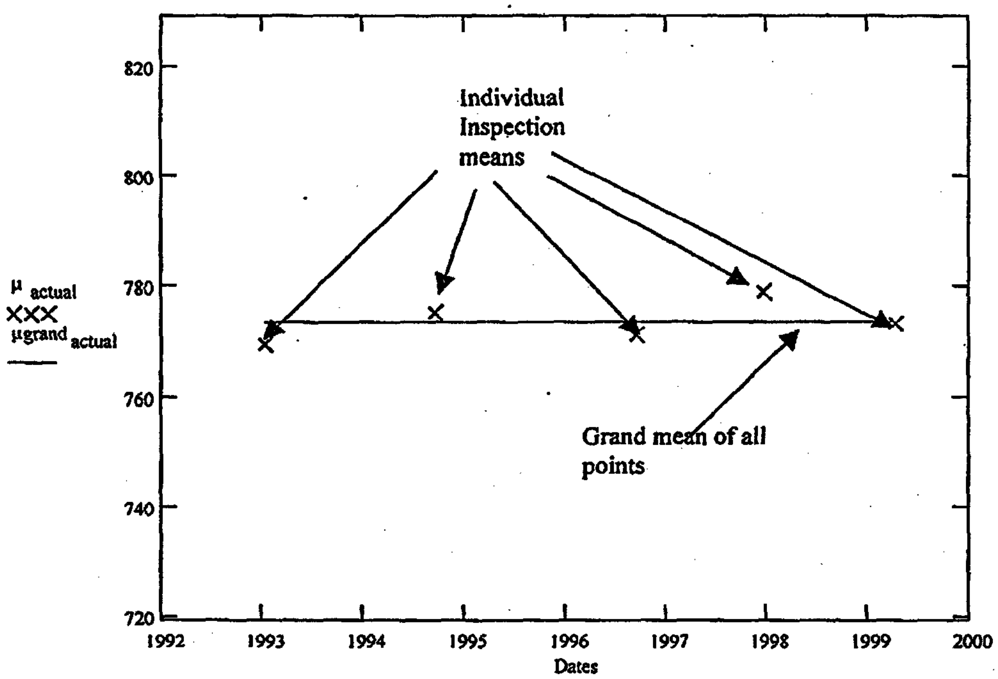
An "F" ratio of 1 or less indicates that the data trend is best explained by the grand mean of the data and the the trend has no slope. The variability in the data is within the distribution profile for the data which is normally distributed. Therefore a grand mean $\mu grand_{actual}$) is best estimate of the thickness of the location.

An F-Ratio of 1.0 is greater occurs when the amount of corrosion which has occurred since the initial measurement is significant compared to the random variations, and four or more measurements have been taken. In these cases the computed corrosion rate more accurately reflects the actual corrosion rate, and there is a very low probability that the actual corrosion rate is zero. The greater the F-Ratio the lower the uncertainty in the corrosion rate (reference 3.22)

Where the F-Ratio of 1.0 or greater provides confidence in the historical corrosion rate, the F-Ratio should be 4 to 5 if the corrosion rate is to be used to predict the thickness in the future. To have a high degree of confidence in the predicted thickness, the ratio should be at least 8 or 9 (reference 3.22 calculation).

The following shows the results in a graph

$$\mu grand_{actual_i} := mean(\mu_{actual})$$



6.5.9.2 "F" Test Results Indicative of Corrosion

To illustrate the case in which the location is corroding the five, 49 point matrixes will now be generated with input means which are descending over time.

$d := 0..4 \qquad \mu\ input_d := 775 - (d \cdot 4)$

$\sigma\ input_d := 20 \qquad Cells_d := rnorm(No\ DataCells, \mu\ input_d, \sigma\ input_d)$

$\mu\ actual_d := mean(Cells_d) \qquad \sigma\ actual_d := Stdev(Cells_d)$

$$\mu\ actual = \begin{bmatrix} 779.579 \\ 775.201 \\ 769.326 \\ 766.983 \\ 762.322 \end{bmatrix} \qquad \sigma\ actual = \begin{bmatrix} 19.489 \\ 17.654 \\ 19.735 \\ 19.979 \\ 20.121 \end{bmatrix}$$

$Dates_i :=$

$1993 + \frac{6}{365}$
$1994 + \frac{243 + 14}{365}$
$1996 + \frac{243 + 16}{365}$
$1997 + \frac{356}{365}$
$1999 + \frac{105}{365}$

$Total_{means} := rows(\mu\ actual) \qquad Total_{means} = 5$

The curve fit equation is then defined for the function "yhat"

$yhat(x, y) := intercept(x, y) + slope(x, y) \cdot x$

The Sum of Squared Error is calculated

$$SSE := \sum_{i=0}^{last(Dates)} \left(\mu\ actual_i - yhat(Dates, \mu\ actual)_i\right)^2 \qquad SSE = 0.818$$

The Sum of Squared Residuals is then calculated

$$SSR := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, \mu_{actual}\right)_i - mean\left(\mu_{actual}\right)\right)^2 \qquad SSR = 184.164$$

Degrees of freedom associated with the sum of squares for residual error.

$$DegreeFree_{ss} := Total_{means} - 2$$

The degrees of freedom for the sum of squares due to regression,

$$DegreeFree_{reg} := Total_{means}$$

$$MSE := \frac{SSE}{DegreeFree_{ss}} \qquad MSE = 0.273$$

$$Standard_{error} := \sqrt{MSE} \qquad Standard_{error} = 0.522$$

$$MSR := \frac{SSR}{DegreeFree_{reg}} \qquad MSR = 36.833$$

$$F_{actaul} := \frac{MSR}{MSE}$$

$$\alpha := 0.05 \qquad F_{critical} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right) \qquad F_{critical} = 9.013$$

The "F" ratio for 95% confidence is calculated:

$$F_{ratio} := \frac{F_{actaul}}{F_{critical}} \qquad F_{ratio} = 14.983$$

The "F" ratio is greater than 1.0, therefore the regression model holds for the data. The curve fit for the five means is best explained by a curve fit with a slope.

6.9.3 Linear Regression with 95% Confidence Bounds

Using data generated in section 6.9.2 the curve fit for linear regression is calculated by the Mathcad functions "$_{slope}$" and "intercept".

$$m_s := \text{slope}(\text{Dates}, \mu_{actual}) \qquad y_b := \text{intercept}(\text{Dates}, \mu_{actual})$$

$$m_s = -2.702 \qquad y_b = 6.165 \cdot 10^3$$

The predicted curve is calculated over time where "$\text{year}_{predict}$" is time (independent variable), and "$\text{Thick}_{predict}$" is thickness (dependent variable).

$$\text{Remaining}_{Pl\_life} := 13 \qquad f := 0 .. \text{Remaining}_{Pl\_life} - 1 \qquad \text{year}_{predict_f} := 1985 + f \cdot 2$$

$$\text{Thick}_{predict} := m_s \cdot \text{year}_{predict} + y_b$$

The 95% Confidence ("$1 \cdot \alpha_t$") curves are calculated as follows (reference 3.3)

$$\alpha_t := 0.05$$

$$\text{Thick}_{actualmean} := \text{mean}(\text{Dates})$$

$$\text{sum} := \sum_d (\text{Dates}_d - \text{mean}(\text{Dates}))^2$$

$$\text{upper}_f := \text{Thick}_{predict_f} \cdots + qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{Standard}_{error} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year}_{predict_f} - \text{Thick}_{actualmean})^2}{\text{sum}}}$$

$$\text{lower}_f := \text{Thick}_{predict_f} \cdots + -\left[qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{Standard}_{error} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year}_{predict_f} - \text{Thick}_{actualmean})^2}{\text{sum}}}\right]$$

6.9.3 Linear Regression with 95% Confidence Bounds

Using data generated in section 6.9.2 the curve fit for linear regression is calculated by the Mathcad functions "$_{slope}$" and "intercept".

$$m_s := \text{slope}(\text{Dates}, \mu_{actual}) \qquad y_b := \text{intercept}(\text{Dates}, \mu_{actual})$$

$$m_s = -2.702 \qquad y_b = 6.165 \cdot 10^3$$

The predicted curve is calculated over time where "$\text{year}_{predict}$" is time (independent variable), and "$\text{Thick}_{predict}$" is thickness (dependent variable).

$$\text{Remaining}_{Pl\_life} := 13 \qquad f := 0 .. \text{Remaining}_{Pl\_life} - 1 \qquad \text{year}_{predict_f} := 1985 + f \cdot 2$$

$$\text{Thick}_{predict} := m_s \cdot \text{year}_{predict} + y_b$$

The 95% Confidence ("$1 \cdot \alpha_t$") curves are calculated as follows (reference 3.3)

$$\alpha_t := 0.05$$

$$\text{Thick}_{actualmean} := \text{mean}(\text{Dates})$$

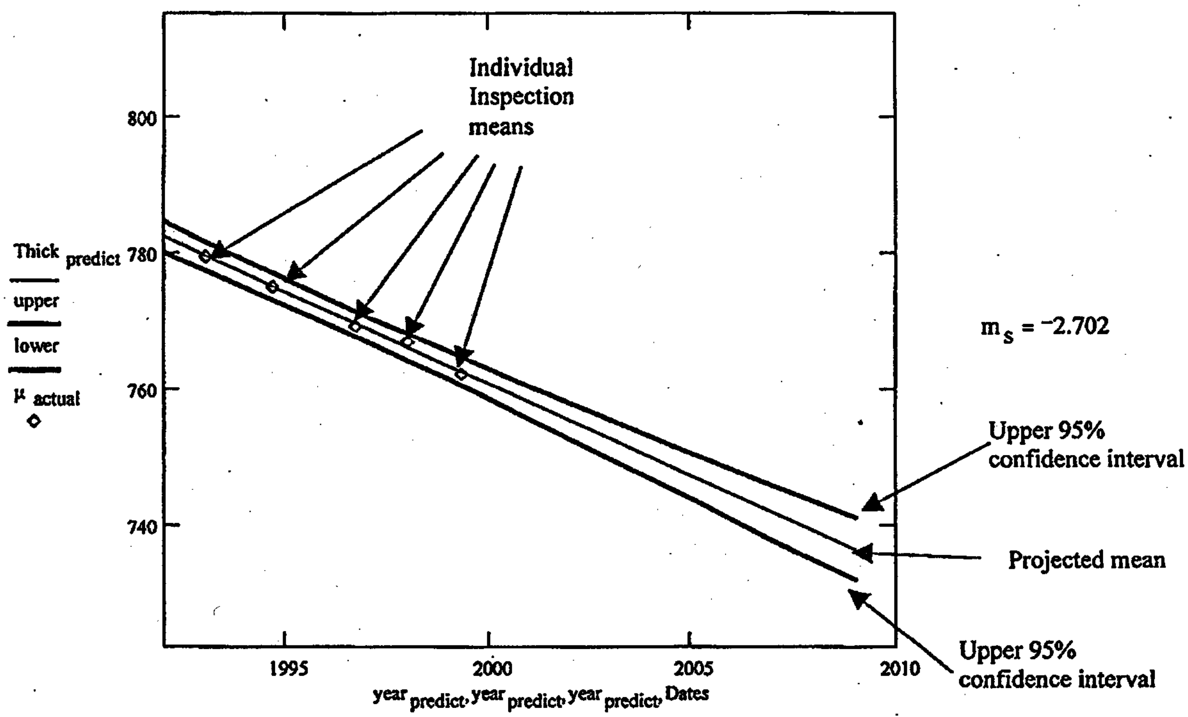
$$\text{sum} := \sum_d (\text{Dates}_d - \text{mean}(\text{Dates}))^2$$

$$\text{upper}_f := \text{Thick}_{predict_f} \cdots$$
$$+ \text{qt}\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{Standard}_{error} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year}_{predict_f} - \text{Thick}_{actualmean})^2}{\text{sum}}}$$

$$\text{lower}_f := \text{Thick}_{predict_f} \cdots$$
$$+ -\left[\text{qt}\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{Standard}_{error} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year}_{predict_f} - \text{Thick}_{actualmean})^2}{\text{sum}}}\right]$$

Subject:	Calculation No.	Rev. No.	System Nos.	Sheet
Statistical Analysis of Drywell Vessel Thickness Data Through September 2000	C-1302-187-E310-037	0	187	28 of 36

Therefore the following is a plot of the curve fit of the data generated in section 6.9.2 and the Upper and Lower 95% confidence Intervals. The Upper and Lower 95% Confidence Intervals are the two curves shown below which bound the data points and the curve fit.



7.0 Calculation

7.1. Elevation 50' 2"

7.1.1 Bay 5 Area D12, Feb. 1990 through Sept. 2000

Refer to Appendix #1 for the complete calculation.

Eleven Inspections have been performed at this location. A plug lies within this location and therefore the nine points over the plug are eliminated from the calculation (see section 5.2). The data collected in Sept. 2000 inspection is normally distributed after the nine points are eliminated.

In addition to the nine points the following adjustments have been made over time:

1) Point 9 is a significant pit and is trended separately
2) Points 1, 4 and 37 in the 4/25/90 data set are much greater than the preceding or succeeding measurements. Therefore these three points were dropped from the 4/25/90 data (ref. 2.22).
3) Points 3 and 36 in the 11/02/91 data set are much greater than the preceding or succeeding measurements. Therefore these two points were dropped from the 11/02/91 data (ref. 2.22).

The data indicates no ongoing corrosion since Feb 1990

Point 9

Analysis of this point prior to Sept. 2000 (ref. 3.22) indicated that there was a potential corrosion rate. The addition of the Sept. 2000 data now drives the F-ratio for this point to 1.7, which now confirms that a rate exists. The calculated rate is 1.3 mils per year. This corrosion rate is very small. Projection based on this corrosion rate using the 95% lower confidence interval shows that this point will not corrode to less than the minimum required thickness by the years 2009 or 2029.

7.1.2 Bay 5 Area 5, March 1990 through Sept. 2000

Refer to Attachment #2 for the complete calculation.

Ten Inspections have been performed at this location. Previous data sets were not normally distributed since there is a large thin area in the center of the grid and several smaller patches on the periphery. Past calculations separated these regions into subsets. The thinner area has 16 points and the thicker area has 32 points. Analysis of past subsets shows that both data sets are normally distributed. The Sept. 2000 data is consistent with past data.

In addition, point 17 is significantly thinner than these two areas. Therefore point 17 is trended separately.

Results of the two subsets are described below:

Thinner Points
This subset is normally distributed. The F-ratio for this subset indicates that there is no ongoing corrosion.

Thicker Points
This subset is normally distributed. The F-ratio for this subset (1.2) indicates that there is ongoing corrosion at a rate of 0.6 mils per year. This corrosion rate is very small. Projection based on this corrosion rate using the 95% lower confidence interval shows that it will not corrode to less than the minimum required thickness by the year 2009 or 2029.

Point 17
The F-ratio for this point indicates no on going corrosion.

7.1.3 Bay 13 Area 31, March 1990 through Sept. 2000
Refer to Appendix #3 for the complete calculation.

Ten Inspections have been performed at this location. Previous data sets have not been normally distributed since there is a thinner area on the left edge of the grid. Past calculations have separated these regions in two subsets. The thinner area has 16 points and the thicker area has 33 points. Analysis of past subsets shows that both data sets are normally distributed. The Sept. 2000 data is consistent with this past data.

Results of the two subsets are described below:

Thinner Points
This subset is normally distributed. The F-ratio for this subset indicates that there is no ongoing corrosion.

Thicker Points
This subset is normally distributed. The F-ratio for this subset indicates that there is no ongoing corrosion.

7.1.4 Bay 13 Area 23 March 1990 through Sept. 2000
Refer to Appendix #4 for the complete calculation.

Ten Inspections have been performed at this location. Previous data sets were not normally distributed since there is a large thinner area in the center of the grid. Past calculations separated these regions into subsets. The thinner area has 15 points and the thicker area has 32 points. Analysis of past subsets shows that both data sets are normally distributed. The Sept. 2000 data is consistent with this past data.

Also point 26 is significantly thinner than these two areas. Therefore point 26 is trended separately

Point 27 in the November 1991 data set is much less than the preceding or succeeding measurements. Therefore this point was dropped from the 11/91 data (ref. 2.22).

Results of the two subsets are described below:

Thinner Points
This subset is normally distributed. The F-ratio for this subset indicates that there is no ongoing corrosion.

Thicker Points
This subset is normally distributed. The F-ratio for this subset indicates that there is no ongoing corrosion.

Point 26
The addition of the Sept. 2000 data now drives the F-ratio to 1.8, which now confirms that a rate does exist. The calculated rate is 1.5 mils per year. This corrosion rate is very small. Projection based on these corrosion rates using the 95% lower confidence interval shows that this point will not corrode to less than the minimum required thickness by the year 2009 or 2029.

7.2 Elevation 51' 10" through September 2000.

7.2.1 Bay 13 Area 32 April 1990 through Sept. 2000

Refer to Appendix #5 for the complete calculation.

Nine inspections have been performed at this location. Previous data sets were not normally distributed since there is a "T" shaped thinner area along the right side of the grid. Past calculations separated these regions into subsets. The thinner area has 13 points and the thicker area has 32 points. Analysis of past subsets shows that both data sets are normally distributed. The Sept. 2000 data is consistent with this past data.

In addition, points 20, 23, 25, and 28 are significantly thinner than these two areas. Therefore these points are trended separately

Point 11 in the 5/23/91 data set was much less than the preceding or succeeding measurements. Therefore this point was dropped from the 5/22/91 data (ref. 2.22).

Results of the two subsets are described below:

Thinner Points
This subset is normally distributed. The F-ratio for this subset indicates that there is no ongoing corrosion.

Thicker Points
This subset is normally distributed. The F-ratio for this subset indicates that there is no ongoing corrosion.

Points 20, 23, 25, and 28
The F-ratio for these points indicates no on going corrosion.

7.3 Elevation 60' 10"

7.3.1 Bay 1 Area 5-22 April 1990 through Sept. 2000

Refer to Appendix #6 for the complete calculation.

Four inspections have been performed at this location. Data collected in all four inspections are normally distributed after point 48 is eliminated. Point 48 is a significant pit and is trended separately

The data indicates no ongoing corrosion since Feb 1990

Point 48
Point 48 may be experiencing a corrosion rate of 4.5 mils per year. This relatively greater calculated rate may be due to the limited amount of inspections. The methodology and analysis results in confidence levels with less inspection information. Never-the-less projection based on this corrosion rates using the 95% lower confidence interval, which is significantly more conservative than other locations, show that this point will not corrode to less than the minimum required thickness by the year 2009.

Since the amount of data on this pit is limited to 4 inspections, the upper and lower 95 % confidence intervals are very broad and conservative. This results in a projected lower 95% confidence thickness value for the year 2029 which is less than the local minimum required thickness. More inspections should narrow the upper and lower 95 % confidence intervals. Assuming the rate is constant over time, it is expected that future projections should show that this pit will not corrode to less than the minimum required local thickness by the year 2029.

7.4 Elevation 87' 5"

7.4.1 Bay 9 Area 20 November 1987 through Sept. 2000

Refer to Appendix #7 for the complete calculation.

Twelve inspections have been performed at this location. UT data collected in September 2000 is normally distributed.

Point 13 in the May 1992 data set was much less than the preceding or succeeding measurements. Therefore this point was dropped from the May 1992 data (ref. 2.22).

Based on a calculated F-ratio of 1.2, this location is experiencing minor a corrosion rate of approximately 1.2 mils per year. This corrosion rate is very small. Projections based on this corrosion rate using the 95% lower confidence interval shows that they will not corrode to less than the minimum required thickness by the year 2009 or 2029.

7.4.2 Bay 13 Area 28 November 1987 through Sept. 2000

Refer to Appendix #8 for the complete calculation.

Twelve inspections have been performed at this location. Previous data sets were not normally distributed. Past calculations separated out points 1, 2, 22, 25, 26, 36, and 48. Analysis of past data sets without these points show that the data is normally distributed. The Sept. 2000 data is consistent with this past data.

Analysis of the data indicates no ongoing corrosion since Feb 1990

Points 1, 2, 22, 25, 26, 36, and 48
Analysis of these individual points show no ongoing corrosion with the possible exception of point 25 which has an F-ratio of 0.96. This point may be experiencing a corrosion rate of 3.0 mils per year. Projection based on these corrosion rates using the 95% lower confidence interval shows that these point will not corrode to less than the minimum required thickness by the year 2009 or 2029.

7.4.1 Bay 15 Area 31 November 1987 through Sept. 2000

Refer to Appendix #9 for the complete calculation.

Twelve inspections have been performed at this location. Previous data sets have not been normally distributed. Past calculations have separated out points 34 and 35. Analysis of past

Appendix 9 - Elevation 87' 5" Bay 15, Area 31

Sept. 17, 2000 Data

The data shown below was collected on 10/17/2000 (reference NDE data sheet 2000-034-009).

page :=

U:\..\D8631_00.txt

$Points_{49} := showcells(page, 7, 17)$

$$Points_{49} = \begin{bmatrix} 0.639 & 0.639 & 0.627 & 0.631 & 0.606 & 0.614 & 0.631 \\ 0.647 & 0.639 & 0.637 & 0.629 & 0.639 & 0.637 & 0.63 \\ 0.631 & 0.65 & 0.629 & 0.628 & 0.64 & 0.619 & 0.627 \\ 0.638 & 0.645 & 0.594 & 0.627 & 0.613 & 0.623 & 0.63 \\ 0.643 & 0.63 & 0.632 & 0.615 & 0.624 & 0.564 & 0.614 \\ 0.649 & 0.619 & 0.617 & 0.602 & 0.616 & 0.602 & 0.609 \\ 0.643 & 0.639 & 0.61 & 0.636 & 0.617 & 0.612 & 0.64 \end{bmatrix}$$

$Cells := convert(Points_{49}, 7)$ $No_{DataCells} := length(Cells)$

The pits at point 34 and 35 are removed from the data an will be trended separately (ref. 3.22).

$Cells := Zero_{one}(Cells, No_{DataCells}, 34)$ $Cells := Zero_{one}(Cells, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(Cells, No_{DataCells})$

$No_{DataCells} := length(Cells)$

Mean and Standard Deviation

$\mu_{actual} := mean(Cells)$ $\mu_{actual} = 627.532$ $\sigma_{actual} := Stdev(Cells)$ $\sigma_{actual} = 13.518$

Standard Error

$$Standard_{error} := \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}}$$ $Standard_{error} = 1.972$

Skewness

$$Skewness := \frac{(No_{DataCells}) \cdot \Sigma\overrightarrow{(Cells - \mu_{actual})^3}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (\sigma_{actual})^3}$$ $Skewness = -0.485$

Kurtosis

$$Kurtosis := \frac{No_{DataCells} \cdot (No_{DataCells} + 1) \cdot \Sigma\overrightarrow{(Cells - \mu_{actual})^4}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (No_{DataCells} - 3) \cdot (\sigma_{actual})^4} - \frac{3 \cdot (No_{DataCells} - 1)^2}{(No_{DataCells} - 2) \cdot (No_{DataCells} - 3)}$$ $Kurtosis = -0.429$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

$j := 0 .. \text{last(Cells)}$ $\quad$ $srt := \text{sort(Cells)}$

Then each data point is ranked. The array rank captures these ranks

$r_j := j + 1$ $\quad$ $rank_j := \dfrac{\Sigma\left(\overrightarrow{\left(srt = srt_j\right) \cdot r}\right)}{\Sigma \overrightarrow{srt = srt_j}}$

$$p_j := \frac{rank_j}{\text{rows(Cells)} + 1}$$

The normal scores are the corresponding *p*th percentile points from the standard normal distribution:

$x := 1$ $\quad$ $N\_Score_j := \text{root}\left[\text{cnorm}(x) - (p_j), x\right]$

Upper and Lower Confidence Values

The Upper and Lower confidence values are calculated based on .05 degree of confidence "α"

$\alpha := .05$ $\quad T\alpha := qt\left[\left(1-\frac{\alpha}{2}\right), 48\right]$ $\quad T\alpha = 2.011$

$$Lower_{95\%Con} := \mu_{actual} - T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 623.567$$

$$Upper_{95\%Con} := \mu_{actual} + T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 631.496$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

$Bins := Make_{bins}(\mu_{actual}, \sigma_{actual})$

$Distribution := hist(Bins, Cells)$

Distribution =

0
1
3
5
6
5
10
11
4
2
0
0

The mid points of the Bins are calculated

$k := 0..11$ $\quad Midpoints_k := \frac{(Bins_k + Bins_{k+1})}{2}$

The Mathcad function pnorm calculates a portion of normal distribution curve based on a given mean and standard deviation

$normal_{curve_0} := pnorm(Bins_1, \mu_{actual}, \sigma_{actual})$

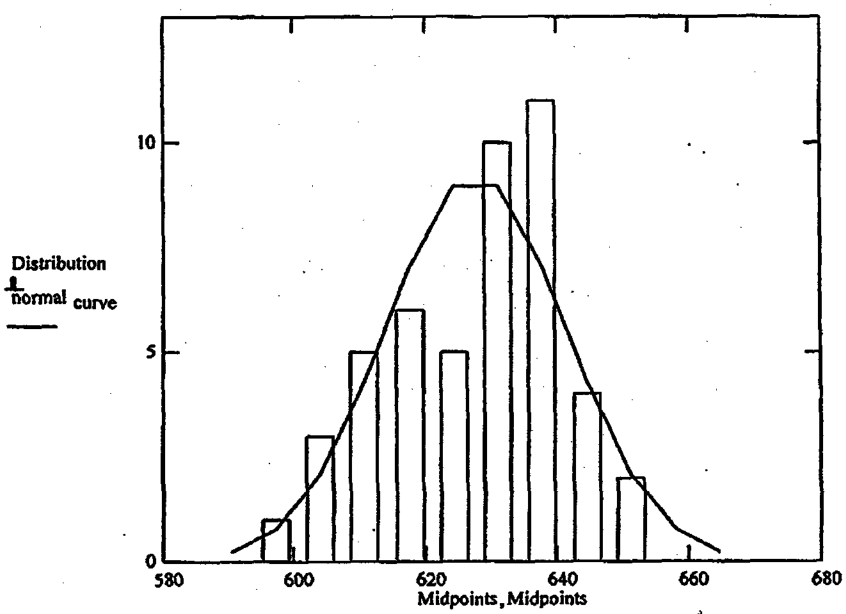
$normal_{curve_k} := pnorm(Bins_{k+1}, \mu_{actual}, \sigma_{actual}) - pnorm(Bins_k, \mu_{actual}, \sigma_{actual})$

$normal_{curve} := No_{DataCells} \cdot normal_{curve}$

Results For Elevation 86' 5" Bay 15, Area 31
Sept. 17, 2000

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 627.532$

$\sigma_{actual} = 13.518$

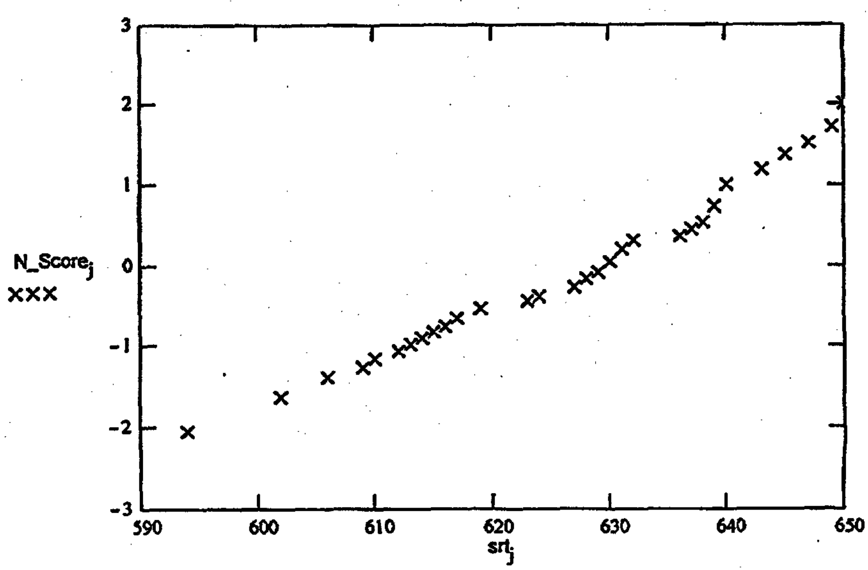
$Standard_{error} = 1.972$

Skewness = -0.485

Kurtosis = -0.429

$Lower_{95\%Con} = 623.567$ $Upper_{95\%Con} = 631.496$

Normal Probability Plot



Based on the Normal Probability Plot, Skewness, and the Kurtosis this data is normally distributed.

Elevation 86' 5" Bay 15, Area 31 Trend

Data from Feb 1990 to Sept 2000 is retrieved.

$d := 0$

For Nov. 10 1987

page := U:\..\D8631_N87.txt

$Dates_d := Day_{year}(11, 10, 1987)$

$Points_{49} := showcells(page, 7, 17)$

Data

$$Points_{49} = \begin{bmatrix} 0.655 & 0.648 & 0.639 & 0.65 & 0.62 & 0.627 & 0.641 \\ 0.659 & 0.643 & 0.646 & 0.64 & 0.634 & 0.651 & 0.641 \\ 0.628 & 0.657 & 0.673 & 0.638 & 0.654 & 0.629 & 0.632 \\ 0.65 & 0.652 & 0.646 & 0.638 & 0.619 & 0.633 & 0.634 \\ 0.656 & 0.633 & 0.637 & 0.623 & 0.634 & 0.568 & 0.62 \\ 0.65 & 0.63 & 0.625 & 0.607 & 0.625 & 0.606 & 0.614 \\ 0.649 & 0.648 & 0.615 & 0.649 & 0.628 & 0.628 & 0.647 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

The pits at points 34 and 35 are removed from the data and will be trended separately (ref 3.22).

$Pit\,34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\,35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For July 20 1988

page := U:\..\D8631_J88.txt

$Dates_d := Day_{year}(7, 20, 1988)$

$Points_{49} := showcells(page, 7, 17)$

Data

$$Points_{49} = \begin{bmatrix} 0.651 & 0.645 & 0.633 & 0.643 & 0.615 & 0.626 & 0.634 \\ 0.651 & 0.642 & 0.643 & 0.641 & 0.651 & 0.644 & 0.638 \\ 0.627 & 0.654 & 0.654 & 0.633 & 0.65 & 0.652 & 0.634 \\ 0.644 & 0.652 & 0.654 & 0.635 & 0.616 & 0.634 & 0.632 \\ 0.652 & 0.63 & 0.64 & 0.622 & 0.635 & 0.566 & 0.623 \\ 0.645 & 0.627 & 0.619 & 0.604 & 0.624 & 0.605 & 0.617 \\ 0.648 & 0.646 & 0.613 & 0.639 & 0.622 & 0.619 & 0.643 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit\ 34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\ 35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For Oct. 8 1988

page := U:\..\D8631_088.txt

$Dates_d := Day_{year}(10, 8, 1988)$

$Points_{49} := showcells(page, 7, 17)$

Data

$$Points_{49} = \begin{bmatrix} 0.651 & 0.645 & 0.632 & 0.642 & 0.618 & 0.622 & 0.636 \\ 0.655 & 0.641 & 0.644 & 0.638 & 0.63 & 0.643 & 0.637 \\ 0.629 & 0.654 & 0.645 & 0.635 & 0.649 & 0.649 & 0.643 \\ 0.651 & 0.65 & 0.619 & 0.636 & 0.616 & 0.632 & 0.636 \\ 0.664 & 0.63 & 0.635 & 0.619 & 0.634 & 0.562 & 0.626 \\ 0.65 & 0.646 & 0.622 & 0.605 & 0.63 & 0.608 & 0.622 \\ 0.654 & 0.645 & 0.612 & 0.642 & 0.628 & 0.622 & 0.643 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit\,34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\,35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For June 26 1989

page := U:\.\D8631_June89.txt

$Dates_d := Day_{year}(6, 26, 1989)$

$Points_{49} := showcells(page, 7, 17)$

Data

$$Points_{49} = \begin{bmatrix} 0.654 & 0.649 & 0.636 & 0.643 & 0.619 & 0.629 & 0.637 \\ 0.656 & 0.644 & 0.649 & 0.641 & 0.651 & 0.649 & 0.642 \\ 0.63 & 0.658 & 0.651 & 0.641 & 0.654 & 0.629 & 0.636 \\ 0.647 & 0.648 & 0.623 & 0.637 & 0.617 & 0.631 & 0.636 \\ 0.655 & 0.633 & 0.641 & 0.623 & 0.632 & 0.576 & 0.619 \\ 0.648 & 0.636 & 0.624 & 0.611 & 0.627 & 0.61 & 0.618 \\ 0.653 & 0.667 & 0.629 & 0.649 & 0.627 & 0.621 & 0.647 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $\qquad No_{DataCells} := length(nnn)$

$Pit\ 34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $\qquad Pit\ 35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $\qquad nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\qquad \sigma_{measured_d} := Stdev(Cells)$ $\qquad Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For March 28 1990

page := U:\..\D8631_March90.txt

$Dates_d := Day_{year}(3, 28, 1990)$

$Points_{49} := showcells(page, 7, 17)$

Data

$$Points_{49} = \begin{bmatrix} 0.653 & 0.646 & 0.644 & 0.644 & 0.621 & 0.626 & 0.635 \\ 0.654 & 0.643 & 0.647 & 0.64 & 0.637 & 0.649 & 0.639 \\ 0.638 & 0.658 & 0.653 & 0.656 & 0.676 & 0.63 & 0.642 \\ 0.646 & 0.65 & 0.631 & 0.644 & 0.633 & 0.652 & 0.636 \\ 0.682 & 0.657 & 0.66 & 0.634 & 0.635 & 0.573 & 0.624 \\ 0.65 & 0.644 & 0.636 & 0.613 & 0.627 & 0.61 & 0.616 \\ 0.651 & 0.648 & 0.614 & 0.646 & 0.655 & 0.622 & 0.647 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit\,34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\,35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For Feb, 23 1991

page := U:\..\D8631_F91.txt

$Dates_d := Day_{year}(2, 23, 1991)$

$Points_{49} := showcells(page, 7, 16)$

Data

$$Points_{49} = \begin{bmatrix} 0.645 & 0.641 & 0.629 & 0.639 & 0.613 & 0.624 & 0.631 \\ 0.646 & 0.637 & 0.639 & 0.633 & 0.629 & 0.641 & 0.634 \\ 0.62 & 0.648 & 0.63 & 0.629 & 0.645 & 0.624 & 0.626 \\ 0.637 & 0.637 & 0.597 & 0.629 & 0.611 & 0.625 & 0.629 \\ 0.644 & 0.624 & 0.631 & 0.615 & 0.626 & 0.556 & 0.615 \\ 0.642 & 0.623 & 0.616 & 0.602 & 0.619 & 0.601 & 0.611 \\ 0.644 & 0.624 & 0.606 & 0.636 & 0.619 & 0.611 & 0.639 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For May 23, 1991

page := U:\...\D8631_M91_cut.txt

$Dates_d := Day_{year}(5, 23, 1991)$

$Points_{49} := showcells(page, 7, 0)$

Data

$$Points_{49} = \begin{bmatrix} 0.647 & 0.641 & 0.631 & 0.636 & 0.613 & 0.621 & 0.63 \\ 0.649 & 0.637 & 0.641 & 0.634 & 0.633 & 0.641 & 0.633 \\ 0.62 & 0.649 & 0.628 & 0.629 & 0.624 & 0.622 & 0.626 \\ 0.639 & 0.642 & 0.595 & 0.629 & 0.611 & 0.625 & 0.629 \\ 0.646 & 0.624 & 0.632 & 0.614 & 0.627 & 0.556 & 0.615 \\ 0.642 & 0.623 & 0.616 & 0.601 & 0.621 & 0.603 & 0.61 \\ 0.645 & 0.624 & 0.607 & 0.636 & 0.619 & 0.612 & 0.613 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit\,34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\,35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For May 30 1992

page := U:\..\D8631_M92.txt

$Dates_d := Day_{year}(5, 30, 1992)$

$Points_{49} := showcells(page, 7, 1)$

Data

$$Points_{49} = \begin{bmatrix} 0.65 & 0.639 & 0.627 & 0.635 & 0.614 & 0.621 & 0.629 \\ 0.651 & 0.635 & 0.64 & 0.635 & 0.608 & 0.642 & 0.635 \\ 0.622 & 0.65 & 0.633 & 0.631 & 0.65 & 0.627 & 0.634 \\ 0.64 & 0.643 & 0.665 & 0.632 & 0.616 & 0.629 & 0.63 \\ 0.651 & 0.628 & 0.635 & 0.617 & 0.629 & 0.565 & 0.613 \\ 0.645 & 0.639 & 0.619 & 0.604 & 0.623 & 0.607 & 0.611 \\ 0.64 & 0.639 & 0.607 & 0.635 & 0.619 & 0.611 & 0.638 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit\,34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\,35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For Dec. 5 1992

page := U:\..\D8631_D92.txt

$Dates_d := Day_{year}(12, 5, 1992)$

$Points_{49} := showcells(page, 7, 16)$

Data

$Points_{49} =$	0.644	0.643	0.632	0.634	0.612	0.622	0.632
	0.649	0.64	0.642	0.629	0.642	0.639	0.633
	0.633	0.647	0.632	0.63	0.643	0.614	0.627
	0.641	0.647	0.601	0.634	0.612	0.629	0.631
	0.648	0.628	0.634	0.623	0.625	0.567	0.615
	0.643	0.621	0.623	0.604	0.62	0.602	0.606
	0.645	0.643	0.615	0.638	0.617	0.618	0.643

$nnn := convert(Points_{49}, 7)$

$No_{DataCells} := length(nnn)$

$Pit\,34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$

$Pit\,35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$

$nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$

$\sigma_{measured_d} := Stdev(Cells)$

$Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For Sept. 14 1994

page := U:\..\D8631_94.txt

$Dates_d := Day_{year}(9, 14, 1994)$

$Points_{49} := showcells(page, 7, 16)$

Data

$$Points_{49} = \begin{bmatrix} 0.648 & 0.643 & 0.614 & 0.638 & 0.614 & 0.626 & 0.633 \\ 0.654 & 0.645 & 0.643 & 0.633 & 0.643 & 0.645 & 0.637 \\ 0.63 & 0.653 & 0.634 & 0.633 & 0.646 & 0.619 & 0.632 \\ 0.642 & 0.65 & 0.6 & 0.636 & 0.617 & 0.63 & 0.636 \\ 0.651 & 0.635 & 0.639 & 0.623 & 0.629 & 0.564 & 0.617 \\ 0.656 & 0.623 & 0.624 & 0.609 & 0.622 & 0.605 & 0.611 \\ 0.674 & 0.644 & 0.616 & 0.641 & 0.622 & 0.617 & 0.646 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit\,34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\,35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For Sept. 9 1996

page := U:\..\D8631_96.txt

$Dates_d := Day_{year}(9, 9, 1996)$

$Points_{49} := showcells(page, 7, 17)$

Data

$$Points_{49} = \begin{bmatrix} 0.647 & 0.64 & 0.627 & 0.636 & 0.61 & 0.622 & 0.636 \\ 0.653 & 0.639 & 0.642 & 0.637 & 0.629 & 0.644 & 0.635 \\ 0.623 & 0.653 & 0.635 & 0.634 & 0.644 & 0.625 & 0.629 \\ 0.643 & 0.643 & 0.601 & 0.633 & 0.615 & 0.628 & 0.634 \\ 0.651 & 0.628 & 0.635 & 0.618 & 0.631 & 0.562 & 0.521 \\ 0.644 & 0.627 & 0.622 & 0.605 & 0.627 & 0.608 & 0.619 \\ 0.649 & 0.646 & 0.612 & 0.641 & 0.624 & 0.616 & 0.647 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit\ 34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\ 35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For Sept. 16 2000

page := U:\..\D8631_00.txt

$Dates_d := Day_{year}(9, 16, 2000)$

$Points_{49} := showcells(page, 7, 17)$

Data

$$Points_{49} = \begin{bmatrix} 0.639 & 0.639 & 0.627 & 0.631 & 0.606 & 0.614 & 0.631 \\ 0.647 & 0.639 & 0.637 & 0.629 & 0.639 & 0.637 & 0.63 \\ 0.631 & 0.65 & 0.629 & 0.628 & 0.64 & 0.619 & 0.627 \\ 0.638 & 0.645 & 0.594 & 0.627 & 0.613 & 0.623 & 0.63 \\ 0.643 & 0.63 & 0.632 & 0.615 & 0.624 & 0.564 & 0.614 \\ 0.649 & 0.619 & 0.617 & 0.602 & 0.616 & 0.602 & 0.609 \\ 0.643 & 0.639 & 0.61 & 0.636 & 0.617 & 0.612 & 0.64 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

$Pit\,34_d := Get\_Pit_{data}(nnn, No_{DataCells}, 34)$ $Pit\,35_d := Get\_Pit_{data}(nnn, No_{DataCells}, 35)$

These points are deleted from the mean calculation

$nnn := Zero_{one}(nnn, No_{DataCells}, 34)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 35)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

Subject:	Calc. No.	Rev. No.	System No.	Sheet No.
Drywell Corrosion	C-1301-187-e310-037	0	187	A9 -18 of 25

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

Dates =

	0
0	$1.988 \cdot 10^3$
1	$1.989 \cdot 10^3$
2	$1.989 \cdot 10^3$
3	$1.989 \cdot 10^3$
4	$1.99 \cdot 10^3$
5	$1.991 \cdot 10^3$
6	$1.991 \cdot 10^3$
7	$1.992 \cdot 10^3$
8	$1.993 \cdot 10^3$
9	$1.995 \cdot 10^3$
10	$1.997 \cdot 10^3$
11	$2.001 \cdot 10^3$

$\mu_{measured}$ =

	0
0	637.894
1	635.702
2	635.936
3	638.043
4	641.915
5	627.681
6	627.021
7	631.064
8	630
9	633.213
10	631.638
11	627.532

Standard_{error} =

	0
0	2.045
1	1.948
2	1.918
3	1.908
4	2.117
5	1.847
6	1.892
7	1.953
8	1.88
9	2.152
10	1.862
11	1.931

$\sigma_{measured}$ =

	0
0	14.318
1	13.636
2	13.428
3	13.356
4	14.819
5	12.928
6	13.243
7	13.674
8	13.158
9	15.064
10	13.032
11	13.518

$Total_{means} := rows(\mu_{measured})$ $\qquad$ $Total_{means} = 12$

The F-Ratio is calculated

$$SSE := \sum_{i=0}^{last(Dates)} \left(\mu_{measured_i} - yhat(Dates, \mu_{measured})_i\right)^2 \qquad SSE = 166.324$$

$$SSR := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, \mu_{measured})_i - mean(\mu_{measured})\right)^2 \qquad SSR = 86.812$$

$DegreeFree_{ss} := Total_{means} - 2$ $\qquad$ $DegreeFree_{reg} := 1$

$MSE := \frac{SSE}{DegreeFree_{ss}}$ $\qquad$ $MSE = 16.632$ $\qquad$ $MSR := \frac{SSR}{DegreeFree_{reg}}$ $\qquad$ $MSR = 86.812$

$StGrand_{err} := \sqrt{MSE}$ $\qquad$ $StGrand_{err} = 4.078$

$F_{actaul} := \frac{MSR}{MSE}$

$\alpha := 0.05$ $F_{critical} := qF(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss})$

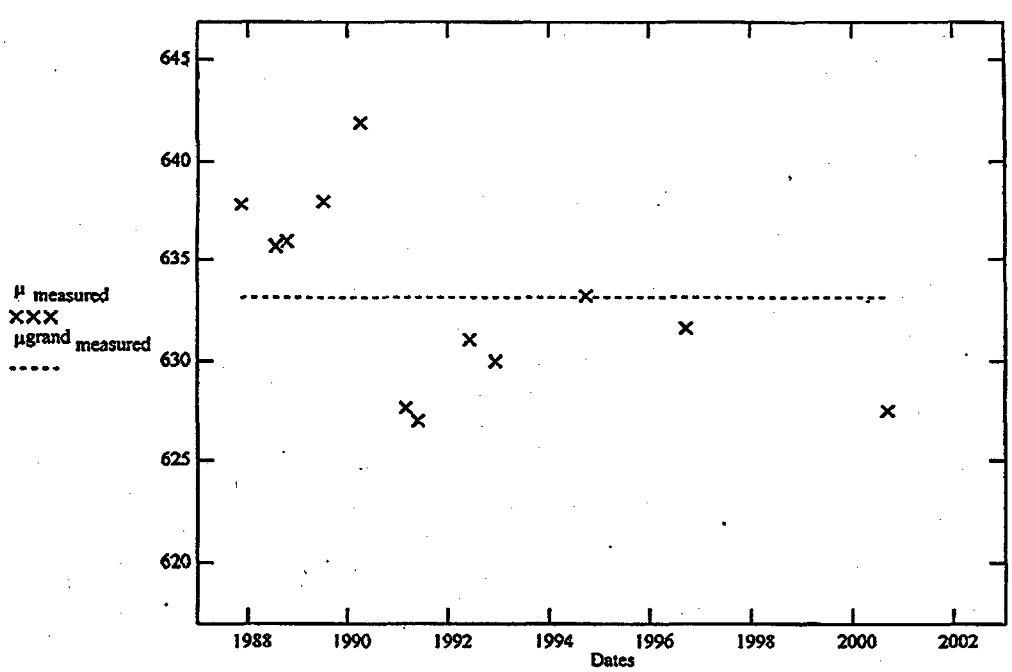
$F_{ratio} := \frac{F_{actaul}}{F_{critical}}$ $F_{ratio} = 1.051$

Therefore the curve fit of the means seems to have a slope and the grandmean is not an accurate measure of the thickness at this location

$i := 0 .. Total_{means} - 1$ $\mu grand_{measured_i} := mean(\mu_{measured})$

$\sigma grand_{measured} := Stdev(\mu_{measured})$ $GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 633.137$ $GrandStandard_{error} = 1.385$

Therefore the corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}(\text{Dates}, \mu_{measured})$ $\quad m_s = -0.746$ $\quad y_b := \text{intercept}(\text{Dates}, \mu_{measured})$ $\quad y_b = 2.119 \cdot 10^3$

The 95% Confidence curves are calculated

$\alpha_t := 0.05 \quad k := 23 \quad f := 0 .. k-1$

$year_{predict_f} := 1985 + f \cdot 2 \qquad Thick_{predict} := m_s \cdot year_{predict} + y_b$

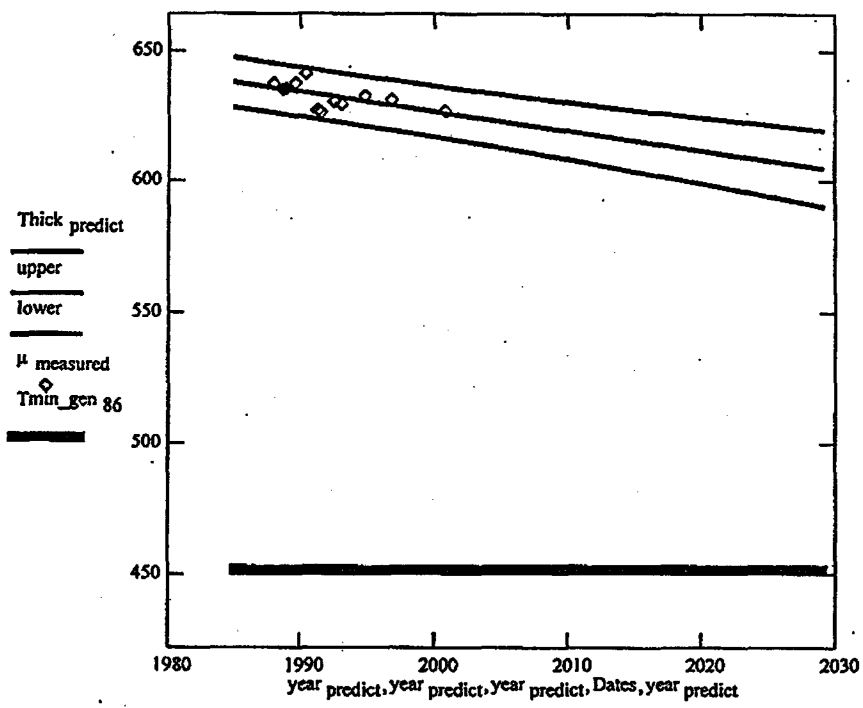
$Thick_{actualmean} := \text{mean}(\text{Dates}) \qquad sum := \sum_i (\text{Dates}_d - \text{mean}(\text{Dates}))^2$

$$upper_f := Thick_{predict_f} + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StGrand_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(year_{predict_f} - Thick_{actualmean})^2}{sum}}$$

$$lower_f := Thick_{predict_f} + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StGrand_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(year_{predict_f} - Thick_{actualmean})^2}{sum}}\right]$$

The minimum required thickness at this elevation is $Tmin\_gen_{86_f} := 452$ (Ref. Calc. SE-000243-002)

Location Curve Fit Projected to Plant End Of Life



$m_s = -0.746$

Therefore the regression model shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

$year_{predict_{12}} = 2.009 \cdot 10^3$ $Thick_{predict_{12}} = 620.515$

The Following trends are shown for the pits

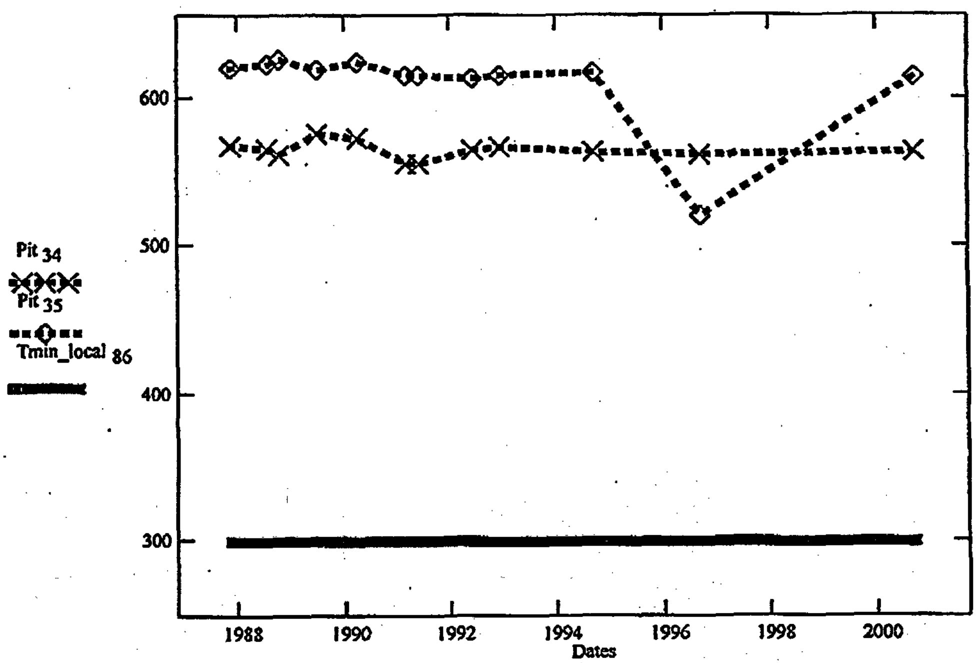
Local Tmin for this elevation in the Drywell $Tmin\_local_{86_f} := 300$ (Ref. Calc. SE-000243-002)

$A_i :=$

$max(Pit_{34})$
$max(Pit_{35})$

$B_i :=$

$min(Pit_{34})$
$min(Pit_{35})$



The following addresses possible corrosion in these pits

The F-Ratio is calculated for the worse pit

$$SSE_{pit} := \sum_{i=0}^{last(Dates)} \left(Pit35_i - yhat(Dates, Pit35)_i\right)^2 \qquad SSE_{pit} = 6.931 \cdot 10^3$$

$$SSR_{pit} := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, Pit35)_i - mean(Pit35)\right)^2 \qquad SSR_{pit} = 1.941 \cdot 10^3$$

$$MSE_{pit} := \frac{SSE_{pit}}{DegreeFree_{ss}} \qquad StPit_{err} := \sqrt{MSE_{pit}} \qquad MSR_{pit} := \frac{SSR_{pit}}{DegreeFree_{reg}}$$

$$Fpit_{actaul} := \frac{MSR_{pit}}{MSE_{pit}} \qquad Fpit_{ratio} := \frac{Fpit_{actaul}}{F_{critical}} \qquad Fpit_{ratio} = 0.564$$

Therefore this pit is not experiencing corrosion

$$m_{pit} := slope(Dates, Pit35) \qquad m_{pit} = -3.526 \qquad y_{pit} := intercept(Dates, Pit35) \qquad y_{pit} = 7.634 \cdot 10^3$$

The 95% Confidence curves are calculated

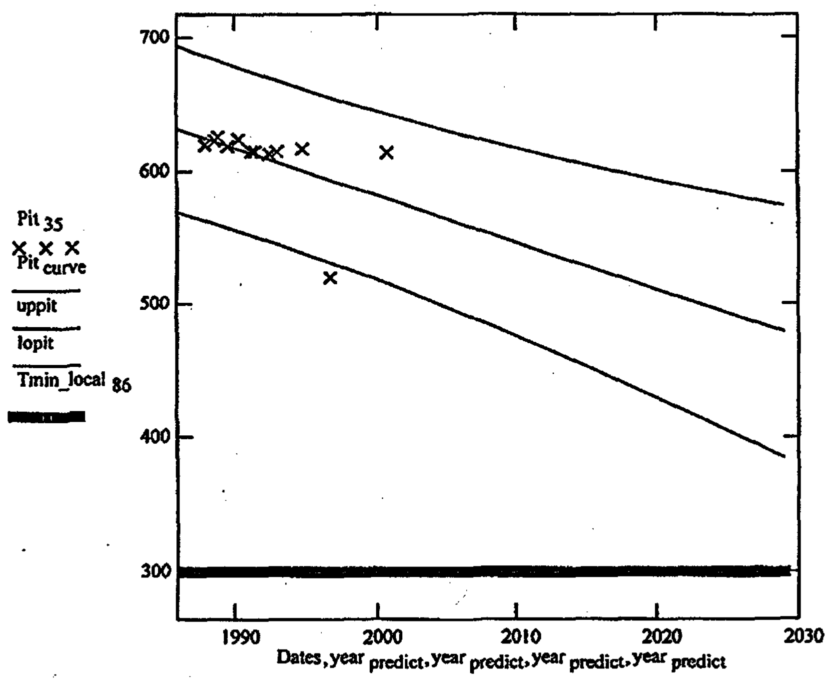
$$Pit_{curve} := m_{pit} \cdot year_{predict} + y_{pit}$$

$$Pit_{actualmean} := mean(Dates) \qquad sum := \sum_i \left(Dates_d - mean(Dates)\right)^2$$

$$uppit_f := Pit_{curve_f} \cdots + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPit_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Pit_{actualmean}\right)^2}{sum}}$$

$$lopit_f := Pit_{curve_f} \cdots + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPit_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Pit_{actualmean}\right)^2}{sum}}\right]$$

Curve Fit For Pit 35 Projected to Plant End Of Life



$m_{pit} = -3.526$

Therefore based on regression model the above curve shows that this pit will not corrode to below minimum required thickness by the plant end of life.

Citizen’s Exhibit NC7

Citizen's Exhibit NC7

GPU Nuclear

Calculation Sheet

Subject		Calc No.	Rev. No.	Sheet No.
OCDW PROJECTED THICKNESS USING DATA THRU 11/02/91		C-1302-187-5300-020	0	1 of 48
Originator: J. P. Moore, Jr.	Date: 12/20/91	Reviewed by		Date 4/15/92

Verification: V-1302-187-005 Rev. 6

4-20-92

1.0 PROBLEM STATEMENT

The statistical analyses of drywell thickness data through November 1991 are documented in Reference 3.1.

The analyses show that there was statistically significant corrosion in Bays 9D, 11A, 11C, 13A, 17A, 17D, 17/19 Frame Cutout, 19A, 19B, and 19C in the sand bed region and in Bay 5 Area D-1 2 at elevation 50'-2". The corrosion at elevation 51'-10" was not statistically significant, and no measurements were taken at elevation 87'-5" due to high temperatures.

The regression analyses in Reference 3.1 provide the best estimates of the linear regression line which defines the drywell thickness in these bays as a function of time.

The purpose of this calculation is to use these linear regression equations to predict the following:

(1) The best estimate of the date on which the mean thickness at a monitored location will equal the minimum allowable.

(2) The latest date for which we have 95% confidence that the mean thickness will not be less than the minimum allowable.

(3) Using the earliest date from (2), compute the lower 95%/95% Tolerance Limit for the local minimum thickness on that date.

These analyses are performed at all locations which have been determined to have a statistically significant corrosion rate.

For the sand bed region, the analyses are performed for the minimum allowable thickness without sand (736 mils).

2. RESULTS

2.1 Sand Bed Region

(1) The earliest best estimate date to reach 736 mils is May 1995 for Bay 19A.

(2) The earliest 95% confidence level date to reach 736 mils is June 1994 for Bay 19A.

(3) It is predicted at the 95%/95% tolerance level that the minimum local thickness in Bay 19C will not be less than 574.1 mils in June 1994. This is the most limiting monitored location in the sand bed.

2.2 Elevation 50'-2"

The only location with statistically significant corrosion is Bay5, Area D-1 2.

(1) The best estimate to reach 670 mils is May 2019.

(2) The 95% confidence level date to reach 670 mils is June 2006.

(3) It is predicted at the 95%/95% tolerance level that the pit at point 9 in Bay 5, Area D-1 2 will have a thickness of not less than 615 mils in June 2006.

2.4 Elevation 51'-10"

The only monitored location at this elevation does not have statistically significant corrosion. This means that the slope of the regression line is not statistically significant and that projected thicknesses determined by using inverse regression are meaningless.

2.5 Elevation 86'

No measurements were taken at this elevation in November 1991 due to high temperatures.

3. REFERENCES

3.1 GPUN Calculation C-1302-187-5300-019, Rev. 0, "Statistical Analysis of Drywell Thickness Thru November 1991."

3.2 "Applied Regression Analysis", 2nd Edition, N.R. Draper & H. Smith, John Wiley & Sons, 1981.

3.3 "Experimental Statistics", (NBS Handbook 91), Mary Gibbons Natrella, John Wiley & Sons, October 1966.

4. ASSUMPTIONS & BASIC DATA

4.1 Mean Thickness vs Time

The mean thickness for each set of measurements at each location is documented in Ref. 3.1. These values are used as input to this calculation.

4.2 Earliest Time To Reach Minimum Allowable Thickness

We need to determine the Best Estimate Date and the date at which we have 95% confidence that the mean thickness at a monitored location will not be less than the minimum allowable thickness.

To accomplish this, we must do the following:

(1) Perform linear regression analysis for each monitored location with statistically significant corrosion, using the data described in 4.1 as input.

(2) Project the regression Line and the two-sided 90% confidence interval about the mean forward in time to locate the intersections with the minimum allowable thickness. This is depicted in the figure below.

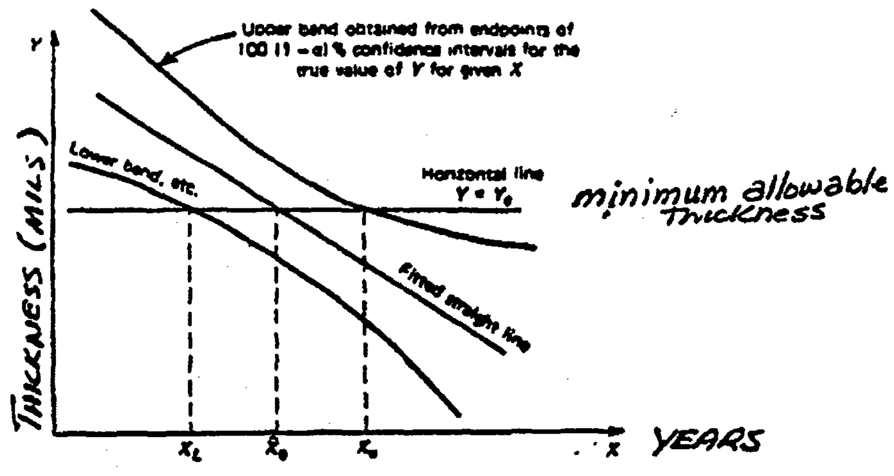


Figure 1.11 Inverse regression: Estimating X by $\hat{X}_0$ from a given Y_0 value, and obtaining a $100(1-\alpha)\%$ "fiducial interval" for X.

In this problem, y is the mean thickness in mils and x is time in years.

The two-sided confidence interval is calculated at a confidence level of 90%. This means that we have 90% confidence that the true mean lies within this interval. Since the confidence interval is centered about the regression line, it also means that we have 95% confidence that the true mean lies above the lower band (90% within the interval between bands plus 5% above the upper band = 95%).

$\hat{x}_0$ represents our best estimate of the time when the true mean thickness will equal 736 mils.

x_L represents the time at which we have 95% confidence that the true mean is not less than y_0.

y_0 = 736 mils.

The equations for the regression line and confidence interval are generally expressed explicitly in terms of y and implicitly in terms of x. If used in this form, the calculation of x_L and x_U would be a trial and error process.

Paragraph 1.7 in Ref. 3.2 rearranges the equations to perform inverse regression and thus solve directly for x_L and x_U.

$\hat{x}_0 = (y_0 - b_0)/b_1$
b_0 = y Intercept
b_1 = Slope
y_0 = 736 mils

$$\begin{pmatrix} x_U \\ x_L \end{pmatrix} = \hat{x}_0 + \frac{(\hat{x}_0 - \overline{x})g \pm (ts/b_1)\,[[(\hat{x}_0 - \overline{x})^2/S_{xx}] + (1-g)/n]^{1/2}}{(1-g)}$$

$$g = t^2 / [b_1 / (s^2/S_{xx})^{1/2}]^2$$

$$t = t(v, 1-\alpha/2)$$

$v = (n-2)$ = *degrees of freedom of* s^2

$$(1-\alpha/2) = (1-0.10/2) = 0.95$$

$$S = \Sigma (x_i - \overline{x})^2$$

n = *number of observations* (y_i, x_i)

$$\overline{x} = \Sigma x_i / n$$

A SPEAKEZ program ("LINPREDX") was written to solve the equations for x_L, $\hat{x}_0$ and x_U. This program calls another SPEAKEZ program ("LINREGN1") which performs a linear regression analysis to calculate the values to input to these equations. Listings of these programs are included in Appendix 6.3.

4.3 Mean Thickness In All Bays At Minimum Time x_L

Having calculated the minimum time x_L to reach $t_{minimum}$, the next step is to predict the true mean thickness in all bays on this date.

A SPEAKEZ program ("(LINPREDY") was written to use the input from 4.1 and 4.2 to predict the true mean thickness on the above date and the 90% confidence interval about this value. A listing of this program is included in Appendix 6.3.

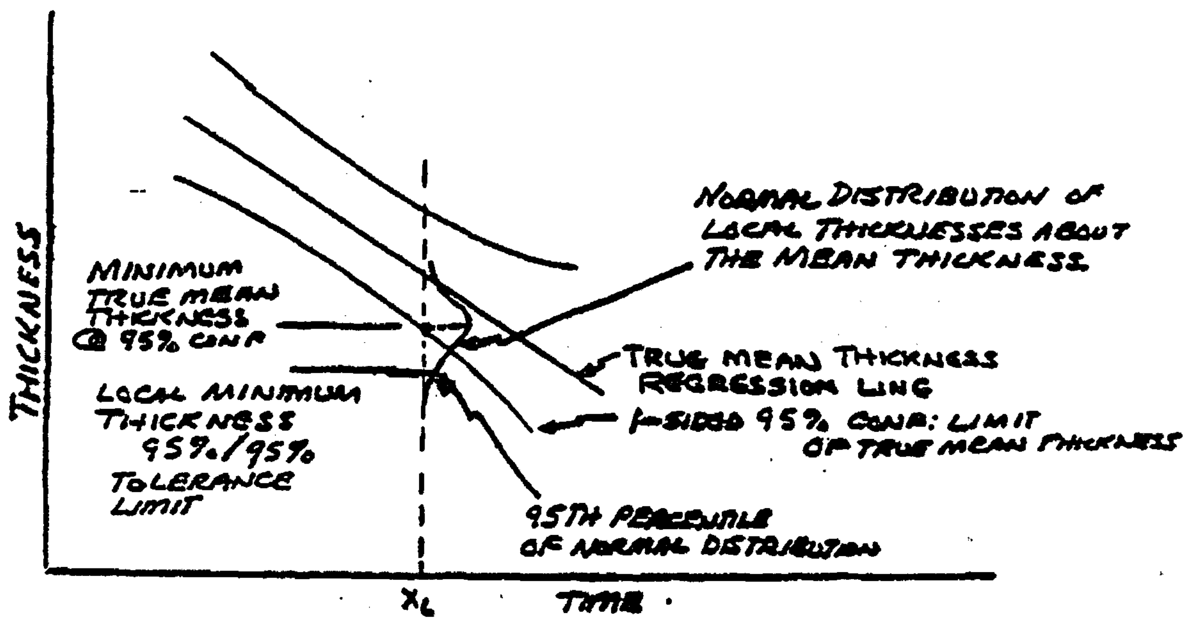
4.4 Local Minimum Thickness

The local minimum thickness at 95%/95% tolerance level is estimated as follows:

(1) The predicted mean thickness and 90% confidence interval at minimum time x_L is calculated for each monitored location in 4.3 with a statistically significant corrosion rate. This represents the mean thickness within the 6"x6" grid.

(2) The thickness at individual points within the grid was determined to be normally distributed in Ref. 3.1. The standard deviation of the individual point thicknesses was also calculated in Ref. 3.1. If the standard deviation at a given location does not vary with time, its mean value can be used as the best estimate of the standard deviation at a future date. However, if it varies with time, regression analysis may be used to predict the standard deviation at a future date.

(3) The one-sided 95%/95% lower tolerance limit for local minimum thickness is equal to the one-sided 95% lower confidence limit for mean thickness (from 4.3) minus 2.092 times the standard deviation (from 4.4(2)), where 2.092 is the factor for 95%/95% one-sided tolerance limit for a sample size of 45 (Ref. 3.6, Table A-7). Most of the grids have about 45 valid data points.


THICKNESS
TIME
X_L
NORMAL DISTRIBUTION OF LOCAL THICKNESSES ABOUT THE MEAN THICKNESS
MINIMUM TRUE MEAN THICKNESS @ 95% CONF
TRUE MEAN THICKNESS REGRESSION LINE
LOCAL MINIMUM THICKNESS 95%/95% TOLERANCE LIMIT
1-SIDED 95% CONF. LIMIT OF TRUE MEAN THICKNESS
95TH PERCENTILE OF NORMAL DISTRIBUTION

5. CALCULATIONS

5.1 Mean Thickness vs Time

The mean thickness for each set of measurements at each location from Ref. 3.1 are tabulated as the variable y on the computer output sheets in Appendix 6.1.

5.2 Sand Bed Without Sand

Minimum allowable thickness = 736 mils.

Bay & Area	Best Estimate Date	95% Confidence Date
9D	11/02/2014	7/08/2005
11A	6/01/1997	3/22/1996
11C Top 3	11/16/2000	7/07/1997
11C Bot 4	1/07/1998	4/06/1996
13A	9/22/1997	6/11/1995
17A Bot 4	4/10/2012	4/24/2004
17D	8/08/1995	9/14/1994
17/19 Bot 4	1/02/2008	8/23/2002
17/19 Top 3	3/16/2011	8/28/2003
19A	5/16/1995	6/10/1994
19B	7/15/2000	8/17/1997
19C	5/16/1996	1/27/1995

Minimum True Mean Thickness in June 1994

Bay & Area	Minimum True Mean Thickness @ 95% Confidence on 6/10/1994
9D	936.0
11A	773.7
11C Top 3	851.3
11C Bot 4	776.7
13A	736.7
17A Bot 4	883.8
17D	742.0
17/19 Bot 4	909.3
17/19 Top 3	903.6
19A	736.0
19B	784.4
19C	749.1

Local Minimum Thickness in June 1994

The variation of the standard deviation of individual point measurements about the mean thickness as a function of time was analyzed using the SAS Procedure "PROC REG". The results of the regression are tabulated below, where:

N	Number of datasets
Mean STD	Mean Standard Deviation for the N datasets
STD Last	Standard Deviation on Date of Last Reading (from the regression line
B1	Slope of regression line
Prob>F	Probability that B1=0
Years	Years from date of last measurement to 6/10/94

Bay & Area	N	Mean Std	Std Last	B1	Prob>F
9D	6	71.1	78.1	6.4	0.01
11A	13	46.2	51.0	1.9	0.11
11C Top3	12	106.7	102.1	-2.0	0.23
11C Bot4	11	26.4	23.1	-1.6	0.34
13A	9	57.6	57.4	-0.1	0.96
17A Bot4	8	53.4	56.7	2.2	0.19
17D	13	60.7	66.0	2.1	0.02
17/19 Bot4	8	33.1	33.0	-0.1	0.98
17/19 Top3	8	23.3	20.4	-2.0	0.54
19A	13	59.2	62.9	1.5	0.05
19B	12	59.4	63.0	1.5	0.07
19C	12	76.7	80.0	1.4	0.43

For those bays where B1 is negative, the standard deviation is assumed to be constant and equal to the Mean Std.

For those bays where B1 is positive, the standard deviation on 6/10/94 is computed from the regression.

Std on 6/10/94 = Std Last + B1 * Years

Years = 2.6

Bay & Area	STD on 6/10/94	K*STD	95% Lower Confidence Limit for Projected Mean	95%/95% Lower Tolerance Limit for Local Minimum Thickness
9D	94.7	198.2	936.0	737.8
11A	55.9	117.0	773.7	656.7
11C Top3	106.7	223.2	851.3	628.1
11C Bot4	26.4	55.2	776.7	721.5
13A	57.6	120.5	736.7	616.2
17A Bot4	62.4	130.6	883.8	753.2
17D	71.5	149.5	742.0	592.5
17/19 Bot4	33.1	69.2	909.3	840.1
17/19 Top3	23.3	48.7	903.6	854.9
19A	66.8	139.8	736.0	596.2
19B	66.9	140.0	784.4	644.4
19C	83.6	175.0	749.1	574.1

5.3 Elevation 50′-2″

The only location at this elevation with statistically significant corrosion is Bay 5, Area D-1 2. It is predicted at the 95% confidence level that the true mean thickness at this location will not decrease below 670 mils prior to 6/30/2006. Thus, Bay 19A in the sand bed is more limiting.

Local Minimum Thickness in June 2006

The standard deviation of individual point measurements about the mean thickness has a mean value of ± 12.0 mils. Regression analysis yielded the following:

STD at last measurement	± 13.9
Slope B1	+ 1.0
Prob>F	0.11

Years from 11/02/91 to 6/30/2006 = 14.7

STD @ 6/30/2006 = 13.9 + 14.7(1.0) = 28.6

t_{95L} = 95% Lower Confidence Limit for Projected Mean Thickness in June 2006

t_{95L} = 670 mils

$t_{min95L} = t_{95L} - K(STD)$

$K_{95/95}$ = 2.126 @ n=40 (Ref. 3.3, Table A-7)

tmin95 = 670 - 2.126(28.6)

= 609.3 mils

Based on the regression, the best estimate of the current thickness of the grid is 742.7 ± 2.4 mils. (Ref. 3.1)

Based on the regression, the best estimate of the current thickness of the pit at point 9 in the grid is 688.1 ± 2.6 mils. (Ref. 3.1)

Thus, the depth of the pit is

$$[742.7 \pm 2.4] - [688.1 \pm 2.6] = 54.6 \pm 3.5 \text{ mils}$$

Where the two uncertainties are propagated using the square root of the sum of the squares.

Based on the conclusion that the pit is corroding at approximately the same rate as the grid (Ref. 3.1, para. 5.2.1), the thickness at the pit in February 2003 at the 95% confidence level will be:

$$670 - 54.6 = 615.4 \text{ mils.}$$

5.4 Elevation 51'-10"

The only monitored location at this elevation does not have statistically significant corrosion. This means that the slope of the regression line is not statistically significant and that projected thicknesses determined by using inverse regression are meaningless.

5.5 Elevation 86'

No measurements were taken at this elevation in November 1991 due to high temperatures which prevented access.

PROGRAM: LINPREDX

BAY NUMBER? 9d

ENTER NAME OF DATE LIST date9d

NAME OF MEAN THICKNESS DATASET? md9d

APPENDIX 6.1

N	DATE9D	MD9D
*	********	*******
1	12/4/86	1071.51
2	12/19/88	1021.39
3	6/26/89	1054.42
4	9/13/89	1020.43
5	2/8/90	1009.96
6	4/24/90	1002.12
7	2/23/91	992.55
8	5/23/91	1002.53
9	11/2/91	992.4

ENTER NO. OF DESIRED DATA ints(4,9)

ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
***	*******	********	*******
9D	9/13/89	0	1020.43
	2/8/90	.405479	1009.96
	4/24/90	.610959	1002.12
	2/23/91	1.44658	992.55
	5/23/91	1.69041	1002.53
	11/2/91	2.13699	992.4

Y0 = 736
XU90 = Nov 22, 2055
X0HAT = Nov 2, 2014
XL90 = Jul 8, 2005
T95 = 2.13182
G = .39709

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:21 AM

```
PROGRAM: LINPREDX
BAY NUMBER? 11a
ENTER NAME OF DATE LIST date11a
NAME OF MEAN THICKNESS DATASET? me11a
```

N	DATE11A	ME11A
**	********	******
1	12/2/86	891.47
2	4/29/87	918.66
3	5/1/87	904.64
4	8/1/87	922.09
5	9/10/87	905.2
6	7/12/88	912.97
7	10/08/88	888.22
8	6/26/89	881.34
9	9/13/89	891.56
10	2/8/90	875.34
11	4/24/90	858.04
12	2/23/91	844.58
13	5/23/91	843.98
14	11/2/91	832.6

```
ENTER NO. OF DESIRED DATA ints(2,14)
ENTER VALUE OF MINIMUM THICKNESS (YO) 736
```

BAY	DATES	X	Y
***	********	**********	******
11A	4/29/87	0	918.66
	5/1/87	.00547945	904.64
	8/1/87	.257534	922.09
	9/10/87	.367123	905.2
	7/12/88	1.20548	912.97
	10/08/88	1.44658	888.22
	6/26/89	2.16164	881.34
	9/13/89	2.37808	891.56
	2/8/90	2.78356	875.34
	4/24/90	2.98904	858.04
	2/23/91	3.82466	844.58
	5/23/91	4.06849	843.98
	11/2/91	4.51507	832.6

```
YO    = 736
XU90  = Jan 27, 1999
XOHAT = May 29, 1997
XL90  = Mar 19, 1996
T95   = 1.79588
G     = .0285006
```

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE
UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS,
THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT
G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH
LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

April 15, 1992
9:53 AM

PROGRAM: LINPREDX
BAY NUMBER? 11c top 3
ENTER NAME OF DATE LIST date11c
NAME OF MEAN THICKNESS DATASET? md11ct

N	DATE11C	MD11CT
**	********	*******
1	5/1/87	1046
2	8/1/87	1108.6
3	9/10/87	1079.12
4	7/12/88	1045.38
5	10/08/88	1008.86
6	6/26/89	1015.78
7	9/13/89	1005
8	2/8/90	978.45
9	4/24/90	974.9
10	3/4/91	981.68
11	5/23/91	1001.79
12	11/2/91	964.3

ENTER NO. OF DESIRED DATA ints(1,12)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
*******	********	********	*******
11C TOP	5/1/87	0	1046
	8/1/87	.252055	1108.6
	9/10/87	.361644	1079.12
	7/12/88	1.2	1045.38
	10/08/88	1.4411	1008.86
	6/26/89	2.15616	1015.78
	9/13/89	2.3726	1005
	2/8/90	2.77808	978.45
	4/24/90	2.98356	974.9
	3/4/91	3.84384	981.68
	5/23/91	4.06301	1001.79
	11/2/91	4.50959	964.3

Y0 = 736
XU90 = Nov 13, 2006
X0HAT = Nov 16, 2000
XL90 = Dec 7, 1997
T95 = 1.81246
G = .118019

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:24 AM

PROGRAM: LINPREDX
BAY NUMBER? 11c bot 4
ENTER NAME OF DATE LIST date11c
NAME OF MEAN THICKNESS DATASET? md11cb

N	DATE11C	MD11CB
**	********	******
1	5/1/87	916.79
2	8/1/87	953.64
3	9/10/87	915.71
4	7/12/88	906.05
5	10/08/88	897
6	6/26/89	876.75
7	9/13/89	890.71
8	2/8/90	869
9	4/24/90	863.29
10	3/4/91	857.54
11	5/23/91	862.64
12	11/2/91	856.3

ENTER NO. OF DESIRED DATA ints(1,12)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
*******	********	********	******
11C BOT	5/1/87	0	916.79
	8/1/87	.252055	953.64
	9/10/87	.361644	915.71
	7/12/88	1.2	906.05
	10/08/88	1.4411	897
	6/26/89	2.15616	876.75
	9/13/89	2.3726	890.71
	2/8/90	2.77808	869
	4/24/90	2.98356	863.29
	3/4/91	3.84384	857.54
	5/23/91	4.06301	862.64
	11/2/91	4.50959	856.3

Y0 = 736
XU90 = Dec 10, 2000
X0HAT = Jan 7, 1998
XL90 = Apr 6, 1996
T95 = 1.81246
G = .0641842

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:25 AM

PROGRAM: LINPREDX

BAY NUMBER? 13a

ENTER NAME OF DATE LIST date13a

NAME OF MEAN THICKNESS DATASET? md13a

N	DATE13A	MD13A
**	********	******
1	11/15/86	919.08
2	12/17/88	905.27
3	6/26/89	882.84
4	9/13/89	882.98
5	2/8/90	859.04
6	3/28/90	852.84
7	4/24/90	855.63
8	2/23/91	854.51
9	5/23/91	852.88
10	11/2/91	848.6

ENTER NO. OF DESIRED DATA ints(2,10)

ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
***	********	********	******
13A	12/17/88	0	905.27
	6/26/89	.523288	882.84
	9/13/89	.739726	882.98
	2/8/90	1.14521	859.04
	3/28/90	1.27671	852.84
	4/24/90	1.35068	855.63
	2/23/91	2.1863	854.51
	5/23/91	2.43014	852.88
	11/2/91	2.87671	848.6

Y0 = 736
XU90 = Aug 3, 2003
X0HAT = Sep 22, 1997
XL90 = Jun 11, 1995
T95 = 1.89458
G = .195334

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:28 AM

PROGRAM: LINPREDX
BAY NUMBER? 17a bot 4
ENTER NAME OF DATE LIST date17a
NAME OF MEAN THICKNESS DATASET? md17ab

N	DATE17A	MD17AB
*	********	******
1	12/17/88	957.36
2	6/26/89	964.5
3	9/13/89	955.18
4	2/8/90	937.5
5	4/24/90	939.61
6	2/23/91	934.71
7	5/23/91	942.39
8	11/2/91	932.8

ENTER NO. OF DESIRED DATA ints(1,8)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
*******	********	********	******
17A BOT	12/17/88	0	957.36
	6/26/89	.523288	964.5
	9/13/89	.739726	955.18
	2/8/90	1.14521	937.5
	4/24/90	1.35068	939.61
	2/23/91	2.1863	934.71
	5/23/91	2.43014	942.39
	11/2/91	2.87671	932.8

Y0 = 736
XU90 = Apr 15, 2041
X0HAT = Apr 10, 2012
XL90 = Apr 24, 2004
T95 = 1.94318
G = .324478

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:29 AM

PROGRAM: LINPREDX
BAY NUMBER? 17d
ENTER NAME OF DATE LIST date17d
NAME OF MEAN THICKNESS DATASET? me17d

N	DATE17D	ME17D
**	********	******
1	12/2/86	903.51
2	2/17/87	922.16
3	5/1/87	895.07
4	8/1/87	890.69
5	9/10/87	895.28
6	7/12/88	877.93
7	10/08/88	862.22
8	6/26/89	856.84
9	9/13/89	847.13
10	2/8/90	833.37
11	4/24/90	826.8
12	2/23/91	825.27
13	5/23/91	829.08
14	11/2/91	822.2

ENTER NO. OF DESIRED DATA ints(2,14)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
***	********	********	******
17D	2/17/87	0	922.16
	5/1/87	.2	895.07
	8/1/87	.452055	890.69
	9/10/87	.561644	895.28
	7/12/88	1.4	877.93
	10/08/88	1.6411	862.22
	6/26/89	2.35616	856.84
	9/13/89	2.5726	847.13
	2/8/90	2.97808	833.37
	4/24/90	3.18356	826.8
	2/23/91	4.01918	825.27
	5/23/91	4.26301	829.08
	11/2/91	4.70959	822.2

Y0 = 736
XU90 = Oct 30, 1996
X0HAT = Aug 8, 1995
XL90 = Sep 14, 1994
T95 = 1.79588
G = .0255943

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:30 AM

PROGRAM: LINPREDX
BAY NUMBER? 1719b
ENTER NAME OF DATE LIST date1719
NAME OF MEAN THICKNESS DATASET? md1719b

N	DATE1719	MD1719B
*	********	*******
1	12/30/88	1003.79
2	6/26/89	1019.07
3	9/13/89	1016.57
4	2/8/90	1000.46
5	4/24/90	988.54
6	2/23/91	987
7	5/23/91	982.39
8	11/2/91	971.1

ENTER NO. OF DESIRED DATA ints(1,8)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
*****	********	********	*******
1719B	12/30/88	0	1003.79
	6/26/89	.487671	1019.07
	9/13/89	.70411	1016.57
	2/8/90	1.10959	1000.46
	4/24/90	1.31507	988.54
	2/23/91	2.15068	987
	5/23/91	2.39452	982.39
	11/2/91	2.8411	971.1

Y0 = 736
XU90 = Aug 15, 2021
X0HAT = Jan 2, 2008
XL90 = Aug 23, 2002
T95 = 1.94318
G = .189737

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:31 AM

PROGRAM: LINPREDX
BAY NUMBER? 1719t
ENTER NAME OF DATE LIST date1719
NAME OF MEAN THICKNESS DATASET? md1719t

N	DATE1719	MD1719T
*	********	*******
1	12/30/88	981.71
2	6/26/89	998.81
3	9/13/89	992.4
4	2/8/90	986.29
5	4/24/90	970.6
6	2/23/91	974.67
7	5/23/91	969.3
8	11/2/91	954.2

ENTER NO. OF DESIRED DATA ints(1,8)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
*****	********	********	******
1719T	12/30/88	0	981.71
	6/26/89	.487671	998.81
	9/13/89	.70411	992.4
	2/8/90	1.10959	986.29
	4/24/90	1.31507	970.6
	2/23/91	2.15068	974.67
	5/23/91	2.39452	969.3
	11/2/91	2.8411	954.2

Y0 = 736
XU90 = Jun 25, 2038
X0HAT = Mar 16, 2011
XL90 = Aug 28, 2003
T95 = 1.94318
G = .321285

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:32 AM

PROGRAM: LINPREDX

BAY NUMBER? 19a

ENTER NAME OF DATE LIST date19a

NAME OF MEAN THICKNESS DATASET? me19a

N	DATE19A	ME19A
**	********	******
1	12/2/86	870.22
2	2/17/87	883.64
3	5/1/87	872.93
4	8/1/87	858.6
5	9/10/87	858.29
6	7/12/88	848.57
7	10/08/88	836.91
8	6/26/89	828.82
9	9/13/89	825.36
10	2/8/90	807.78
11	4/24/90	807.8
12	2/23/91	816.67
13	5/23/91	802.8
14	11/2/91	803.2

ENTER NO. OF DESIRED DATA ints(2,14)

ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
***	********	********	******
19A	2/17/87	0	883.64
	5/1/87	.2	872.93
	8/1/87	.452055	858.6
	9/10/87	.561644	858.29
	7/12/88	1.4	848.57
	10/08/88	1.6411	836.91
	6/26/89	2.35616	828.82
	9/13/89	2.5726	825.36
	2/8/90	2.97808	807.78
	4/24/90	3.18356	807.8
	2/23/91	4.01918	816.67
	5/23/91	4.26301	802.8
	11/2/91	4.70959	803.2

Y0 = 736
XU90 = Sep 6, 1996
XOHAT = May 16, 1995
XL90 = Jun 10, 1994
T95 = 1.79588
G = .0302474

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:33 AM

PROGRAM: LINPREDX
BAY NUMBER? 19b
ENTER NAME OF DATE LIST date19b
NAME OF MEAN THICKNESS DATASET? md19b

N	DATE19B	MD19B
**	********	******
1	12/2/86	880.84
2	5/1/87	897.63
3	8/1/87	892.21
4	9/10/87	887.6
5	7/12/88	863.98
6	10/08/88	856.41
7	6/26/89	852.55
8	9/13/89	854.94
9	2/8/90	840.67
10	4/24/90	839.1
11	2/23/91	852.53
12	5/23/91	844.4
13	11/2/91	846.3

ENTER NO. OF DESIRED DATA ints(2,13)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
***	********	********	******
19B	5/1/87	0	897.63
	8/1/87	.252055	892.21
	9/10/87	.361644	887.6
	7/12/88	1.2	863.98
	10/08/88	1.4411	856.41
	6/26/89	2.15616	852.55
	9/13/89	2.3726	854.94
	2/8/90	2.77808	840.67
	4/24/90	2.98356	839.1
	2/23/91	3.81918	852.53
	5/23/91	4.06301	844.4
	11/2/91	4.50959	846.3

Y0 = 736
XU90 = Dec 12, 2005
XOHAT = May 7, 2000
XL90 = Jul 26, 1997
T95 = 1.81246
G = .11486

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

April 15, 1992
9:55 AM

PROGRAM: LINPREDX
BAY NUMBER? 19c
ENTER NAME OF DATE LIST date19c
NAME OF MEAN THICKNESS DATASET? me19c

N	DATE19C	ME19C
**	********	******
1	12/2/86	866.02
2	5/1/87	900.51
3	8/1/87	888.16
4	9/10/87	888.31
5	7/12/88	873.46
6	10/08/88	856.27
7	6/26/89	845
8	9/13/89	844.7
9	2/8/90	830.51
10	4/24/90	822.52
11	2/23/91	842.8
12	5/23/91	823.22
13	11/2/91	822.3

ENTER NO. OF DESIRED DATA ints(2,13)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 736

BAY	DATES	X	Y
***	********	********	******
19C	5/1/87	0	900.51
	8/1/87	.252055	888.16
	9/10/87	.361644	888.31
	7/12/88	1.2	873.46
	10/08/88	1.4411	856.27
	6/26/89	2.15616	845
	9/13/89	2.3726	844.7
	2/8/90	2.77808	830.51
	4/24/90	2.98356	822.52
	2/23/91	3.81918	842.8
	5/23/91	4.06301	823.22
	11/2/91	4.50959	822.3

Y0 = 736
XU90 = May 31, 1998
X0HAT = May 16, 1996
XL90 = Jan 27, 1995
T95 = 1.81246
G = .0508207

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:36 AM

PROGRAM: LINPREDX
BAY NUMBER? 5/51/d12
ENTER NAME OF DATE LIST date5112
NAME OF MEAN THICKNESS DATASET? mf5112

N	DATE5112	MF5112
**	********	******
1	11/01/87	755.05
2	7/12/88	751.07
3	10/08/88	751.51
4	6/26/89	750.9
5	9/13/89	757.27
6	2/8/90	740.83
7	3/28/90	743.85
8	4/25/90	746.29
9	2/23/91	741.56
10	5/23/91	745.28
11	11/2/91	748.1

ENTER NO. OF DESIRED DATA ints(1,11)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 670

BAY	DATES	X	Y
********	********	********	******
5/51/D12	11/01/87	0	755.05
	7/12/88	.69589	751.07
	10/08/88	.936986	751.51
	6/26/89	1.65205	750.9
	9/13/89	1.86849	757.27
	2/8/90	2.27397	740.83
	3/28/90	2.40548	743.85
	4/25/90	2.48219	746.29
	2/23/91	3.31507	741.56
	5/23/91	3.5589	745.28
	11/2/91	4.00548	748.1

Y0 = 670
XU90 = Nov 6, 2114
XOHAT = Mar 15, 2019
XL90 = Jun 30, 2006
T95 = 1.83311
G = .586272

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:37 AM

PROGRAM: LINPREDX
BAY NUMBER? 5/51/d12
ENTER NAME OF DATE LIST date5112
NAME OF MEAN THICKNESS DATASET? mf5112

N	DATE5112	MF5112
**	********	******
1	11/01/87	755.05
2	7/12/88	751.07
3	10/08/88	751.51
4	6/26/89	750.9
5	9/13/89	757.27
6	2/8/90	740.83
7	3/28/90	743.85
8	4/25/90	746.29
9	2/23/91	741.56
10	5/23/91	745.28
11	11/2/91	748.1

ENTER NO. OF DESIRED DATA ints(1,11)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 673

BAY	DATES	X	Y
********	********	********	******
5/51/D12	11/01/87	0	755.05
	7/12/88	.69589	751.07
	10/08/88	.936986	751.51
	6/26/89	1.65205	750.9
	9/13/89	1.86849	757.27
	2/8/90	2.27397	740.83
	3/28/90	2.40548	743.85
	4/25/90	2.48219	746.29
	2/23/91	3.31507	741.56
	5/23/91	3.5589	745.28
	11/2/91	4.00548	748.1

Y0 = 673
XU90 = Jan 24, 2110
X0HAT = Jan 30, 2018
XL90 = Nov 10, 2005
T95 = 1.83311
G = .586272

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:38 AM

PROGRAM: LINPREDX
BAY NUMBER? 5/51/d12
ENTER NAME OF DATE LIST date5112
NAME OF MEAN THICKNESS DATASET? mf5112

N	DATE5112	MF5112
**	********	******
1	11/01/87	755.05
2	7/12/88	751.07
3	10/08/88	751.51
4	6/26/89	750.9
5	9/13/89	757.27
6	2/8/90	740.83
7	3/28/90	743.85
8	4/25/90	746.29
9	2/23/91	741.56
10	5/23/91	745.28
11	11/2/91	748.1

ENTER NO. OF DESIRED DATA ints(1,11)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 597

BAY	DATES	X	Y
********	********	********	******
5/51/D12	11/01/87	0	755.05
	7/12/88	.69589	751.07
	10/08/88	.936986	751.51
	6/26/89	1.65205	750.9
	9/13/89	1.86849	757.27
	2/8/90	2.27397	740.83
	3/28/90	2.40548	743.85
	4/25/90	2.48219	746.29
	2/23/91	3.31507	741.56
	5/23/91	3.5589	745.28
	11/2/91	4.00548	748.1

Y0 = 597
XU90 = Mar 22, 2231
XCHAT = Jun 22, 2046
XL90 = Dec 12, 2021
T95 = 1.83311
G = .586272

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:39 AM

PROGRAM: LINPREDX
BAY NUMBER? 5/51/d12
ENTER NAME OF DATE LIST date5112
NAME OF MEAN THICKNESS DATASET? mf5112

N	DATE5112	MF5112
**	********	******
1	11/01/87	755.05
2	7/12/88	751.07
3	10/08/88	751.51
4	6/26/89	750.9
5	9/13/89	757.27
6	2/8/90	740.83
7	3/28/90	743.85
8	4/25/90	746.29
9	2/23/91	741.56
10	5/23/91	745.28
11	11/2/91	748.1

ENTER NO. OF DESIRED DATA ints(1,11)
ENTER VALUE OF MINIMUM THICKNESS (Y0) 540

BAY	DATES	X	Y
********	********	********	******
5/51/D12	11/01/87	0	755.05
	7/12/88	.69589	751.07
	10/08/88	.936986	751.51
	6/26/89	1.65205	750.9
	9/13/89	1.86849	757.27
	2/8/90	2.27397	740.83
	3/28/90	2.40548	743.85
	4/25/90	2.48219	746.29
	2/23/91	3.31507	741.56
	5/23/91	3.5589	745.28
	11/2/91	4.00548	748.1

Y0 = 540
XU90 = Feb 2, 2322
X0HAT = Oct 7, 2067
XL90 = Jan 3, 2034
T95 = 1.83311
G = .586272

INVERSE ESTIMATION IS NOT OF MUCH PRACTICAL VALUE UNLESS THE REGRESSION IS WELL DETERMINED, THAT IS, THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPLIES THAT G SHOULD BE SMALLER THAN ABOUT 0.20. WHEN G IS MUCH LARGER THAN THIS, THE RESULTS ARE MEANINGLESS.

December 18, 1991
9:40 AM

Appendix 6.2

PROGRAM: LINPREDY
BAY NUMBER? 9d
ENTER NAME OF DATE LIST date9d
NAME OF MEAN THICKNESS DATASET? md9d

N	DATE9D	MD9D
*	********	*******
1	12/4/86	1071.51
2	12/19/88	1021.39
3	6/26/89	1054.42
4	9/13/89	1020.43
5	2/8/90	1009.96
6	4/24/90	1002.12
7	2/23/91	992.55
8	5/23/91	1002.53
9	11/2/91	992.4

ENTER NO. OF DESIRED DATA ints(4,9)
ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
***	*******	********	*******
9D	9/13/89	0	1020.43
	2/8/90	.405479	1009.96
	4/24/90	.610959	1002.12
	2/23/91	1.44658	992.55
	5/23/91	1.69041	1002.53
	11/2/91	2.13699	992.4

X0 = 6/10/94

YL90	Y0HAT	YU90	T95
*******	*******	******	*******
936.012	962.366	988.72	2.13182

F-RATIO = 2.51832

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:26 PM

PROGRAM: LINPREDY
BAY NUMBER? 11a
ENTER NAME OF DATE LIST date11a
NAME OF MEAN THICKNESS DATASET? me11a

N	DATE11A	ME11A
**	********	******
1	12/2/86	891.47
2	4/29/87	918.66
3	5/1/87	904.64
4	8/1/87	922.09
5	9/10/87	905.2
6	7/12/88	912.97
7	10/08/88	888.22
8	6/26/89	881.34
9	9/13/89	891.56
10	2/8/90	875.34
11	4/24/90	858.04
12	2/23/91	844.58
13	5/23/91	843.98
14	11/2/91	832.6

ENTER NO. OF DESIRED DATA ints(2,14)
ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
***	********	**********	******
11A	4/29/87	0	918.66
	5/1/87	.00547945	904.64
	8/1/87	.257534	922.09
	9/10/87	.367123	905.2
	7/12/88	1.20548	912.97
	10/08/88	1.44658	888.22
	6/26/89	2.16164	881.34
	9/13/89	2.37808	891.56
	2/8/90	2.78356	875.34
	4/24/90	2.98904	858.04
	2/23/91	3.82466	844.58
	5/23/91	4.06849	843.98
	11/2/91	4.51507	832.6

X0 = 6/10/94

YL90	YOHAT	YU90	T95
******	*******	*******	*******
773.58	789.971	806.363	1.79588

F-RATIO = 35.0869

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

April 15, 1992
9:57 AM

PROGRAM: LINPREDY

BAY NUMBER? 11c top 3

ENTER NAME OF DATE LIST date11c

NAME OF MEAN THICKNESS DATASET? md11ct

N	DATE11C	MD11CT
**	********	*******
1	5/1/87	1046
2	8/1/87	1108.6
3	9/10/87	1079.12
4	7/12/88	1045.38
5	10/08/88	1008.86
6	6/26/89	1015.78
7	9/13/89	1005
8	2/8/90	978.45
9	4/24/90	974.9
10	3/4/91	981.68
11	5/23/91	1001.79
12	11/2/91	964.3

ENTER NO. OF DESIRED DATA ints(1,12)

ENTER DATE OF MINIMUM THICKNESS (XO) 6/10/94

BAY	DATES	X	Y
*******	********	********	*******
11C TOP	5/1/87	0	1046
	8/1/87	.252055	1108.6
	9/10/87	.361644	1079.12
	7/12/88	1.2	1045.38
	10/08/88	1.4411	1008.86
	6/26/89	2.15616	1015.78
	9/13/89	2.3726	1005
	2/8/90	2.77808	978.45
	4/24/90	2.98356	974.9
	3/4/91	3.84384	981.68
	5/23/91	4.06301	1001.79
	11/2/91	4.50959	964.3

XO = 6/10/94

YL90	YOHAT	YU90	T95
*******	*******	*******	*******
851.317	895.162	939.008	1.81246

F-RATIO = 8.47318

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:27 PM

PROGRAM: LINPREDY

BAY NUMBER? 11c bottom 4

ENTER NAME OF DATE LIST date11c

NAME OF MEAN THICKNESS DATASET? md11cb

N	DATE11C	MD11CB
**	********	******
1	5/1/87	916.79
2	8/1/87	953.64
3	9/10/87	915.71
4	7/12/88	906.05
5	10/08/88	897
6	6/26/89	876.75
7	9/13/89	890.71
8	2/8/90	869
9	4/24/90	863.29
10	3/4/91	857.54
11	5/23/91	862.64
12	11/2/91	856.3

ENTER NO. OF DESIRED DATA ints(1,12)

ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
********	********	********	******
11C BOTT	5/1/87	0	916.79
	8/1/87	.252055	953.64
	9/10/87	.361644	915.71
	7/12/88	1.2	906.05
	10/08/88	1.4411	897
	6/26/89	2.15616	876.75
	9/13/89	2.3726	890.71
	2/8/90	2.77808	869
	4/24/90	2.98356	863.29
	3/4/91	3.84384	857.54
	5/23/91	4.06301	862.64
	11/2/91	4.50959	856.3

X0 = 6/10/94

YL90	Y0HAT	YU90	T95
*******	*******	*******	*******
776.699	800.132	823.566	1.81246

F-RATIO = 15.5802

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:29 PM

PROGRAM: LINPREDY
BAY NUMBER? 13a all pts
ENTER NAME OF DATE LIST date13a
NAME OF MEAN THICKNESS DATASET? md13a

N	DATE13A	MD13A
**	********	******
1	11/15/86	919.08
2	12/17/88	905.27
3	6/26/89	882.84
4	9/13/89	882.98
5	2/8/90	859.04
6	3/28/90	852.84
7	4/24/90	855.63
8	2/23/91	854.51
9	5/23/91	852.88
10	11/2/91	848.6

ENTER NO. OF DESIRED DATA ints(2,10)
ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
*******	********	********	******
13A ALL	12/17/88	0	905.27
	6/26/89	.523288	882.84
	9/13/89	.739726	882.98
	2/8/90	1.14521	859.04
	3/28/90	1.27671	852.84
	4/24/90	1.35068	855.63
	2/23/91	2.1863	854.51
	5/23/91	2.43014	852.88
	11/2/91	2.87671	848.6

X0 = 6/10/94

YL90	Y0HAT	YU90	T95
*******	******	*******	*******
761.348	793.96	826.572	1.89458

F-RATIO = 5.11944

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

April 15, 1992
9:59 AM

PROGRAM: LINPREDY

BAY NUMBER? 17a bottom 4

ENTER NAME OF DATE LIST date17a

NAME OF MEAN THICKNESS DATASET? md17ab

N	DATE17A	MD17AB
*	********	******
1	12/17/88	957.36
2	6/26/89	964.5
3	9/13/89	955.18
4	2/8/90	937.5
5	4/24/90	939.61
6	2/23/91	934.71
7	5/23/91	942.39
8	11/2/91	932.8

ENTER NO. OF DESIRED DATA ints(1,8)

ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
********	********	********	******
17A BOTT	12/17/88	0	957.36
	6/26/89	.523288	964.5
	9/13/89	.739726	955.18
	2/8/90	1.14521	937.5
	4/24/90	1.35068	939.61
	2/23/91	2.1863	934.71
	5/23/91	2.43014	942.39
	11/2/91	2.87671	932.8

X0 = 6/10/94

YL90	YOHAT	YU90	T95
*******	******	*******	*******
883.791	906.56	929.329	1.94318

F-RATIO = 3.08187

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:30 PM

PROGRAM: LINPREDY

BAY NUMBER? 17d

ENTER NAME OF DATE LIST date17d

NAME OF MEAN THICKNESS DATASET? me17d

N	DATE17D	ME17D
**	********	******
1	12/2/86	903.51
2	2/17/87	922.16
3	5/1/87	895.07
4	8/1/87	890.69
5	9/10/87	895.28
6	7/12/88	877.93
7	10/08/88	862.22
8	6/26/89	856.84
9	9/13/89	847.13
10	2/8/90	833.37
11	4/24/90	826.8
12	2/23/91	825.27
13	5/23/91	829.08
14	11/2/91	822.2

ENTER NO. OF DESIRED DATA ints(2,14)

ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
***	********	********	******
17D	2/17/87	0	922.16
	5/1/87	.2	895.07
	8/1/87	.452055	890.69
	9/10/87	.561644	895.28
	7/12/88	1.4	877.93
	10/08/88	1.6411	862.22
	6/26/89	2.35616	856.84
	9/13/89	2.5726	847.13
	2/8/90	2.97808	833.37
	4/24/90	3.18356	826.8
	2/23/91	4.01918	825.27
	5/23/91	4.26301	829.08
	11/2/91	4.70959	822.2

X0 = 6/10/94

YL90	Y0HAT	YU90	T95
******	*******	*******	*******
742.02	758.955	775.891	1.79588

F-RATIO = 39.0712

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:31 PM

PROGRAM: LINPREDY
BAY NUMBER? 17/19 bottom 4
ENTER NAME OF DATE LIST date1719
NAME OF MEAN THICKNESS DATASET? md1719b

N	DATE1719	MD1719B
*	********	*******
1	12/30/88	1003.79
2	6/26/89	1019.07
3	9/13/89	1016.57
4	2/8/90	1000.46
5	4/24/90	988.54
6	2/23/91	987
7	5/23/91	982.39
8	11/2/91	971.1

ENTER NO. OF DESIRED DATA ints(1,8)
ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
********	********	********	*******
17/19 BO	12/30/88	0	1003.79
	6/26/89	.487671	1019.07
	9/13/89	.70411	1016.57
	2/8/90	1.10959	1000.46
	4/24/90	1.31507	988.54
	2/23/91	2.15068	987
	5/23/91	2.39452	982.39
	11/2/91	2.8411	971.1

X0 = 6/10/94

YL90	Y0HAT	YU90	T95
*******	*******	*******	*******
909.277	936.099	962.922	1.94318

F-RATIO = 5.27046

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:33 PM

PROGRAM: LINPREDY

BAY NUMBER? 17/19 top 3

ENTER NAME OF DATE LIST date1719

NAME OF MEAN THICKNESS DATASET? md1719t

N	DATE1719	MD1719T
*	********	*******
1	12/30/88	981.71
2	6/26/89	998.81
3	9/13/89	992.4
4	2/8/90	986.29
5	4/24/90	970.6
6	2/23/91	974.67
7	5/23/91	969.3
8	11/2/91	954.2

ENTER NO. OF DESIRED DATA ints(1,8)

ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
********	********	********	******
17/19 TO	12/30/88	0	981.71
	6/26/89	.487671	998.81
	9/13/89	.70411	992.4
	2/8/90	1.10959	986.29
	4/24/90	1.31507	970.6
	2/23/91	2.15068	974.67
	5/23/91	2.39452	969.3
	11/2/91	2.8411	954.2

X0 = 6/10/94

YL90	Y0HAT	YU90	T95
*******	*******	*******	*******
903.606	931.145	958.684	1.94318

F-RATIO = 3.1125

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:32 PM

PROGRAM: LINPREDY
BAY NUMBER? 19a
ENTER NAME OF DATE LIST date19a
NAME OF MEAN THICKNESS DATASET? me19a

Calc. No. C-1302-187-5300-020
Rev. 0
Page 40 of 48

N	DATE19A	ME19A
**	********	******
1	12/2/86	870.22
2	2/17/87	883.64
3	5/1/87	872.93
4	8/1/87	858.6
5	9/10/87	858.29
6	7/12/88	848.57
7	10/08/88	836.91
8	6/26/89	828.82
9	9/13/89	825.36
10	2/8/90	807.78
11	4/24/90	807.8
12	2/23/91	816.67
13	5/23/91	802.8
14	11/2/91	803.2

ENTER NO. OF DESIRED DATA ints(2,14)
ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
***	********	********	******
19A	2/17/87	0	883.64
	5/1/87	.2	872.93
	8/1/87	.452055	858.6
	9/10/87	.561644	858.29
	7/12/88	1.4	848.57
	10/08/88	1.6411	836.91
	6/26/89	2.35616	828.82
	9/13/89	2.5726	825.36
	2/8/90	2.97808	807.78
	4/24/90	3.18356	807.8
	2/23/91	4.01918	816.67
	5/23/91	4.26301	802.8
	11/2/91	4.70959	803.2

X0 = 6/10/94

YL90	Y0HAT	YU90	T95
*******	*******	*******	*******
736.008	751.182	766.356	1.79588

F-RATIO = 33.0607

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:33 PM

PROGRAM: LINPREDY
BAY NUMBER? 19b
ENTER NAME OF DATE LIST date19b
NAME OF MEAN THICKNESS DATASET? md19b

N	DATE19B	MD19B
**	********	******
1	12/2/86	880.84
2	5/1/87	897.63
3	8/1/87	892.21
4	9/10/87	887.6
5	7/12/88	863.98
6	10/08/88	856.41
7	6/26/89	852.55
8	9/13/89	854.94
9	2/8/90	840.67
10	4/24/90	839.1
11	2/23/91	852.53
12	5/23/91	844.4
13	11/2/91	846.3

ENTER NO. OF DESIRED DATA ints(2,13)
ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
***	********	********	******
19B	5/1/87	0	897.63
	8/1/87	.252055	892.21
	9/10/87	.361644	887.6
	7/12/88	1.2	863.98
	10/08/88	1.4411	856.41
	6/26/89	2.15616	852.55
	9/13/89	2.3726	854.94
	2/8/90	2.77808	840.67
	4/24/90	2.98356	839.1
	2/23/91	3.81918	852.53
	5/23/91	4.06301	844.4
	11/2/91	4.50959	846.3

X0 = 6/10/94

YL90	Y0HAT	YU90	T95
*******	*******	*******	*******
783.755	803.851	823.948	1.81246

F-RATIO = 8.70624

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

April 15, 1992
10:00 AM

PROGRAM: LINPREDY
BAY NUMBER? 19c
ENTER NAME OF DATE LIST date19c
NAME OF MEAN THICKNESS DATASET? me19c

N	DATE19C	ME19C
**	********	******
1	12/2/86	866.02
2	5/1/87	900.51
3	8/1/87	888.16
4	9/10/87	888.31
5	7/12/88	873.46
6	10/08/88	856.27
7	6/26/89	845
8	9/13/89	844.7
9	2/8/90	830.51
10	4/24/90	822.52
11	2/23/91	842.8
12	5/23/91	823.22
13	11/2/91	822.3

ENTER NO. OF DESIRED DATA ints(2,13)
ENTER DATE OF MINIMUM THICKNESS (X0) 6/10/94

BAY	DATES	X	Y
***	********	********	******
19C	5/1/87	0	900.51
	8/1/87	.252055	888.16
	9/10/87	.361644	888.31
	7/12/88	1.2	873.46
	10/08/88	1.4411	856.27
	6/26/89	2.15616	845
	9/13/89	2.3726	844.7
	2/8/90	2.77808	830.51
	4/24/90	2.98356	822.52
	2/23/91	3.81918	842.8
	5/23/91	4.06301	823.22
	11/2/91	4.50959	822.3

X0 = 6/10/94

YL90	YOHAT	YU90	T95
*******	******	*******	*******
749.124	768.93	788.735	1.81246

F-RATIO = 19.677

WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO BE USED TO PREDICT FUTURE VALUES. TO HAVE A HIGH DEGREE OF CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT LEAST 8 OR 9.

December 19, 1991
4:35 PM

Appendix 6.3

LISTING OF PROGRAM LINPREDX

```
100.00 PROGRAM
200.02 $ PROGRAM: LINPREDX
300.00 $ PROGRAMMED BY J.P. MOORE    1/25/89
400.02 $     REVISED BY J.P. MOORE    2/27/91
500.02 $     REVISED BY J.P. MOORE    3/19/91
600.00 $ REFERENCE: "APPLIED REGRESSION ANALYSIS", 2ND EDITION
700.00 $            N.R. DRAPER & H. SMITH
800.00 $            JOHN WILEY & SONS, 1981, PP 47-51
900.00   JOURNAL ON
1000.00  NEWPAGE
1100.00  TYPE "PROGRAM: LINPREDX"
1200.00  ASKNAME("BAY NUMBER?","BAY= ")
1300.00  ASK("ENTER NAME OF DATE LIST","HENCEFORTH DATELIST IS ")
1400.02  ASK("NAME OF MEAN THICKNESS DATASET?","HENCEFORTH DATASET IS ")
1500.02 $ GET DATASET ON OCDAT
1600.02  N = INTS(1,NOELS(DATASET))
1700.02  TABULATE N,DATELIST,DATASET
1800.02  ASK ("ENTER NO. OF DESIRED DATA", "SELECT = ")
1900.02  DATES = DATELIST(SELECT)
2000.02  Y = DATASET(SELECT)
2100.00  ASK("ENTER VALUE OF MINIMUM THICKNESS (Y0)","Y0= ")
2200.00  DAYNO = DAYNUMBER(DATES)
2300.00  X = (DAYNO-DAYNO(1))/365
2400.00  NDF = NOELS(Y) - 2
2500.00  EXECUTE LINREGN1
2600.00 $  T95 = ONE-SIDED T TABLE VALUE AT .95 WITH NDF DEG OF FREEDOM
2700.00    T95 = ABS(TPROBINVERSE(.95,NDF))
2800.00 $  EQUATION 1.7.7, PAGE 49
2900.00    G = T95**2/(B1/SQRT(SSQ/SXX))**2
3000.00    X0HATYR = (Y0-B0)/B1
3100.00    X1 = (X0HATYR-XBAR)*G/(1-G)
3200.00    X2 = (T95*S/B1)*SQRT(((X0HATYR-XBAR)**2/SXX)+(1-G)/N)/(1-G)
3300.00 $  EQUATION 1.7.6, PAGE 49
3400.00    X90YR = X0HATYR+X1+X2, X0HATYR+X1-X2
3500.00 $  XU90YR = UPPER BOUND OF 90% CONFIDENCE INTERVAL ABOUT X0
3600.00    XU90YR = MAX(X90YR)
3700.00 $  XL90YR = LOWER BOUND OF 90% CONFIDENCE INTERVAL ABOUT X0
3800.00    XL90YR = MIN(X90YR)
3900.00    X0HATNO = DAYNO(1) + INTPART(X0HATYR*365)
4000.00    X0HAT = MAKEDATE(X0HATNO:DATEIN=DAYNUMBER,ABBRAMER)
4100.00    XU90NO = DAYNO(1) + INTPART(XU90YR*365)
4200.00    XU90 = MAKEDATE(XU90NO:DATEIN=DAYNUMBER,ABBRAMER)
4300.00    XL90NO = DAYNO(1) + INTPART(XL90YR*365)
4400.00    XL90 = MAKEDATE(XL90NO:DATEIN=DAYNUMBER,ABBRAMER)
4500.00 TABULATE BAY,DATES,X,Y
4600.00 TYPE "Y0    ="Y0
4700.00 TYPE "XU90  ="XU90
4800.00 TYPE "X0HAT ="X0HAT
4900.00 TYPE "XL90  ="XL90
5000.00 TYPE "T95   ="T95
5100.02 TYPE "G     ="G
```

```
5200.02 SPACE(2)
5300.02 TYPE "INVERSE ESTIMATION IS NOT OF MUCH PRACTIC
5400.02 TYPE "UNLESS THE REGRESSION IS WELL DETERMINED,
5500.02 TYPE "THE SLOPE (B1) IS SIGNIFICANT, WHICH IMPL
5600.03 TYPE "G SHOULD BE SMALLER THAN ABOUT 0.20.  WHE
5700.03 TYPE "LARGER THAN THIS, THE RESULTS ARE MEANING
5800.00 $TABULATE B0,B1,SSQ,SXX,S,XBAR
5900.00 $TABULATE G,X1,X2
6000.00 SPACE(2)
6100.00 DATE;TIME
6200.00 JOURNAL OFF
6201.00 END
```

LISTING OF PROGRAM LINPREDY


```
100 PROGRAM
200 $ PROGRAM: LINPREDY
300 $ PROGRAMMED BY J.P. MOORE    1/27/89
400 $    REVISED BY J.P. MOORE    4/09/91
500 $ REFERENCE: "APPLIED REGRESSION ANALYSIS", 2ND ED
600 $            N.R. DRAPER & H. SMITH
700 $            JOHN WILEY & SONS, 1981, PP 28-31, 129-133
800   JOURNAL ON
900   NEWPAGE
1000  TYPE "PROGRAM: LINPREDY"
1100  ASKNAME("BAY NUMBER?","BAY= ")
1200  ASK("ENTER NAME OF DATE LIST","HENCEFORTH DATELIST IS ")
1300  ASK("NAME OF MEAN THICKNESS DATASET?","HENCEFORTH DATASET IS ")
1400 $ GET DATASET ON OCDAT
1500  N = INTS(1,NOELS(DATASET))
1600  TABULATE N,DATELIST,DATASET
1700  ASK ("ENTER NO. OF DESIRED DATA", "SELECT = ")
1800  DATES = DATELIST(SELECT)
1900  Y = DATASET(SELECT)
2000  ASKNAME("ENTER DATE OF MINIMUM THICKNESS (X0)","X0= ")
2100  DAYNO = DAYNUMBER(DATES)
2200  X = (DAYNO-DAYNO(1))/365
2300  X0NO = DAYNUMBER(X0)
2400  X0YR = (X0NO - DAYNO(1))/365
2500  NDF = NOELS(Y) - 2
2600  EXECUTE LINREGN1
2700 $ T95 = ONE-SIDED T TABLE VALUE AT .95 WITH NDF DEG OF FREEDOM
2800  T95 = ABS(TPROBINVERSE(.95,NDF))
2900 $ EQUATION 1.7.7, PAGE 49
3000  G = T95**2/(B1/SQRT(SSQ/SXX))**2
3100  Y0HAT = B0 + B1*X0YR
3200  VARY0HAT = SSQ*((1/N) + (X0YR-XBAR)**2/SUM((X-XBAR)**2))
3300 $ SDY0HAT = STD ERROR OF ESTIMATE (SEE) OF MEAN THICKNESS
3400  SDY0HAT = ABS(SQRT(VARY0HAT))
3500 $ YU90 = UPPER BOUND OF 90% CONFIDENCE INTERVAL ABOUT Y0
3600  YU90 = Y0HAT + T95*SDY0HAT
3700 $ YL90 = LOWER BOUND OF 90% CONFIDENCE INTERVAL ABOUT Y0
3800  YL90 = Y0HAT - T95*SDY0HAT
3900  TABULATE BAY,DATES,X,Y
4000  TYPE "X0 ="X0
4100  TABULATE YL90,Y0HAT,YU90,T95
4200 $ TABULATE B0,B1,SSQ,S,XBAR
4300 $ TABULATE VARY0HAT,SDY0HAT
4400  TYPE "F-RATIO =" 1/G
4500  SPACE(2)
4600  TYPE "WHEREAS AN F-RATIO OF 1.0 OR GREATER PROVIDES CONFIDENCE"
4700  TYPE "IN THE SLOPE AND INTERCEPT OF THE HISTORICAL DATA, THE"
4800  TYPE "F-RATIO SHOULD BE 4 OR 5 IF THE REGRESSION EQUATION IS TO"
4900  TYPE "BE USED TO PREDICT FUTURE VALUES.  TO HAVE A HIGH DEGREE OF"
5000  TYPE "CONFIDENCE IN THE PREDICTED VALUE, THE RATIO SHOULD BE AT"
5100  TYPE "LEAST 8 OR 9."
5200  SPACE(2)
5300  DATE;TIME
5400  JOURNAL OFF
5401 END
```

LISTING OF PROGRAM LINPREDZ

```
 1.0 PROGRAM
 2.0 $ PROGRAMMED BY J.P. MOORE    1/27/89
 2.1 $ REFERENCE: "APPLIED REGRESSION ANALYSIS", 2ND ED
 2.2 $            N.R. DRAPER & H. SMITH
 2.3 $            JOHN WILEY & SONS, 1981, PP 28-31
 3.0 ASKNAME("BAY NUMBER?","BAY= ")
 4.0 ASK("ENTER NAME OF DATE LIST","DATES= ")
 5.0 ASK("ENTER VALUES OF Y","Y= ")
 6.0 ASK("ENTER X0 DATE","X0= ")
 7.0 DAYNO = DAYNUMBER(DATES)
 8.0 X = (DAYNO-DAYNO(1))/365
 8.2 XONO = DAYNUMBER(X0)
 8.4 XOYR = (XONO - DAYNO(1))/365
 9.0 NDF = NOELS(Y) - 2
10.0 EXECUTE LINREGN1
11.0    T99 = ABS(TPROBINVERSE(.99,NDF))
13.0    YOHAT = B0 + B1*XOYR
14.0    VARYOHAT = SSQ*((1/N) + (XOYR-XBAR)**2/SUM((X-XBAR)**2))
14.5 $  SDYOHAT = STD ERROR OF ESTIMATE (SEE) OF MEAN THICKNESS
15.0    SDYOHAT = ABS(SQRT(VARYOHAT))
15.5 $  YU98 = UPPER BOUND OF 98% CONFIDENCE INTERVAL ABOUT YO
16.0    YU98 = YOHAT + T99*SDYOHAT
16.5 $  YL98 = LOWER BOUND OF 98% CONFIDENCE INTERVAL ABOUT YO
17.0    YL98 = YOHAT - T99*SDYOHAT
20.0 JOURNAL ON
21.0 TYPE "PROGRAM: LINPREDY"
22.0 TABULATE BAY,DATES,X,Y
22.5 TYPE "X0 ="X0
23.0 TABULATE YL98,YOHAT,YU98,T99
24.0 $ TABULATE B0,B1,SSQ,S,XBAR
25.0 $ TABULATE VARYOHAT,SDYOHAT
26.0 DATE;TIME
27.0 JOURNAL OFF
28.0 END
```

LISTING OF PROGRAM LINPROJ

```
1.0 PROGRAM
2.0 $ PROGRAMMED BY J.P. MOORE    1/25/89
3.0 ASKNAME("BAY NUMBER?","BAY= ")
4.0 ASK("ENTER NAME OF DATE LIST","DATES= ")
5.0 ASK("ENTER VALUES OF Y","Y= ")
5.5 ASK("ENTER VALUE OF Y0","Y0= ")
6.0 DAYNO = DAYNUMBER(DATES)
7.0 X = (DAYNO-DAYNO(1))/365
8.0 NDF = NOELS(Y) - 2
9.0 EXECUTE LINREGN1
10.0 T95 = ABS(TPROBINVERSE(.95,NDF))
11.0 S = SQRT(SSQ)
12.0 G = T95**2/(B1/SQRT(SSQ/SXX))**2
13.0 X0HAT = (Y0-B0)/B1
14.0 X1 = (X0HAT-XBAR)*G/(1-G)
15.0 X2 = (T95*S/B1)*SQRT(((X0HAT-XBAR)**2/SXX)+(1-G)/N)/(1-G)
16.0 X90 = X0HAT+X1+X2, X0HAT+X1-X2
16.5 XU90 = MAX(X90)
17.0 XL90 = MIN(X90)
18.0 JOURNAL ON
19.0 TYPE "PROGRAM: LINPROJ"
20.0 TABULATE BAY,DATES,X,Y
21.0 TABULATE Y0,XU90,X0HAT,XL90
22.0 TABULATE B0,B1,SSQ,SXX,S,XBAR
23.0 TABULATE T95,G,X1,X2
24.0 DATE;TIME
25.0 JOURNAL OFF
26.0 END
```

LISTING OF PROGRAM LINREGN1

```
 1.0 PROGRAM
 1.1 $ PROGRAM: LINREGN1
 2.0 $ THIS PROGRAM PERFORMS LINEAR REGRESSION
 3.0 $ REFERENCE: "APPLIED LINEAR REGRESSION", 2ND EDIT
 4.0 $            BY N.R. DRAPER & H. SMITH
 5.0 $            JOHN WILEY & SONS, 1981
 6.0 $ PROGRAMMED BY J.P.MOORE  1/26/89
 7.0 $ INPUTS:
 8.0 $     X = INDEPENDENT VARIABLE ARRAY
 9.0 $     Y = DEPENDENT VARIABLE ARRAY
10.0 $     NDF = NUMBER OF DEGREES OF FREEDOM
11.0 $
12.0 $ OUTPUTS:
13.0 $     B0 = Y INTERCEPT OF FITTED STRAIGHT LINE
14.0 $     B1 = SLOPE OF FITTED LINE
15.0 $     YHAT = PREDICTED VALUES OF Y
16.0 $     SDB0 = STD ERROR OF ESTIMATE OF THE INTERCEPT B0
17.0 $     SDB1 = STD ERROR OF ESTIMATE OF THE SLOPE B1
18.0
19.0 $ CALCULATIONS
20.0    N = NOELS(X)
21.0    SUMY = SUM(Y)
22.0    YBAR = SUMY/N
23.0    SUMX = SUM(X)
24.0    XBAR = SUMX/(N)
25.0    SUMXY = SUM(X*Y)
26.0    SUMXSQ = SUM(X**2)
27.0    SXY = SUMXY - SUMX*SUMY/N
28.0    SXX = SUM(X**2) - (SUM(X))**2/N
29.0    SYY = SUM(Y**2) - (SUM(Y))**2/N
30.0    B1 = SXY/SXX
31.0    B0 = YBAR-B1*XBAR
32.0    SSB1B0 = (SXY**2)/SXX
32.5 $  SSQ = MEAN SQUARED ERROR (MSE)
33.0    SSQ = ABS(SYY - SSB1B0)/(N-2)
33.2 $  S = ROOT MEAN SQUARE ERROR (RMSE)
33.5    S = SQRT(SSQ)
33.7 $  SDB1 = STD ERROR OF ESTIMATE (SEE) OF SLOPE B1
34.0    SDB1 = SQRT(SSQ/SXX)
34.5 $  SDB0 = STD ERROR OF ESTIMATE (SEE) OF INTERCEPT B0
35.0    SDB0 = SQRT((SSQ*SUMXSQ)/(N*SXX))
36.0    YHAT = B0 + B1*X
37.0    RES = YHAT-Y
38.0    RSQ = SUM((YHAT - YBAR)**2)/SUM((Y - YBAR)**2)
39.0 END
```

Citizen's Exhibit NC8

GPU Nuclear

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

Citizen's Exhibit NC

Unit OCNGS	Page 1 of 69
Document/ActivityTitle Drywell Steel Shell Plate Thickness Reduction	SE Rev. No. 11
Document No. *(if applicable)* Doc. Rev. No.	SE No. 000243-002

Type of Activity *(modification, procedure, test, experiment, or document)*: Document

1. Does this document involve any potential non-nuclear environmental concern? ☐ Yes ☒ No

To answer this question, review the Environmental Determination (ED) form. Any YES answer on the ED form requires an Environmental Impact Assessment by Environmental Controls, per 1000-ADM-4500.03. If in doubt, consult Environmental Controls or Environmental Licensing for assistance. If all answers are NO, further environmental review is not required. In any event, continue with Question 2, below.

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

If the answer to question 1 is NO, stop here. This procedure is not applicable and no documentation is required. (If this activity/document is listed in Section IV of 1000-ADM-1291 review on a case-by-case basis to determine applicability.) If the answer is YES, proceed to question 3.

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

If the answer to question 3 is NO, stop here and complete the approval section below. This procedure is not applicable and no documentation is required. If the answer is YES, proceed to answer all remaining questions. These answers become the Safety/Environmental Determination and 50.59 Review.

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

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

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

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

IF ANY OF THE ANSWERS TO QUESTIONS 4, 5, 6, OR 7 ARE YES, PREPARE A WRITTEN SAFETY EVALUATION FORM.

If the answers to 4, 5, 6, and 7 are NO, this precludes the occurrence of an Unreviewed Safety Question or Technical Specifications change. Provide a written statement in the space provided below (use back of sheet if necessary) to support the determination, and list the documents you checked.

NO, because: ____________________

Documents checked: ____________________

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

If YES, indicate how resolved: ____________________

APPROVALS *(print name and sign)*

Engineer/Originator	A. Collado [signature]	Date 4-18-95
Section Manager	J. D. Abramovici [signature]	Date 6-26-?
Responsible Technical Reviewer	S. D. Leshnoff [signature]	Date 8/2/95
Other Reviewer(s)		Date

N5047 (05-93)

OCLR00001306

1.0 PURPOSE

The purpose of this safety evaluation is to assess the structural integrity of the Oyster Creek drywell pressure vessel. This revision incorporates data on vessel thickness, sandbed coating inspections and resulting corrosion rates based on data obtained through September 1994 and assesses the period of time for which vessel structural integrity can be assured.

1.1 Introduction

The Oyster Creek drywell pressure vessel is of steel construction. Its original design incorporates a sandbed which is located around the outside circumference between elevations 8'11¼" and 12'3". The sand was removed during the 14R outage (December 1992) and the steel surfaces coated. Leakage was observed from the sandbed drains during the early to mid 1980's, indicating that water had intruded into the annular region between the drywell pressure vessel and the concrete shield wall. The presence of water in the sand was confirmed later when a water level (i.e., free water) was discovered during core boring operations to install anodes for cathodic protection (CP). Concerns about the potential for corrosion of the vessel resulted in thickness measurements being taken in the sandbed region in 1986. These measurements indicated that the vessel in the sandbed region was thinner than the 1.154 inch nominal thickness originally specified by Chicago Bridge & Iron Company (CBI) (Reference 2.3.1). Additional thickness measurements at elevations 50'2" and 87'5" were taken in 1987. These measurements also indicated areas where the pressure vessel was thinner than the originally specified. The specified nominal thickness at these elevations is 0.770 inches and 0.640 inches respectively.

Since 1987 GPUN has developed and implemented a drywell vessel corrosion monitoring program (Reference 3.1.4.21) in which inspections are conducted at identified corroded locations. Inspections have been periodically performed during refueling outages and outages of opportunity in the former sandbed region, in the spherical region (elevation 50'2" and 51'10"), and in the cylindrical region (elevation 87'5").

1.2 Background Discussion

Discovering that the drywell pressure vessel thickness was less than originally specified necessitated a number of activities. The purpose of these activities was to establish that the vessel was structurally acceptable to support continued safe operation of Oyster Creek. A summary of the activities undertaken and the resulting conclusions are provided herein.

1.2.1 Vessel Thickness Measurements

References 3.1.4.1, 3.1.4.5, 3.1.4.6, 3.1.4.22 and 3.1.4.23 document the non destructive ultrasonic testing examination methods utilized to measure vessel thickness, the locations chosen for thickness measurements, the locations for metallurgical plug samples taken from the drywell vessel and the extensive amount of data taken (in excess of 1,000 individual UT

readings). Obtaining the thickness measurements over a large portion of the vessel's circumference at four elevations enabled GPUN to establish an ongoing corrosion rate monitoring program and assess the structural integrity of the vessel.

As documented in Reference 3.1.4.29 in April of 1991 a supplemental augmented series of inspections were performed on the drywell vessel. Results were that all inspected locations meet code requirements.

1.2.2 Corrosion Assessment

References 3.1.4.2 and 3.1.4.3 document the metallurgical evaluations of the two inch plug samples which were removed from the vessel in the sandbed region in December, 1986 and the upper elevation (EL. 50'2") in November, 1987. Reference 3.1.4.24 documents metallurgical evaluation of an additional two inch plug removed in April, 1990. The type of corrosion noted, coupled with an assessment of the vessel construction and operating history, allowed GPUN to establish the probable cause of the corrosion and to conservatively project corrosion rates. GPUN conducts ongoing periodic vessel thickness measurements which statistically monitor and establish corrosion rates.

The ongoing measurements are not taken in all the locations where measurements were taken initially in 1986, 1987 and 1990. The initial locations where corrosion/material loss was most severe were selected for the ongoing program. This reduction of inspection scope was done primarily to reduce the man-rem exposure received when taking drywell measurements. Note that a spot check of locations measured initially was performed during the 12R (October, 1988) outage which confirmed proper selection for ongoing measurements.

In March, 1990 an additional check was performed at elevation 50'2". This check consisted of a continuous UT "A" scan in all accessible areas in a one inch band at elevation 50'2". Results confirmed that the existing grid in Bay 5 was among the thinnest at this elevation. As a result of this check, three additional grids at elevation 50'2" were added to the program.

Elevation 50'2" is representative of vessel plates originally delivered with a mean nominal thickness of .770 inch and installed between elevation 23'6" to 51'.

In April, 1990 an additional elevation was investigated for corrosion. This elevation at 51'10" is representative of drywell vessel plate originally delivered with mean nominal thicknesses of .722 inch and installed between elevation 51' to 65'. This investigation was performed by continuous UT "A" scan in a one inch band, at elevation 51'10". Results showed only one area which was less than nominal. An inspection grid of this area (Bay 13) was added to the inspection program.

Corrosion assessments have been periodically accomplished as summarized herein. The previous bounding corrosion rate projections (discussed in previous versions of this Safety Evaluation and in Ref. 3.1.4.2 and 3.1.4.3) are no longer accurate and are not discussed in this revision of this safety evaluation.

1.2.3 Corrosion Rate Assessment

Reference 3.1.4.7, 3.1.4.10, 3.1.4.11 through 3.1.4.14, 3.1.4.25 through 3.1.4.28, 3.1.4.31 through 3.1.4.34, 3.1.4.36, 3.1.4.37, and 3.1.4.40 document the ongoing statistical analysis of vessel ultrasonic thickness (UT) measurements as they are taken at specific locations over time. The corrosion rate monitoring program involves the establishment of six inch by six inch grid locations on the vessel interior, the use of a template with 49 holes on one inch centers for locating the UT probe, a specified ± 1/8 inch tolerance on the location of subsequent measurements and taking thickness measurements periodically. This program has enabled GPUN to statistically determine corrosion rates at these grid locations.

Since the grid locations are in the known areas where corrosion/material loss is most severe, the corrosion rates and projected wall thicknesses are determined over a small fraction of the drywell but conservatively applied uniformly.

1.2.4 Structural Assessment

References 3.1.4.17 through 3.1.4.19 provide an overall analysis of the Oyster Creek drywell pressure vessel structural requirements. The UT readings obtained through September, 1994 and resulting statistical analysis coupled with the GE Nuclear structural analyses and a recently NRC approved license amendment establishing a 44 psig design pressure in place of 62 psig (Reference 3.1.2) provide the structural basis for assuring safe operation of Oyster Creek until end of plant license (April 9, 2009).

The corrosion rates, where available, have been used to project material loss. The structural evaluations have been performed assuming minimum uniform thicknesses in the areas of concern. Since corrosion is confined to specific areas, the existing evaluations and resulting vessel thickness requirements are very conservative in that they do not take credit for actual wall thicknesses in excess of the minimum used in the evaluations. In addition, the coating inspection of the former sandbed region insures the corrosion rate at this area remains at zero.

1.3 Purpose Summary

This safety evaluation will demonstrate that (based on data collected through September, 1994) plant operations can continue until end of license life based on the structural evaluation of the drywell. Action has been taken to eliminate leakage from the reactor cavity region, and for periodic surveillance (Ref. 3.1.4.21) of vessel thickness at intervals that ensure that the wall thickness will not decrease below acceptable levels between inspections.

The former sandbed area of the drywell has been cleaned and coated (during 14R Outage) to stop corrosion. The coating is visually inspected to ensure it remains effective. Additionally, the analysis of the UT data collected during the most recent inspection (September 1994) indicates that for the upper elevations of the drywell, there is no evidence of ongoing corrosion.

2.0 SYSTEMS AFFECTED

2.1 System No. 243, Drywell and Suppression System, particularly the drywell vessel structure.

2.2 Drawing showing original thickness - Chicago Bridge and Iron Co., Contract Drawings 9-0971, Drawing Nos. 1 through 11.

2.3 Documents which describe the Oyster Creek drywell pressure vessel design.

2.3.1 "Structural Design of the Pressure Suppression Containment Vessel" for JCP&L/Burns and Roe, Inc., Contract No. 9-0971, by CB&I Co., 1965.

3.0 EFFECTS ON SAFETY

3.1 Documents that Describe Safety Function & Evaluations

3.1.1 OCNGS Unit 1 Facility Description and Safety Analysis Report

3.1.1.1 Licensing Application, Amendment 3, Section V

3.1.1.2 Licensing Application, Amendment 11, Question III-18

3.1.1.3 Licensing Application, Amendment 15

3.1.1.4 Licensing Application, Amendment 68

3.1.2 Technical Specification Documents

3.1.2.1 Technical Specification and Bases - OCNGS Unit, Appendix A to Facility License DRP-16, JCP&L Docket No. 50-219, Sections 3.5, 4.5, 5.2.

3.1.2.2 Technical Specification Amendment 165.

3.1.3 Regulatory Documents

3.1.3.1 10CRF50, Appendix A. General Design Criteria for Nuclear Power plants

- Criterion 2 - Design basis for Protection against natural phenomena
- Criterion 4 - Environmental and Missile Design Bases
- Criterion 16 - Containment Design
- Criterion 50 - Containment Design Basis

3.1.4 GPUN Technical Data Reports (TDR), Calculations and Drawings

3.1.4.1 TDR 851 Assessment of Oyster Creek Drywell Shell.

3.1.4.2 TDR 854 Drywell Sandbed Region Corrosion Assessment.

3.1.4.3 TDR 922 Drywell Upper Elevation, Wall Thinning Evaluation.

3.1.4.4 (This reference has been superseded by References 3.1.4.17 through 3.1.4.19).

3.1.4.5 Sketch 3E-SK-S-89, Ultrasonic Testing - Drywell Level 50'2" - 87'5" Plan.

3.1.4.6 Sketch 3E-SK-S85, Drywell Data UT Location Plan.

3.1.4.7 TDR 948, Statistical Analysis of Drywell Thickness Data.

3.1.4.8 NRC Letter Docket 50-219, dated October 26, 1988, subject "Oyster Creek Drywell Containment".

3.1.4.9 Primary Containment Design Report, dated 9/11/67, Ralph M. Parson Company.

3.1.4.10 Calc. C-1302-187-5360-006 "Projection of Drywell Mean Thickness thru October, 1992".

3.1.4.11 Calc. C-1302-187-5300-008 "Statistical Analysis of Drywell Thickness Data thru 2/8/90".

3.1.4.12 Calc. C-1302-187-5300-009 Rev. 0 "OC Drywell Projected Thickness".

3.1.4.13 Calc C-1302-187-5300-001 Rev. 0, "Statistical Analysis of Drywell Thickness Data thru 4/14/90".

3.1.4.14 Calc C-1302-187-5300-012 Rev. 0, "OCDW Projected Thickness Using Data thru 4/24/90".

3.1.4.15 This reference no longer applicable, therefore, is deleted.

3.1.4.16 This reference no longer applicable, therefore, is deleted.

3.1.4.17 "Justification For Use of Section III, Subsection NE, Guidance in Evaluating The Oyster Creek Drywell", Technical Report TR-7377-1, dated November 1990, Teledyne Engineering Services.

3.1.4.18 "An ASME Section VIII Evaluation of Oyster Creek Drywell for without Sand Case, Part I, Stress Analysis", dated February 1991, GE Nuclear Energy, San Jose, CA.

3.1.4.19 "An ASME Section VIII Evaluation of the Oyster Creek Drywell for without Sand Case, Part 2, Stability Analysis", Rev. 2, dated November 1992, GE Nuclear Energy, San Jose, CA.

3.1.4.20 This reference no longer applicable, therefore is deleted.

3.1.4.21 GPUN Specification IS-328227-004, Revision 10, "Functional Requirements For Drywell Containment Vessel Thickness Examination".

3.1.4.22 Sketch 3E-Sk-M-275, Rev. 0, "UT Drywell Level 50'2", March 1990 Readings".

3.1.4.23 Sketch 3E-Sk-M-358, Rev. 0, "UT Drywell Level 51'-10", April 1990 Readings".

3.1.4.24 "Oyster Creek Drywell Corrosion Evaluation", dated June 1990, GE Nuclear Energy, San Jose, CA.

3.1.4.25 Calc C-1302-187-5300-015, "Statistical Analysis of Drywell Thickness Data Thru 3/3/91".

3.1.4.26 Calc C-1302-187-5300-016, "OCDW Projected Thickness Using Data Thru 3/3/91".

3.1.4.27 Calc C-1302-187-5300-017 "Statistical Analysis of Drywell Thickness Data thru May, 1991".

3.1.4.28 Calc C-1302-187-5300-018, "OCDW Projected Thickness using Data thru May, 1991".

3.1.4.29 GE Report "Final Report - Oyster Creek Drywell Containment Vessel Random UT Project" dated May 8, 1991.

3.1.4.30 IS-402950-001, Rev. 0 Functional Requirements for Augmented Drywell Inspections.

3.1.4.31 Calc C-1302-187-5300-19 "Statistical Analysis of Drywell Thickness Data thru November, 1991".

3.1.4.32 Calc C-1302-187-5300-20 "OCDW Projected Thickness Using Data thru November 1991".

3.1.4.33 Calc C-1302-187-5300-021 "Statistical Analysis of Drywell Thickness Data thru May, 1992".

3.1.4.34 Calc C-1302-187-5300-022 "OCDW Projected Thickness Using Data thru May, 1992".

3.1.4.35 Safety Evaluation SE-402950-005 "Removal of Sand from Drywell Sandbed".

3.1.4.36 Calc C-1302-187-5300-025 "Statistical Analysis of Drywell Thickness Data thru December 1992".

3.1.4.37 Calc C-1302-187-5300-024 "OC DW Projected Thickness Using Data thru December, 1992".

3.1.4.38 TDR 1108 Summary Report of Corrective Action Taken form Operating Cycle 12 through 14R Outage.

3.1.4.39 Calc C-1302-187-5300-024 "O.C. Drywell External UT Evaluations" in the Sandbed.

3.1.4.40 Calc C-1302-187-5300-028 - Statistical Analysis of Drywell Thickness Data thru September, 1994.

3.1.4.41 Memo #5514-94-319 - Dated September 30, 1994 - Subject: Inspection D.W. Sandbed Coating in Bay 11 - O.C.

3.1.4.42 Calc C-1302-243-5320-071 - Rev. 1, "Drywell Thickness Margins."

3.1.4.43 Memo #5340-94-120 - Dated November 9, 1994 - Subject: Video Inspection of DW Sandbed Bay #3.

3.1.4.44 Memo #5340-95-062 - Dated July 12, 1995 - Subject: Life Expectancy of Drywell Shell Coating in Former Sandbed O.C.

3.1.5 <u>Industry Codes and Standards Applicable Codes</u>

3.1.5.1 The ASME Boiler and Pressure Vessel Code and applicable nuclear code cases utilized for the design of the drywell pressure vessel are as listed in References 3.1.4.17 through 3.1.4.19.

3.1.5.2 Applicable Drywell Shell Plate Material Standards/Specification

SA-212 High Tensile Strength Carbon - Silicon Steel Plates for Boilers and other Pressure Vessels.

3.2 Drywell Pressure Vessel Safety Function Drywell Geometry Description

3.2.1 The drywell, sometimes referred to as the containment vessel or containment structure, houses the reactor vessel, reactor coolant recirculating loops, and other components associated with the reactor system. The structure is a combination of a sphere, cylinder, and 2:1 ellipsoidal dome that resembles an inverted light bulb. The spherical section has an inside diameter of 70'.

The cylindrical portion connecting the sphere to the dome has a diameter of 33'. The structure is approximately 99' high. The plate thicknesses vary from a maximum of 2.56" at the transition between the sphere and the cylinder down to a minimum of 0.640" in the cylinder. The dome wall thickness is 1.18".

Figure 1 illustrates the drywell structure along with the pertinent dimensions. The top closure, which is 33' in diameter, is made with a double tongue and groove seal which permits periodic checks for leak tightness. Ten vent pipes, six feet six inches in diameter, are equally spaced around the circumference to connect the drywell and vent header to the pressure suppression chamber.

The drywell interior is filled with concrete to elevation 10'3" to provide a level floor. Concrete curbs follow the contour of the vessel up to elevation 12'3" with cutouts around the vent lines.

On the exterior, the drywell is encapsulated in concrete of varying thickness from the base elevation up to the elevation of the top head. From there, the concrete continues vertically to the level of the top of the spent fuel pool.

The base of the drywell is supported on a concrete pedestal conforming to the curvature of the vessel. For erection purposes a structural steel skirt was first provided supporting the vessel. A portion of the steel skirt was left in place which serves as one of the shear rings that prevent rotation of the drywell during an earthquake.

The proximity of the biological shield concrete surface to the steel shell varies with elevation. The concrete is in full contact with the shell over the bottom of the sphere at its invert elevation 2'3" up to elevation 8'11¼". At that point, the concrete is stepped back 15 inches radially to form a pocket which continues up to elevation 12'3". The pocket was originally filled with sand which formed a cushion to smooth the transition of the shell plate from a condition of fully clamped

between two concrete masses to a free standing condition. The sand pocket was connected to drains which allowed drainage of any water which might enter the sand. The sand was removed during the 14R outage (December 1992).

The sand "springs" helped to ease this transition. GE analysis (Ref. 3.1.4.18 and 3.1.4.19) has shown that the sand is not required so long as vessel thickness in that region is greater than or equal to .736 inches (with margin as stated in 3.3.2.1). Justification for removing sand from the sandbed is covered under a separate Safety Evaluation (Ref. 3.1.4.35). As stated above, the sand was completely removed and the drywell vessel was coated in the sandbed region during the 14R refueling outage (Figure 2). The sand was removed via ten (10) 20" diameter access holes drilled equally spaced through the containment concrete shield wall.

Up from elevation 12'3" there is a 3" gap between the drywell and the concrete biological shield wall which is filled with foam material that provides no structural support. An upper lateral seismic restraint, attached to the cylindrical portion of the drywell at elevation 82.17 ft., allows for thermal, deadweight, and pressure deflection, but not for lateral movement due to seismic excitation. All penetrations for piping, instrumentation lines, vent ducts, electrical lines, equipment accesses, and personnel entrance have expansion joints and double seals where applicable.

The spherical area is described by 10 segments, one at each downcomer, referred to as bays. The bays are odd numbered 1 thru 19 (Figure 3).

3.2.2 Drywell Pressure Vessel Safety Function

3.2.2.1 Functional Design

The drywell pressure vessel is one of the major structural components of the Primary Containment System (PCS) discussed in Section 6.2 of the Oyster Creek Nuclear Generating System Update FSAR. The safety function of the Primary Containment System is to accommodate, with a minimum of leakage, the pressures and temperatures resulting from the break of any enclosed process pipe; and, thereby, to limit the release of radioactive fission products to values which will insure offsite does rates well below 10CFR100 guideline limits.

3.2.2.2 Design Criteria

The design criteria for the Containment are as follows:

a. To withstand the peak transient pressures (coincident with an earthquake) which could occur due to the postulated break of any pipe inside the drywell.

b. To channel the flows from postulated pipe breaks to the torus.

c. To withstand the force caused by the impingement of the fluid from a break in the largest local pipe or connection, without containment failure.

d. To limit primary containment leakage rate during and following a postulated break in the primary system to substantially less than that which would result in offsite doses approaching the limiting values in 10CFR100.

e. To include provisions for leak rate tests.

f. To be capable of being flooded following a Design Basis Accident to a height which permits unloading of the core.

3.2.2.3 Drywell Vessel Design Pressure and Temperature Parameters

- The drywell and connecting vent system tubes are designed for 44 psig, internal pressure at 292°F, and an external pressure of 2 psig at 205°F.

- The design lowest temperature to which the primary containment vessel is subjected is 30°F.

3.3 Effects of Drywell Pressure Vessel Thickness Reduction

In order to demonstrate that the vessel thickness reduction will not adversely affect the ability of the drywell to perform its safety function, GPUN establishes a conservative corrosion rate, projects vessel thickness, and shows by analysis that allowable stresses are not exceeded for the design basis load conditions.

3.3.1 Results of Corrosion Monitoring Program

3.3.1.1 Monitoring Program Summary

Reference 3.1.4.21 defines the drywell corrosion inspection program. This program identifies nine (9) locations for UT inspection. These nine locations were selected for inspection based on extensive drywell thickness investigation performed during the initial corrosion investigation phase (1986 through 1991). These nine (9) locations (exclusive of the former sandbed region) exhibited that worst metal loss and therefore were selected for monitoring wall thickness.

Originally, the knowledge of the extent of corrosion was based on a UT inspection plan involving going completely around the inside of the drywell at several locations. Nine six-by-six grids on either side of each vent penetration were used to characterize the situation at the elevation of the sandbed. At each of the upper elevations a belt-line sweep was used with readings taken on as little as one inch centers wherever thickness changed between successive nominal 6" centers. Grids were established in the upper elevations in this way.

As experience increased with each data collection campaign, only grids showing evidence of change were retained in the inspection program. Additional assurance regarding the adequacy of this inspection plan was obtained by a completely randomized inspection, involving 59 grids,that showed that all inspection locations satisfied code requirements.

As a minimum, the nine locations above the former sandbed region specified in the program, will be inspected during the 16R refueling outage and every third refueling outage thereafter. This frequency of

inspection is considered adequate because most recent data obtained indicates that there is no evident of ongoing corrosion at the upper elevations of the drywell vessel.

Reference 3.1.4.21 also covers coating inspection of the drywell shell exterior at the former sandbed region. The corrosion in this area of the drywell vessel was arrested during the 14R refueling outage (December 1992), as the steel surface was coated for corrosion protection.

As stated in 3.3.1.7 of this safety evaluation, the coating was inspected during the 15R refueling outage on a sample basis. Results of the inspection were satisfactory with no indications of coating failures.

As a minimum, additional inspections of the coating will be conducted during the 16R refueling outage and again during refueling outage 18R. This frequency of inspections is adequate based on results of prior coating inspection and estimated coating life (8-10 years) per reference 3.1.4.44. After the inspection in refueling outage 18R, an assessment will be made, appropriate actions will be taken, and the need for future inspections will be determined to ensure that the drywell integrity is maintained until at least April 2009. The scope of the inspection as set forth in reference 3.1.4.21 of inspecting two bays, is adequate because the environmental conditions and coating application methods were similar for all ten bays when the coating was applied. Also, the two bays selected for inspection are known to be worst leakage areas with most corrosion attack prior to the coating application.

In summary, the inspection program (Reference 3.1.4.21) is adequate to assure drywell vessel integrity until at least April 9, 2009 (end of plant license).

3.3.1.2 Corrosion Rates

Reference 3.1.4.40 discusses the statistical analysis of the UT data taken over the time period February, 1987 through September, 1994 for the sandbed region grids and November, 1987 through September, 1994 for the upper elevation grids. A new monitored location (#50-22) above the sandbed was added to the program in December of 1992. The corrosion rate was determined by calculating the rate of change of the mean thickness at each measured grid using linear regression

analysis. The corrosion rate has previously been expressed as the slope of the regression line ± the standard error of the slope. Below are the current corrosion status assessments in the most limiting areas for each of the major elevations. The corrosion at the sandbed region was arrested in December, 1992 when the subject surfaces were cleaned and coated. Inspection of the coated surfaces performed in September of 1994 revealed that the coating is performing satisfactory as documented in reference 3.1.4.41.

Sandbed Region - Corrosion arrested.
Elevation 50'2" - F-Ratio <1.0
Elevation 51'10" - F-Ratio <1.0
Elevation 87'5" - F-Ratio <1.0
Elevation 60'-11" - Insufficient Data

Evaluation of the September, 1994 inspection data indicates that for Elevations 50'-2", 51'-10", 60'11", and 87'5", there is no evidence of ongoing corrosion. This assessment (Ref. 3.1.4.40) is based on the fact that the statistical regression estimate can not be used to define a corrosion rate because the F-ratio is far too low for reliable use, or that there are fewer than four measurements. (See paragraph 3.3.1.3--Sphere elevation 60'-11")

Because the statistical F-test for significance of the regression rate estimate is very low, there is no evidence of ongoing corrosion, only random variation associated with measuring techniques.

3.3.1.3 Projections

Projections are determined by performing regression analysis, when appropriate.

Sandbed

The entire sandbed region of the drywell shell O.D. was coated during the 14R refueling outage (December 1992). This coating was inspected in September 1994. This inspection showed no coating failure or signs of deterioration. Therefore, the corrosion in this region has been arrested and no further corrosion is expected to occur. To ensure that the coating applied will remain effective, visual inspections by direct and/or remote methods will be conducted per reference 3.1.4.21. The coating will again be inspected during refueling outage 16R and again during refueling outage 18R. Should an inspection reveal coating failure, an assessment will

be made, appropriate actions will be taken, and the need for additional inspections will be determined to ensure that the drywell integrity is maintained until at least April 2009 (end of License). The coating has an estimated life prediction of 8-10 years, before signs of local deterioration are expected (Reference 3.1.4.44). Currently, a margin of 70 mils exists between the required metal thickness and the actual mean metal thickness at the thinnest location as measured during the 15R outage in September 1994. This margin provides additional assurance for drywell integrity in the unlikely case of coating failure between inspection intervals.

Based upon the arrested corrosion, and future monitoring of the coating, it is reasonable to conclude that this region will not become limiting prior to April 2009.

Cylinder, Elevation 87'-5"

As a result of low F-ratio at this elevation, it can be concluded that there is no evidence of ongoing corrosion at this location. The September, 1994 data indicates that the thinnest location at this elevation has a mean thickness of 613 mils. Therefore, a margin of 161 mils exists between actual and minimum mean acceptable thickness. With the 161 mils margin which currently exists, minimum mean acceptable thickness could not be reached by April 2009, unless there was an ongoing corrosion rate of approximately 11 MYP. A corrosion rate of this magnitude would be observable. A corrosion rate of 11 MPY has not been observed in any location above the sandbed.

Additional assurance will be provided by volumetric inspection during the next refueling outage (16R) and at least every third refueling outage thereafter.

Sphere, Elevation 50'-2"

As a result of low F-ratio at this elevation, it can be concluded that there is no evidence of ongoing corrosion at this location.

The September, 1994 data indicates that the thinnest location at this elevation has a mean thickness of 733 mils. Therefore a margin of 192 mils exists between actual and minimum mean acceptable thickness.

Although the data on hand does not permit a statistically rigorous calculation of corrosion rate, it is adequate to support a conclusion that this region will not become limiting prior to April 2009, unless there was an ongoing corrosion rate of approximately 13 MPY. A corrosion rate of this magnitude would be observable. A corrosion rate of 13 MPY has not been observed in any location above the sandbed.

Additional assurance will be provided by volumetric inspection during the next refueling outage (16R) and at least every third refueling outage thereafter.

Sphere, Elevation 51'-10"

As a result of low F-ratio at this elevation, it can be concluded that there is no evidence of ongoing corrosion at this location.

The September, 1994 data indicates that the thinnest location at this elevation has a mean thickness of 695 mils. Therefore a margin of 177 mils exists between actual and minimum mean acceptable thickness.

Although the data on hand does not permit a statistically rigorous calculation of corrosion rate, it is adequate to support a conclusion that this region will not become limiting prior to April 2009. With the 177 mils margin which currently exists, minimum mean acceptable thickness could not be reached by April 2009, unless there was an ongoing corrosion rate approximately 12 MPY. A corrosion rate of this magnitude would be observable. A corrosion rate of 12 MPY has not been observed in any locations above the sandbed.

Additional assurance will be provided by volumetric inspection during the next refueling outage (16R) and at least every third refueling outage thereafter.

Sphere, Elevation 60'-11"

This location was added to the Drywell Corrosion monitoring program with the first UT data set taken in December 10 1992 and a second UT data set taken in September 1994. As a result of the limited data at this elevation, a statistical analysis of the corrosion rate, could not be performed. Therefore, a projection based on regression analysis will not be meaningful. The

September, 1994 data indicates that the thinnest location at this elevation has a mean thickness of 709 mils. Therefore, a margin of 191 mils exists between actual and minimum mean accepted thickness.

Although the data on hand does not permit a statistically rigorous calculation of corrosion rate, it is adequate to support a conclusion that this region will not become limiting prior to April 2009. With the 191 mils margin which currently exists, minimum mean acceptable thickness could not be reached by April 2009, unless there was an ongoing rate of approximately 13 MPY. A corrosion rate of this magnitude would be observable. A corrosion rate of this magnitude has not been observed in any locations above the sandbed.

Additional assurance will be provided by volumetric inspection during the next refueling outage (16R) and at least every third refueling outage thereafter.

3.3.1.4 Projected Local Vessel Thicknesses

Because mean uniform thickness can consist of local values less than the mean, consideration has been given to the significance of such readings. The number of such readings is extremely limited and have been evaluated as not structurally significant as follows (Ref. 4.1.4.40)

Sandbed

The lowest local reading is .770 inches (Ref. 3.1.4.40). The local acceptable thickness for the sandbed region is .49 inches (Section 3.3.2). As mentioned in 3.3.1.3, the sandbed region was coated and no further corrosion is expected in this area, and the .280" margin is more than adequate for the balance of plant life (April 2009).

Cylinder, Elevation 87'5"

The lowest local reading is .551 inches (Ref. 3.1.4.40). The local acceptable thickness for this elevation is .300 inches (Section 3.3.2). Therefore, a margin of approximately 251 mils exists between actual and local acceptable thickness. If this local area is actually corroding, it would have to corrode at a rate of approximately 17 mils/year to reach the minimum local acceptable thickness by April 2009. A corrosion rate of approximately 17 mils/year has not been observed to date (above the sandbed) and is not considered credible.

Citizen’s Exhibit NC9

GPU Nuclear

Technical Data Report

TDR No. 1011 Revision No. 0

Budget Activity No. ______	Page 1 of 18
Project: OYSTER CREEK	Department/Section E&D/Mechanical Systems
	Revision Date ______

Document Title: EVALUATION OF FEBRUARY 1990 DRYWELL UT EXAMINATION DATA

Originator Signature	Date	Approval(s) Signature	Date
Peter Tamburro	3/8/90	Fred P. Barbieri	4-18-90
		Approval for External Distribution	Date

Does this TDR include recommendation(s)? X Yes ___ No If yes, TFWR/TR# ____ see next page

*	Distribution
	A. Baig
*	F. P. Barbieri
	D. Bowman
*	G. R. Capodanno
	B. D. Elam
	S. Giacobi
	L. C. Lanese
	S. D. Leshnoff
	J. Pelicone
*	H. Robinson
	P. Tamburro

Abstract:

Summary and Purpose

The purpose of this report is to document the preliminary evaluation of the February 1990 Drywell UT Examination Data as well as document the possible reasons for why corrosion has not significantly abated.

Results of UT examination data obtained February 9, 1990 indicated that some locations of the drywell vessel may be experiencing corrosion rates greater than recently projected.

Conclusions

Although a more detailed review is currently underway (to be documented by revision to References 7.6 and 7.8), this report is intended to document preliminary analysis which determined that the drywell would be serviceable up to the 13R outage.

Based on a preliminary analysis of the February, 1990 data, this evaluation projects the most limiting drywell vessel region to be Bay 5 at the 51 foot elevation. The most conservative rates project that this area will not reach minimum thickness until the 13R outage scheduled in January 1991.

(For Additional Space Use Side 2)

* Abstract Only

Recommendations:

1. SE 000243-002 Rev. 3 needs to be revised to indicate the new corrosion rates and projections.
2. The use of actual material properties (CMTR) should be pursued for the 50'2" elevation.
3. The drywell design pressure of the drywell should be lowered.
4. Operation of the Cathodic Protection system needs to be verified and corrected as necessary.
5. Means of abating-corrosion at the upper drywell elevations must be evaluated.

NOTE: All recommendations are being performed through ongoing activities.

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background Information

GPUN has established a drywell corrosion abatement and monitoring program. (References 7.1, 7.2, 7.3, 7.4, 7.5, 7.6 and 7.7.) This program includes: the installation and operation of the cathodic protection system in the sand bed region (3/89); reduction of water inleakage sources (10-12/88), mechanical agitating and draining water from the sand bed region (10-11/88), monitoring the most limiting areas (ongoing), and continued analysis of the situation (ongoing).

The most limiting areas are listed in the table below:

PRIORITY	UT INSPECTION ELEVATION	AREA
1	11'-3"	Eleven 6" x 6" grids in Bays 9, 11, 13, 15, 17, 19 and frame 17/19
1	50'-2"	One 6" x 6" grid above Bays 5
2	87'-5"	Three 6" x 6" grid above Bays 11 & 15
2	11'-3"	Eight strips (1" x 6" reading 1" apart) in Bays 1, 3, 5, 7, 9, 13

Priority 1 areas are inspected at each outage of opportunity but not more frequently than once every three (3) months. Priority 2 areas are inspected in an outage of opportunity if the previous set of data was taken eighteen months (18) or more before the outage.

Review of UT data up to October 1988 (References 7.6 and 7.7) indicated that the most limiting area (sand bed bay 17D) would not corrode below the minimum thickness before June of 1992. The installation of cathodic protection and sand bed draining were intended to significantly abate corrosion and allow extension of the projected date. Interim data taken in September 1989 indicated that corrosion rates in the sand bed regions had been reduced. On February 9, 1990 UT examinations were performed on all Priority 1 locations. Results from this data suggests corrosion rates in some areas may be greater than projected in October 1988 and September 1989. This report documents the assumptions, methods, results of the preliminary analysis, and engineering judgement used to evaluate the corrosion rates in each region.

2.0 METHODOLOGY

In order to understand the results from the February 1990 data the following were evaluated and reviewed:

2.1 A preliminary review of the data was performed to determine the data's validity and calculate new conservative corrosion rates.

2.2 A review of the UT measuring device was performed, in addition to a review of the physical application of the device in the field.

2.3 A review of GPUN's understanding of the perceived corrosion mechanism was performed.

2.4 A review of the Cathodic Protection System operation since installation was conducted to identify any operational changes which may have affected the corrosion mechanism in the sand bed region. As part of this effort, a meeting was held with a cathodic protection expert, Mr. Ian Munroe of Corrosion Services, who designed the present system at OC.

2.5 A review of the existing Safety Evaluation (Reference 7.7) which justified continued operation through June 1992 was performed to determine if the conclusions of the SE were still valid.

3.0 RESULTS

3.1 Results of February 1990 UT Examination

Although the February 1990 UT examination data is not completely understood, the data seems to be valid. To ensure a completely thorough and conservative approach, this data was used in establishing new corrosion rates.

3.1.1 Mean Thickness Values

Each priority 1 inspection location consists of an 6" x 6" area. Measurements were made using the template with 49 holes (7 x 7) laid out on a 6" x 6" grid with 1" between centers.

A mean of all points in each grid was calculated. This approach is consistent with earlier mean thicknesses calculations as is documented in Reference 7.5.

Table 1 presents the calculated mean thickness values derived from February 1990 and October 1988 examinations.

TABLE #1

Area	Bay	Mean Thickness as of 10/88 (mils)	Mean Thickness as of 2/90 (mils)	Difference (mils)
Protected Sand Bed Regions	11A	908.6	880.4	-28.2
	11C Top 3	916.6	978.4	-
	Bottom 4		869.0	-
	17D	864.8	839.1	-25.7
	19A	837.9	807.8	-30.1
	19B	856.5	840.7	-15.8
	19C	860.9	830.5	-30.4
	17/19 Frame	981.7	994.4	-
Unprotected Sand Bed Region	9D	1021.4	1010.0	-11.4
	13A	905.3	859.0	-46.3
	15D	1056.0	1057.3	-
	17A Top 3	957.4	1120.2	-
	Bottom 4		937.5	-
50'2" Elevation	5	750.0	739.6	-10.4

Note: After October 1988, Bays 11C and 17A were split into two regions (the top three rows and bottom four rows). This is because these bays showed regions which were corroding at different rates. The February 1990 data show these differences while the October 1988 data presents a mean for the entire grid.

TABLE 2 - ESTIMATED CORROSION RATES - SAND BED REGION

BAY	(1) CORROSION RATE UP TO 10/88 (MPY)	(2) CORROSION RATE FROM 6/89-2/90 (POST CP & H20 DRAIN) (MPY)	(3) CORROSION RATE FROM 10/88 - (2/90 PRE-CP & POST H20 DRAIN) (MPY)	(4) CORROSION RATE TO 2/90 ALL DATA (MPY)	(5) FEB. 1990 THICKNESS (MILS)	(6) REQ. MIN. THICK. (MILS)	(7) DATE WHICH MINIMUM THICK IS REACHED (COL. 2)	(8) DATE WHICH MINIMUM THICK IS REACHED (COL. 3)	(9) DATE WHICH MINIMUM THICK IS REACHED (COL. 4)
11A	NOT SIGNIFICANT	-5.0 ±19.5 (128.1)	-4.1 ±6.3 (-22.5)	-12.4 ±3.0 [3] (-18.1)	880.4±	700	5/91	6/97	3/99
11C TOP 3	INDETERMINABLE	-62.0 ±3.8 [3] (-86.4)	-20.3 ±15.2 (-64.7)	-35.0 ±8.5 [3] (-51.5)	978.4±	700	1/93	1/94	1/95
11C BOTTOM 4	INDETERMINABLE	-18.3 ±30.4 (-210.2)	-13.4 ±10.0 (-42.6)	-22.1 ±5.3 [3] (-32.4)	869.0±	700	10-11/90	9/93	11/94
17D [2]	-27.6 ±6.1 [3] (-41.1)	-27.8 ±6.6 (-69.5)	-17.7 ±4.3 (-30.25)	-24.0 ±2.4 [3] (-28.5)	839.1±	700	12/91	4/94	7/94
19A	-23.7 ±4.3 [3] (-32.9)	-35.7 ±7.0 (-79.9)	-20.7 ±5.96 [3] (-38.1)	-21.8 ±1.8 [3] (-25.2)	807.8±	700	5/91	9/92	1/94
19B	-29.2 ±0.5 [3] (-30.4)	-21.6 +11.7 (-95.5)	-10.2 ±5.6 (-26.6)	-19.6 ±2.1 [3] (-23.7)	840.7±	700	6/91	12/95	7/95
19C	-25.9 ±4.1 [3] (-35.5)	-25.3 ±8.6 (-79.6)	-18.4 ±3.8 [3] (-29.5)	-23.9 ±1.5 [3] (-26.8)	830.5±	700	8/91	2/94	7/94
17/19	INDETERMINABLE	-13.0 ±0.9 [3] (-18.7)	-	-2.8 ±8.2 (-26.7)	994.4±	700	2004	-	2000
9D	INDETERMINABLE	-69.0 ±41.4 (-330.)	-11.1 ±28.0 (-92.8)	-16.4 ±7.5 (-34.0)	1010.0±	700	12/90	2/93	5/98

NOTE: 1) RATES IN PARENTHESIS REPRESENT MOST CONSERVATIVE RATES WHICH CAPTURES 95% CERTAINTY.
2) BAY 17D WAS THE MOST LIMITING BAY AFTER OCTOBER 1988 UT RESULTS
3) STATISTICAL REGRESSION MODELING MORE APPROPRIATE THAN MEAN MODEL.

TABLE 2 - ESTIMATED CORROSION RATES - SAND BED REGION

BAY	(1) CORROSION RATE UP TO 10/88 (MPY)	(2) CORROSION RATE FROM 6/89-2/90 (POST CP & H20 DRAIN)	(3) CORROSION RATE FROM 10/88 - (2/90 PRE-CP & POST H20 DRAIN)	(4) CORROSION RATE TO 2/90 ALL DATA	(5) FEB. 1990 THICKNESS	(6) REQ. MIN. THICK. (MILS)	(7) DATE WHICH MINIMUM THICK IS REACHED (COL. 2)	(8) DATE WHICH MINIMUM THICK IS REACHED (COL. 3)	(9) DATE WHICH MINIMUM THICK IS REACHED (COL.4)
13A	INDETERMINABLE	-41.8 ±15.4 (-139.)	(3) -39.3 ±6.0 (-56.8)	(3) -16.3 +4.8 (-27.6)	859.0±	700	2/91	8/92	5/95
15D	NOT SIGNIFICANT	-5.2 ±3.2 (-25.4)	-	-1.54 ±3.4 (-11.5)	1057.7±	700	2002	-	2018
17A TOP 3	INDETERMINABLE	+17.4 ±7.6 (-65.4)	-	-10.9 ±4.3 (-23.5)	1120.2±	700	12/95	-	2006
17B BOTTOM 4		-44.3 ±.01 (3) (-44.4)	-	-18.1 ±12.3 (-54.)	937.5±	700	12/94	-	2/94

NOTE: 1) RATES IN PARENTHESIS REPRESENT MOST CONSERVATIVE RATES WHICH CAPTURES 95% CERTAINTY.

2) BAY 17D WAS THE MOST LIMITING BAY AFTER OCTOBER 1988 UT RESULTS.

3) STATISTICAL REGRESSION MODELING MORE APPROPRIATE THAN MEAN MODEL.

012/071A.2

TABLE 3- ESTIMATED CORROSION RATES - UPPER ELEVATIONS

BAY	(1) CORROSION RATE UP TO 10/88 (MPY)	(2) CORROSION RATE BASED ON SECTION 3.3	(3) CORROSION RATE BASED ON STRAIGHT AVG. 6/89 - 2/90	(4) CORROSION RATE TO 2/90 ALL DATA	(5) FEB. 1990 THICKNESS	(6) REQ. MIN. THICK. (MILS)	(7) DATE WHICH MINIMUM THICK IS REACHED (COL. 2)	(8) DATE WHICH MINIMUM THICK IS REACHED (COL. 3)	(9) DATE WHICH MINIMUM THICK IS REACHED (COL.4)
51' (ALL DATA)	- 4.3 ±0.03 (3) (-4.5)	16	15	-3.6 ±2.9 (-9.8)	739.6±	725	1/91	2/91	6/91
51' (9/89 DELETED)	N/A	N/A	N/A	-5.6 ±1.6 (3) (-9.5)	739.6±	725	N/A	N/A	7/91
51' (USING CMTRs)	N/A	16	15	-3.6 ±2.9 (-9.8)	739.6±	671	5/94	7/94	6/96
86' 9	NOT SIGNIFICANT	16	N/A	USING (-9.8)	(AS OF 6/26/89) 619.1	591	3/91	N/A	1/92

NOTE: 1) RATES IN PARENTHESIS REPRESENT MOST CONSERVATIVE RATES WHICH CAPTURES 95% CERTAINTY.
3) STATISTICAL REGRESSION MODELING MORE APPROPRIATE THAN MEAN MODEL.

012/071A.3

In addition the NDE/ISI group at Oyster Creek performed an equipment functional check on the UT meter (D-meter) and probe used to record the data. Different D-meter and probe combinations were used on various thickness. The results were generally identical with variances of only several thousands on an inch.

3.3 Existing Corrosion Mechanism

3.3.1 Corrosion Mechanism in Sand Bed Region

Per Reference 7.2, the cause of the corrosion in the sand bed region is the result of water trapped in the sand bed. The water which may have leaked into the sand bed during construction and/or outages in 1980, 1983 and 1986 was contaminated with chlorides, sulfates and numerous other metal ions. Per Reference 7.2, a likely corrosion rate (based on plug samples, analysis of inleakage water, laboratory testing, and literature research of related phenomena) is 17 mils/year. However, to ensure conservatism, Reference 7.8 arrived at a conservative rate assuming all material loss observed in 1986 had occurred in the six year period of water intrusion since 1980. The resulting rate -48 MPY was used to justify continued plant operation to June 1992.

3.3.2 Corrosion Mechanism in Upper Elevation

Per reference 7.3 the cause of the corrosion in the upper elevation was the result of the drywell steel exposed to the "firebar" insulation laden with chloride containing water. This was based on analysis of drywell vessel plug samples, analysis of inleakage water, laboratory testing, and literature research of related phenomena. Reference 7.3 concludes that the most conservative corrosion rate (based on plug samples, analysis of inleakage water, laboratory testing, and literature research of related phenomena) is 16 mils per year.

3.4 Review of Cathodic Protection System Operation Since Installation

A review was performed on the Drywell Cathodic Protection System (CPS). This review included verification of the electrical installation and system operating parameters. According to the design documentation, the system is configured correctly. Review of system electrical potential data has shown that since the initial draining of water from the sand bed, generally there has been a steady reduction of current as a function of time.

The data indicates that since June of 1989, many of the cathodic protection system probes have experienced zero current. There are several possible reasons for this occurrence.

1) The sand bed could have become uniformly dry, including the sand in contact with the vessel wall. With the sand bed completely dry, the corrosion mechanism and subsequent rate were expected to halt.

2) Only the sand in areas close to and around the CPS probes has completely dried. The remaining sand bed region, including the sand in contact with the vessel wall, is still wet and the corrosion mechanism is still in place. The locally dry sand around the probes may be developing very high resistivity factors which have resulted in low and/or zero currents. Per discussions with Ian Munroe, of Corrosion Services, this is thought to be unlikely because the current density of the system is not high enough for this kind of phenomena.

3) The current provided initially is too low. Per discussing with Ian Munroe, of Corrosion Services, the electrical power supplied to the system may need to be increased. This may be required due to the grade positioning being different than the conceptual layout of grades.

3.5 Review of Safety Evaluation 000243-002, Rev. 3 (Reference 7.7)

3.5.1 Sand Bed Region

The above referenced Safety Evaluation projects Bay 17D in the sand bed region as the most limiting of all monitored locations. Mean thickness was expected to reach the minimum allowable mean thickness of .700 inches by June 1992.

3.5.2 Elevation 50'-2"

The above referenced Safety Evaluation projects mean thickness on EL. 50'-2" as .730 inch by June 1992 which is above the minimum mean thickness of .725 inches. Note that this value does not take credit for the actual material properties of the steel plate (CMTRs). Minimum allowable thickness using actual stress values from CMTRs is .671 inches (Ref. 7.4).

3.5.3 Elevation 87 Foot

The above referenced Safety Evaluation does not project mean thickness on Elevation 86-'5" as no corrosion was ongoing at this elevation. However, the minimum allowable mean thickness at this elevation is .591. Note that this value is derived from actual material properties of the steel (CMTRs).

The minimum allowable thickness for localized areas at this elevation is .425 inches.

4.0 EVALUATION

4.1 Evaluation Approach

This evaluation documents and illustrates the preliminary approach used to estimate corrosion rates, identify the limiting bay and project the date at which minimum shell thickness is reached. The statistical appropriateness of these analyses is to be verified by revision to Reference 7.5. Reference 7.5 will be updated to provide statistically appropriate corrosion rates.

4.1.1 Sand Bed Region

A logical approach based on an understanding of the corrosion phenomena, a vigorous application of statistics, and sound engineering judgement was necessary to develop appropriate conservative corrosion rates.

Rates based on data from June 1989 to February 1990 were intended to capture a rate post cathodic protection installation and sand bed draining. These rates may have indicated the most recent changes in corrosion. However, these rates are based on only three observations (6/89, 9/89 and 2/90 data) which generally resulted in statistically inappropriate rates.

Corrosion rates based on all data up to February 1990 would capture an overall rate and would statistically be more accurate (Table 2, Column 4). However, these rates may not capture possible recent increases in corrosion rates. Therefore, this approach may not be the most conservative.

Rates were also calculated based on data from 10/88 to 2/90. Although these rates are based on only four observations, the time period is almost doubled (compared to the 6/88 to 2/90 period).

Table 2 shows which of the rates are based on data which fit the regression model more appropriately than the mean model (indicated by Note #3). (This will be referred to as "statistical appropriateness" throughout this report.) However, the most "statistically appropriate" rate may not be the most conservative. Therefore, to take a consistently conservative approach, the greatest rate must be chosen, unless that value can be discounted (based on sound engineering judgement coupled with an understanding of the corrosion phenomena).

The evaluation approach was to find the date in columns 7, 8 and 9 which would occur soonest in time. The rate used in projecting this date was then evaluated to see if it was based on a statistically appropriate curve fit and if the rate could be realistically expected (i.e. ≤ 60 MPY). If the rate was not realistic and not statistically appropriate, then it would be disregarded and the next date in time in column 7, 8 and 9 would be chosen.

The date which occurs soonest in time is Bay 11C (bottom four rows) which projects a 10-11/90 date (in column 7). The corresponding corrosion rate is -18.3 ± 30.4 (column 2). This suggests a standard error which is almost twice as much as the rate. As a result of this uncertainty, and the small number of observations, the 95% confidence rate is -210.4 MPY. This type of corrosion rate is considered unrealistic (see Section 3.3). Therefore, this rate and the projected date based on this rate must be disregarded.

For the next, Bay 9D, the column 2 rate is -69 ± 41.4 MPY. This results in a 95% confidence rate of -330.0 MPY. This rate is considered unrealistic and is not based on a statistically appropriate model. Again, this rate and the projected date are disregarded. Bays 11A, 11C (top 3 rows), 13A, 17D, 19A, 19B and 19C showed similar unrealistic results in column 2. In general, all column 2 results and projected dates (column 7) were not considered reasonable.

4.1.2 Upper Elevations

Table #3 presents 3 rows for Bay 5 at the 51 foot elevation. The first row presents an overall rate up to October 1988 (column 1), a rate based on section 3.3 (column 2), a rate based on straight line average from June 1989 to February 1990 (column 3), and an overall rate up to February 1990 (column 4).

Since it appears that a significant amount of material was lost from June 1989 to February 1990 (see Table #4) a straight average using mean thicknesses on these two dates was developed.

TABLE 4

Bay 5 Elevation 51 Mean Thickness

Date of UT	Mean Thickness
11/1/87	753.8
7/12/88	750.0
10/8/88	750.2
6/26/89	749.6
9/13/89	755.6
2/9/90	739.6

The second row presents a rate with the September 1989 data disregarded. Review of the September 1989 mean thickness value shows an increase over the June 1989 mean thickness (by approximately 6 mils). This increase, coupled with a resulting overall rate which is based on a curve fit which is not statistically appropriate, prompted an analysis of the data with the September 1989 observation deleted. The resulting rate of -5.6 $\pm$ 1.6 is based on a curve fit which is statistically appropriate.

Regardless, the more conservative of either resulting 95% confidence rate (with or without the September 1989 data) was chosen as the most conservative projection (-9.8 MPY).

The third row for the 51 foot elevation presents the same rates as in the first, except a CMTR based minimum mean thickness is applied. Resulting projections are presented in column 7, 8 and 9.

4.2 Sand Bed Region

4.2.1 Most Limiting Bay In The Sand Bed Region

The October 1988 Safety Evaluation (Reference 7.11) projected Bay 17D (in the sand bed region) has the most limiting of all monitored locations. Based on a rate of -27.6 $\pm$ 6.1 MPY and a 95% confidence conservative rate of -41 MPY, mean thickness was projected to reach the minimum allowable mean thickness of 0.700 inch by June 1992.

Results from February 1990 data now suggests that a conservative rate of -17.7 ± 4.3 MPY and a 95% confidence conservative rate of -30.25 MPY can be applied, and that this bay is projected to reach a mean thickness of 700 mils by April of 1994.

The February data now indicates that Bay 19A is the most limiting bay of all monitored locations in the sand bed region. Based on a new conservative rate of -20.7 ± 5.6 MPY and 95% confidence rate of -38.1 MPY, it is projected that this bay may reach a mean thickness of 700 mils by September 1992. The conservative rate is both realistic and is based on a statistically appropriate curve fit. Note, this rate is based on data recorded from October 1988 through February 1990 (column 4).

4.2.2 <u>Protected Bays</u>

Interim data recorded in September 1989 indicated that corrosion rates in the protected sand bed region had generally decreased, yet the February 1990 data indicates that corrosion rates generally increased almost to former levels before cathodic protection installation.

A possible explanation for this may be the reduced or zero probe current rates which has occurred since June 1989 (Section 3.4).

Up to June 1989 the sand bed region may have been uniformly wet and Cathodic Protection System may have performed its intended purpose by inducing a current throughout the sand bed. Then in June the sand close to and around the probes may have completely dried with the remaining sand (including the sand in contact with the vessel wall) remaining wet. The locally dried sand around the probe may have developed very high resistivity factors resulting in very low and zero currents.

The lack of impressed current prevents the cathodic protection system from performing it's function. This may explain the increased corrosion rates observed in February 1990.

4.3 <u>50"-2" Elevation</u>

The most limiting bay at the 50 feet elevation is Bay 5. October 1988 data had resulted in a mean thickness of approximately .75 inches. October 1988 data indicated an on-going rate of -4.3 ± .03 MPY.

February 1990 data indicates a loss of material resulting in a mean thickness of .7396 inches. Although the February 1990 data is not been thoroughly understood an overall rate of -3.6 ± 2.9 MPY and a 95% confidence conservative rate of -9.8 MPY has been calculated. Based on this rate, it is projected that this area may reach a minimum mean thickness of .725 inches by June 1991. This thickness is based on code allowable stress values for the steel and not CMTR results.

The minimum mean thickness at this elevation based on measured stress values (per vendor CMTRs) is .671 inch (Reference 7.7). Use of this minimum (instead of a minimum based on code allowable stress values) and the -9.8 MPY rate allow a projection for serviceability to June 1996.

The more conservative rates of 16 and 15 MPY were also considered. The most limiting projection based on these rates (without CMTR stress values) resulted in a January 1991 date. Use of CMTR stress values and resulting minimum mean thickness result in a May 1994 date.

4.4 <u>86 Foot Elevation</u>

The most limiting bay at the 86 foot elevation is bay 9. June 1989 data indicates that this bay had a mean thickness of .6191 inches. As of June 1989 this bay was considered to be experiencing a rate of 0 MPY.

UT examination was not performed at this elevation in February 1990. Although it is very likely that this area is continuing to experience rates close to zero MPY, the conservative rate calculated at the 51 foot elevation applied to the June 1989 mean thickness at Bay 9 on the 86 foot elevation projects that this bay may reach the minimum mean thickness of .591 inches by January of 1992.

A more conservative rate of 16 mils/year based on the original safety evaluation (Section 3.3) was considered. Projection based on this rate resulted in a March 1991 date.

If CMTR stress values are applied to the 51 foot elevation projection, then bay 9 on the 86 foot elevation becomes the most limiting bay with a serviceability date of March 1991.

5.0 <u>CONCLUSION</u>

5.1 Based on this evaluation, the sand bed region is no longer the limiting elevation for drywell vessel service. Bay 5 at the 51 foot elevation is now the most limiting. Based on February 1990 mean thickness of .7396 inches and a conservative rate of 16 MPY (Sec. 3.3), this area is projected to reach the minimum mean thickness of .725 inch by January 1991. This projection is based

on a theoretical rate of 16 MPY. The detailed review currently underway may determine a different projection which is based on a statistically derived rate from the data. However, this conservative projection does show that the drywell will be serviceable until January 1991.

5.2 Use of CMTR stress values applied to bay 5 at the 51 foot elevation projects this area to reach the minimum mean thickness of .671 inch by May 1994.

5.3 Although no data was taken in February 1990 at the 86 foot elevation and it is likely that corrosion rates remain at zero MPY, the conservative rate of 16 MPY (Sec. 3.3) projects bay 9 on the 86 foot elevation to reach the minimum mean thickness by March 1991.

5.4 February 1990 data now indicates that Bay 17D in the sand bed is no longer the most limiting bay. Results from the February 1990 data projects the most limiting bay in the sand bed is 19A. It is conservatively projected that this area will reach the minimum mean thickness by September 1992.

Based on these results in the sand bed region, it is concluded that cathodic protection is currently producing very limited positive results in abating corrosion in the sand bed region.

6.0 RECOMMENDATIONS

6.1 Safety Evaluation 000243-002 Rev. 3 (Reference 7.6) which projects drywell service life up to June 1992 must be revised to reflect the new rate and a new date of January 1991. This is ongoing.

6.2 The minimum mean thickness at the 50'2" elevation is .725 inches. This value is based on code requirements. It is recommended that GPUN pursue using CMTR results to calculate a reduced minimum mean thickness value of .671 inches. This would result in projected serviceability date (at this elevation only) of June 1996. This is ongoing.

6.3 It is recommended that GPUN pursue lowering the design pressure of the drywell. This would further reduce the minimum mean thickness value in the upper elevation and provide more margin. This is ongoing.

6.4 Current cathodic protection system potential data indicates a postulated mechanism which may be defeating cathodic protection. The proper operation of this system needs to be verified and corrected as necessary. This is ongoing.

6.5 Evaluate methods for abating corrosion in the upper elevations. This is ongoing.

7.0 REFERENCES

7.1 TDR 851 Assessment of Oyster Creek Drywell Shell.

7.2 TDR 854 Drywell Sand Bed Region Corrosion Assessment.

7.3 TDR 922 Drywell Upper Elevation, Wall Thinning Evaluation.

7.4 TDR 926 OC Drywell Structural Evaluations.

7.5 TDR 948, Statistical Analysis of Drywell Thickness Data.

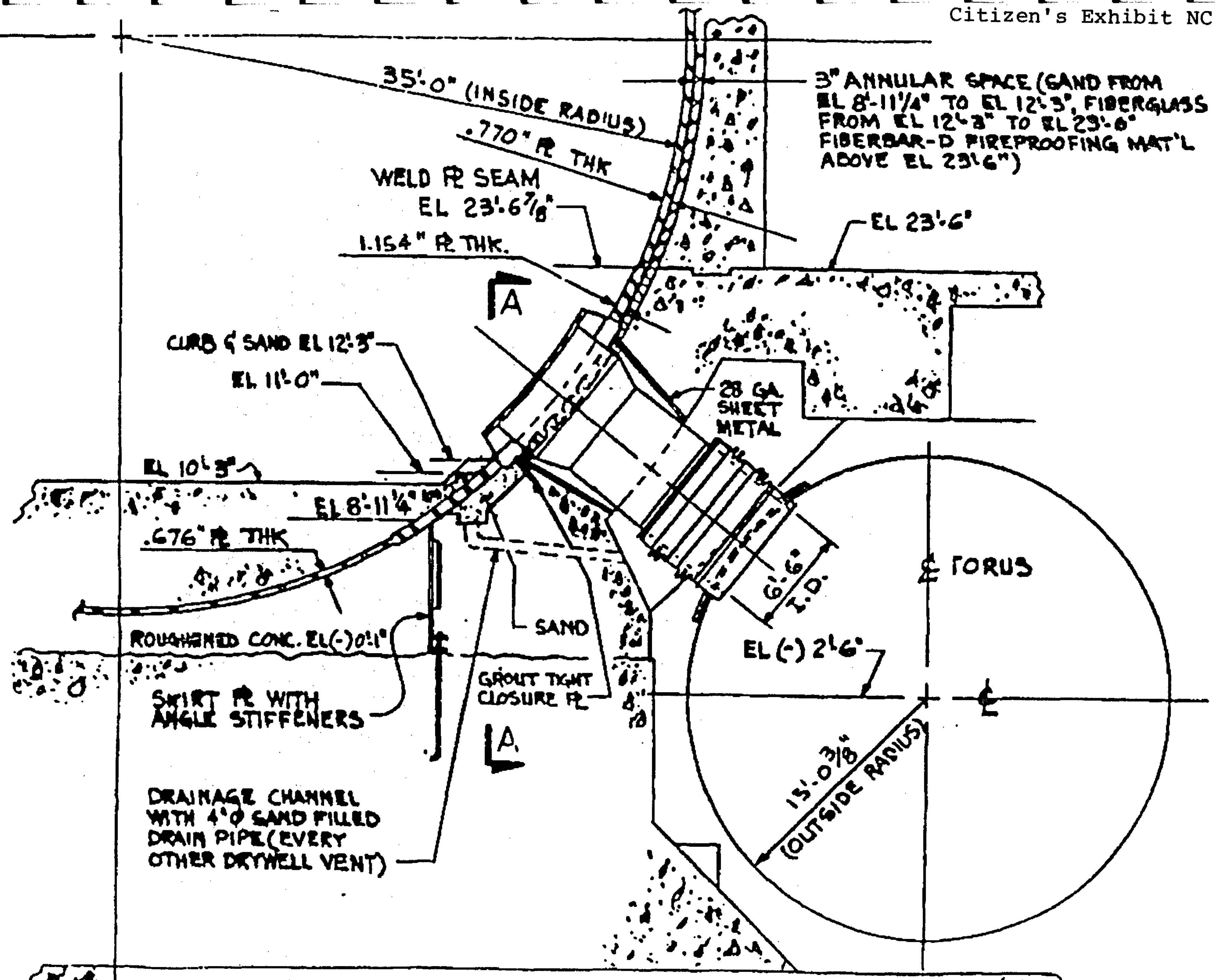
7.6 Calculation C-1302-187-5360-006 Projection of Drywell Mean Thickness through October, 1992.

7.7 Safety Evaluation SE 000243-002, Rev. 3.

7.8 Safety Evaluation SE 000243-002, Rev. 1.

Citizen's Exhibit NC10

Citizen's Exhibit NC10



PARTIAL CROSS SECTION OF DRYWELL & TORUS