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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	)	
	)	April 26, 2007
AMERGEN ENERGY COMPANY, LLC	)	
	)	Docket No. 50-0219-LR
(License Renewal for the Oyster Creek	)	
Nuclear Generating Station)	)	
	)	

CITIZENS' ANSWER OPPOSING AMERGEN'S MOTION FOR SUMMARY DISPOSITION

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") oppose the summary disposition motion (the "Motion") filed by AmerGen Energy Co. LLC ("AmerGen") on legal and factual grounds.

The facts show that summary disposition is inappropriate. AmerGen seeks summary disposition even though its own analyses, despite some inconsistency, showed that margins are narrower than 0.064 inches and potential corrosion rates are greater than 0.017 inches per year. The combination of these two facts leads to a conclusion that a measurement frequency of every 4 years is too long, because corrosion in excess of the margin could occur in less than 4 years.

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For the purposes of summary disposition, the facts must be construed in favor of Citizens. Thus, these two facts alone indicate that summary disposition is inappropriate at this time.

In addition, as a matter of law, summary disposition is also unavailable to AmerGen based on its pleadings. Where there is a clash of expert opinion, summary disposition is only possible where one expert's opinion is so flawed that it would be inadmissible at trial. Here, AmerGen has failed to show that the opinions of Citizens' expert are flawed. It has also proffered an affidavit regarding acceptance criteria and available margin that is contradicted by documents in the record that were written by the affiant. At this stage, AmerGen's testimony on these issues should therefore be disregarded as unreliable. Because AmerGen has failed to present any other testimony regarding the available margin, as a matter of law it has failed to meet its burden to show that there are no open issues for adjudication.

In fact, discovery in this proceeding has confirmed that there are currently four main open issues for adjudication: i) what are the acceptance criteria that must be met by the thickness results from the ultrasonic ("UT") testing in the sandbed region of the drywell shell at the Oyster Creek Nuclear Generating Station ("Oyster Creek") ii) when the results from the UT testing are compared to the acceptance criteria, what is the minimum margin iii) how fast could corrosion occur between inspections; and iv) what frequency of UT testing is required to ensure that required safety margins would be maintained during any extended license renewal period. AmerGen's inconsistent statements and methods mean that there are open issues concerning all of the above. In addition, the latest opinion from Citizens' expert shows that AmerGen has incorrectly claimed that a small number of measurements from the interior of the sandbed represent the behavior of the entire region. Careful analysis of the data actually shows that these

measurements actually tend to overestimate the average thickness of the sandbed region. Thus, margin calculations regarding the average thickness cannot use the interior measurements alone.

When Citizens proffered the contention, they alleged that the margin could be as low as 0.026 inches. AmerGen continues to allege that the margin is 0.064 inches. Citizens have now compared the latest results with the latest acceptance criteria for average thickness, the thickness of local areas that are less than 0.736 inches thick, and the thickness of very localized areas. For average thickness the known margin at 95% confidence is 0.044 inches or less, because the uncertainty in the mean thickness measurement is plus or minus 0.02 inches at 95% confidence and these measurements may overestimate the average thickness. Furthermore, using the latest external thickness measurements in Bay 11, Citizens currently estimate the minimum margin compared to the average thickness acceptance criterion is only 0.014 inches at 95% confidence. For small areas that are greater than around two inches in diameter, but less than 12 inches by 12 inches, the current margin is highly uncertain, but may already be less than zero. For very localized areas that are than around two inches in diameter or less, the known margin at 95% confidence may also be less than zero, depending the statistical approach taken to estimate the thinnest point on the drywell shell.

The potential future corrosion rate in case of corrosive conditions occurring is also poorly defined, but Citizens' expert estimated that it could be around 0.017 inches per year, while AmerGen's expert has assumed it could be as high as 0.039 inches per year. Thus, assuming that AmerGen can establish some margin, the appropriate monitoring frequency could be more than once per year. The current proposed monitoring frequency is once every four years. Thus, the contention alleging that monitoring frequency is inadequate cannot be dismissed summarily.

With regard to the corrosion rate, AmerGen states that the 2006 results show that corrosion at 0.017 inches per year has not been occurring. That is irrelevant because Citizens did not state that corrosion had been occurring at that rate. Instead, Citizens asserted that corrosive conditions could occur between inspections during any extended licensed period of operation because the protective coating is at or close to the end of its life and water could be present. AmerGen has neither denied that corrosive conditions could occur in the future, nor that corrosion could occur at a significant rate under such conditions. Thus, AmerGen has failed to show that the potential for significant future corrosion is not an issue.

The required monitoring frequency is a function of the available margin and the potential corrosion rate. The combination of open issues regarding the acceptance criteria, the available margins and the corrosion rate mean that the contention, which concerns appropriate monitoring frequency, cannot be dismissed through summary disposition. Instead these issues must be adjudicated through a hearing or, at minimum, clarified through further document disclosure and discussion between the parties.

STATEMENT OF FACTS

I. Undisputed Issues

This proceeding concerns AmerGen's ability to ensure that the drywell shell, which forms the primary containment system at the Oyster Creek, does not corrode below acceptable safety margins during any extended period of licensed operation beyond April 2009, when the Plant is currently scheduled to close. The containment system is a safety critical component whose failure could lead to the inability to contain products from a nuclear accident and, under certain circumstances, could even initiate a nuclear accident.

II. Specific Factual Issues Already Decided By The ASLB

Citizens already demonstrated a basis for their initial contention about the lack of adequate UT testing. As recognized by the ASLB in its decision admitting the initial contention, Citizens had ample basis for the following points:

i) water could intrude into the sand bed region in the future, leading to corrosive conditions on the outside of the drywell shell, LBP-06-07 at 36;

ii) 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;

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

In the decision admitting the current contention the Board reaffirmed its findings, stating that the existence of a corrosive environment was a possibility. LBP-06-22 at 15.

III. Factual Errors Made By AmerGen

In the Motion and the affidavits AmerGen makes a number of factual errors about the acceptance criteria, the remaining margins, and Citizens' statement about corrosion rates. This Section details these errors and thereby illustrates that many of the "facts" asserted by AmerGen are in dispute.

A. The Local Area Acceptance Criterion Is In Dispute

With regard to the acceptance criteria, AmerGen alleges that the "local area average thickness" criterion is 0.536 inches for a 1 square foot area, but the total area that can be thinner than 0.736 inches is *nine square feet*. Affidavit of Peter Tamburro, dated March 26, 2007 ("Tamburro Aff.") at ¶¶ 20, 22, 23 (emphasis added). However, NRC Staff in the Safety Evaluation Report ("SER") quote AmerGen stating that the local acceptance 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 inches thick." Oyster Creek SER, 4-56 (March 2007)

(emphasis added). In March of 2006, Mr. Tamburro himself wrote that "the Local Wall Acceptance Criteria . . . is applicable for area up to *12 x 12*." Citizens' Ex. ANC 8 at 2 (emphasis added). Furthermore, AmerGen also stated that areas corroded to less than 0.736 inches in thickness "could be contiguous, provided their total area did not exceed *one square foot*" and their average thickness was greater than 0.536 inches. E-mail to NRC Staff dated April 5, 2006, Ex. NC 1 at 10 (available at ML060960563) (emphasis added). Thus, in contrast to Mr. Tamburro's Affidavit, AmerGen's statements, and those of the affiant himself, directly contradict the proffered affidavit and state that the local acceptance criterion only applies to small areas that are less than one square feet in area.

Given these various statements, it is therefore hardly surprising that Dr. Hausler concluded that the local area acceptance criterion meant that contiguous areas that are thinner than 0.736 inches should be less than one square foot in area. This belief was buttressed by AmerGen documents which actually purported to show that the area thinner than 0.736 inches, but thicker than 0.536 inches, was 0.68 sq. ft, and thus less than one square foot. Citizens' Ex. NC 1 at 10.

The latest calculations detailing how the UT measurements have been accepted show that since Citizens made their contention the local area acceptance criterion has become more stringent. In mid-2006, AmerGen applied a local thickness criterion of 0.636 inches to areas that are less than 12 inches square. AmerGen Ex. 3 attached to Answer dated March 5, 2006 ("1992 Acceptance Report") at 5. Most recently, in December 2006, AmerGen applied the following local acceptance criterion: "if an area is thinner than 0.736" thick, then that area shall be greater than 0.693 inches thick and shall be no larger than 6" by 6" wide." Calculation C-1302-187-E310-041, Ex. SJA 1, at 11. This is considerably more stringent than the criterion put forward

by Dr. Hausler (and used previously by AmerGen) at the time Citizens proffered the admitted contention. This more stringent formulation of the local acceptance criterion provides further support for the contention because the margins calculated using this more stringent criterion will inevitably be narrower than previously estimated.

Instead of discussing the various approaches that it has actually used to determine whether the 2006 UT results are acceptable, AmerGen has stated that the total allowable area that is thinner than 0.736 inches is nine square feet. Tamburro Aff. at ¶¶ 20-23. As shown above, AmerGen's own documents contradict this assertion. Further, even if AmerGen had actually used such a criterion, it could not be justified. A uniform thickness of 0.736 inches is believed by AmerGen to exactly satisfy the AMSE criteria. Citizens' Ex. ANC 2 at 6-9; Tamburro Aff. at ¶ 17. In addition, as Mr. Tamburro himself noted, when a nine square foot area thinner than 0.736 inches was modeled by General Electric, the safety factor decreased by 9.5%. Citizens' Ex. ANC 8 at 2. Thus, AmerGen cannot show that a nine square foot area thinner than 0.736 inches would meet the ASME code, because when the average thickness is close to 0.736 inches, as is currently found, the localized thickness reduction could cause the shell to fail the ASME code requirements. This appears to have been one of Mr. Tamburro's concerns when he authored ANC 8 in March, 2006. From the timing, it appears that the local acceptance criterion has become more stringent over the last year in response to these concerns. It is therefore not surprising that Mr. Tamburro's affidavit fails to give any examples of actual use of the purported local area acceptance criterion of nine square feet thinner than 0.736 inches. This is because this purported criterion has never been applied in practice. Instead, this more lax version of the local area acceptance criterion appears to have been concocted solely for this litigation.

In summary, AmerGen's own documents indicate that Mr. Tamburro is incorrect in his assertions about the local area acceptance criterion. Although AmerGen claims that Dr. Hausler was mistaken about the local acceptance criterion, Tamburro Aff. at ¶¶ 21-22, some of AmerGen's documents indicate that Dr. Hausler was correct and others show that the applied criterion is now actually more stringent than before. Thus, one issue that requires adjudication or, at minimum, further document disclosure, is the proper statement of the local area acceptance criterion.

B. The Measurements For Evaluation Against The Acceptance Criteria Are In Dispute

In addition to the dispute about the correct local acceptance criterion to use, Citizens have raised many factual issues with the way in which the margins have been calculated. In evaluating the 1992 external results, instead of using the actual measurements, AmerGen used an adjusted result based on some casts that had been taken of the dimples in the external drywell surface. *E.g.* 1992 Acceptance Report at 33-39. At the thinnest location measured, this procedure changed the evaluation thickness from 0.618 inches, which is what was measured by UT, to 0.673 inches. *Id.* at 39. The report further stated that this thickness "could conservatively exist over an area of 6 x 6 inches." *Id.* at 36.

Dr. Hausler examined this procedure in detail in his memorandum dated June 23, 2006 ("Hausler June Memo"), which supported the contention. Dr. Hausler found the procedure to be "highly arbitrary" and opined that it masked the full extent of the corrosion. Hausler June Memo at 14. Indeed, even AmerGen appears to have realized that the procedure used by AmerGen for the 1992 results is not justified because the acceptance report for the 2006 results does not utilize the approach used in 1992. Calculation C-1302-187-E310-041.

Furthermore, AmerGen misreported the 2006 external measurements. AmerGen has stated that the areas that were not measured were thicker than the areas that were measured externally. Transcript from January 18, 2007 ACRS meeting at 201. Indeed, by design, the 1992 measurements were supposed to be taken at the thinnest points. Calculation C-1302-187-E310-041, Ex. SJA 1 at 48. Unfortunately, because the locations of the points measured in 1992 were not marked on the coating, the exact locations could not be repeated. Ex. SJA 1 at 48; *see also* Ex. SJA 2 Attachment 4 at 8 (some locations not found). However, the results for 2006, show that at some points in Bays 7, 15, 17 and 19 AmerGen scanned a 0.25 inch area around the nominal location of the point. Ex. SJA 2 Attachment 4 at 8, 16, 18, 20. Strikingly, in Bay 15, the reported results were actually the maximum readings obtained. In this Bay, the minimum readings were as much as 0.068 inches less than the recorded value. *Id.* at 16. Similarly, in Bay 19 the recorded results were up to 0.07 inches more than the minimum measured value. *Id.* at 20. AmerGen Ex. 4 at 5-1.

According to AmerGen's own consultant, scanning a small area around an uncertainly located point can help reduce locational uncertainty, if the minimum or average reading is systematically reported. AmerGen Ex. 4 at 5-1. In this case, because the objective was to find minimum values, AmerGen should have reported the minimum reading obtained in 2006 as the measurement for evaluation and marked that point as the baseline. Its failure to do so means that the statistical evaluation of whether ongoing corrosion was occurring was compromised, because the 2006 results were overstated. Furthermore, margin calculations based on the overstated results are incorrect.

C. Margins Are Less Than 0.021 Inches

AmerGen asserts that the minimum margin is 0.064 inches, calculated by subtracting the average of the measurements taken from the 6 inch by 6 inch grid in Bay 19 from the 0.736

inches acceptance criterion for the average thickness. Tamburro Aff. at 6. However, this statement is inconsistent with AmerGen's own documents. The minimum margin compared to the average thickness criterion evaluated by AmerGen to date was actually taken from the external results in Bay 11 in 1992. This showed a mean thickness of 0.792 inches, 1992 Acceptance Report at 5, 30, yielding a margin of 0.056 inches. Using the latest results taken in Bay 11, that average has now decreased to 0.783 inches. *See* Ex. SJA 2 Attachment 4 page 12. Thus, if AmerGen had determined the acceptability of the latest external results using the approach that it used in September of 2006 to evaluate the 1992 results, it would have found the minimum margin to be 0.047 inches. Furthermore, the mean of the minimum data measured at each point in Bay 15 is 0.768 inches, yielding a minimum margin of 0.032 inches. Thus, AmerGen has failed to accurately describe the results of its own calculations and has inconsistently applied the acceptance criteria to the external data.

In addition, these margin calculations above are overly simplistic, because they take no account of the uncertainty of the measurements. Looking first at the mean data gathered from the 49-point grids, AmerGen has admitted that it must take account of the variance of the means of these data, SER at 4-55, but it has failed to so do for the most part. One exception is that in taking account of the variability of the mean of the measured data in the trenches, AmerGen subtracted 0.02 inches before it compared the mean to the acceptance criterion. *See e.g.* Ex. SJA 2 at 8.

Taking a more rigorous account of the variance of the means requires explicit consideration of the number of measurements available. For the data from the interior grid at location 19A, which AmerGen used to claim that the margin is 0.064 inches, the standard deviation is around 0.06 inches, SJA 1 at 50, giving rise to a standard deviation in the mean of

around 0.01 inches, because 49 points were used to calculate the mean. Thus, even if the grids were representative of the surface of each bay, which close analysis shows they are not, around 0.02 inches should be subtracted from any margin obtained to take account of the uncertainty in the determination of the mean thickness based on so few points. Thus, at best, the Bay 19 grid data quoted by AmerGen as the basis for its estimate of minimum margin could only show that the margin in that Bay is greater 0.044 inches at 95% confidence.

Unfortunately, as Dr. Hausler shows comprehensively, the grids measured from the interior are not representative of the mean surface and may overestimate the mean thickness. Hausler Aff. at 3-5. Therefore, it is essential to look at the external data in addition to the grids. For the external data, provided a genuine effort is used to find the points of minimum thickness and use those as the basis for the analysis, using the lower 95th percentile of the minimum points is very conservative. However, no such effort was made in 2006. Therefore, Dr Hausler believes that it is prudent to consider the 95th percentile intervals of the means of the external data. Hausler Aff. at 5. Applying this method requires derivation of the uncertainty in the means of the external data. In Bay 11, the standard deviation of the data is 0.048 inches. Because eight points were measured, the standard deviation of the mean is 0.017 inches. Therefore, the lower 95% confidence limit for the mean thickness is 0.750 inches. Thus, the 2006 external UT data show that the average thickness margin in Bay 11 is 0.014 inches with 95% confidence. More dramatically, in Bay 15, the lower 95th percentile of the mean of the corrected data is 0.731 inches, which is below the acceptable limit of 0.736 inches.

Turning to the local area criterion, the most recent formulation requires areas that are thinner than 0.736 inches to be thicker than 0.693 inches and smaller than 6 inches by 6 inches. In 1992, the thinnest area measured was 0.618 inches, which AmerGen stated could extend over

a 6 inch by 6 inch area. AmerGen Ex. 3 at 36. Even the "corrected" result, which was evaluated against the old local area criterion, was given as 0.673 inches. *Id.*. Thus, if AmerGen compared the 1992 results to the current local area criterion, it appears that it would be violated.

The 2006 results are even worse. The thickness in the same location measured in 1992 as 0.618 inches was measured in 2006 as 0.602 inches. Ex. SJA 2, Attachment 4 at 14. However, it appears that in contrast to the approach taken in September of 2006 with regard to the acceptance of the external results from 1992, AmerGen did not compare the 2006 external results with the local area acceptance criterion. *Compare* AmerGen Ex. 3 at 16-17, 35-36 *with* SJA 1 at 48-49. Citizens are unaware of any justification for this omission.

In addition, the latest results indicate that an area of around 4 square feet in Bay 13 may be thinner than 0.736 inches. Hausler Aff. at 8. This also appears to violate the local acceptance criterion stated in Calculation C-1302-187-E310-041. Ex. SJA 1 at 11. Once again, it remains unclear how AmerGen decided to accept these results.

Similarly, in Bay 1 AmerGen previously calculated that a 4 inch by 4 inch area had an average thickness of 0.692 inches. AmerGen Ex. 3 at 17; Ex. NC 3 at 9. Depending on the thickness of the 2 inch strip surrounding this 4 by 4 area, this zone may just have met the latest statement of the local area acceptance criterion in 1992. However, the 2006 results were around 0.02 inches thinner on average than the 1996 results. *See* Ex. SJA 2, Attachment 4 at 2. Thus, it is quite possible that this area has already expanded to 6 inches by 6 inches or larger. While the exact margin in unknown, it is clear that the margin compared to the local acceptance criterion must be at best extremely narrow, but that it has not been estimated by AmerGen.

In summary, since Citizens filed their contention, the local area acceptance criterion has become more stringent, while the measured thickness has decreased. Thus, the latest reports and

results confirm that, at best, margins are razor thin and are less than the 0.021 inches which Citizens calculated when they proffered the contention. In contrast, AmerGen has not produced any new justification for its long disputed assertion that the margin is actually 0.064 inches.

D. There Is Potential For Significant Future Corrosion

AmerGen is being inconsistent about the potential for future corrosion. In the latest acceptance report for the 2006 external data, AmerGen compared the points measured in 1992 with those measured in 2006. It found that the largest apparent corrosion rate was 0.034 inches per year. Ex. SJA 1 at 49. It then calculated that at this rate the thinnest measured point would be 0.515 inches thick in 2008. *Id.* It therefore decided to take another round of external measurements in 2008.[1] *Id.*

In contrast, solely for the purpose of this litigation, AmerGen has alleged that a corrosion rate of 0.017 inches could not occur in the future. Tamburro Aff. at ¶ 38. However, this is inconsistent with the recommendation of Mr. Tamburro in Calculation C-1302-187-E310-041 which stated that another round of external UT measurements is prudent within 2 years to "provide additional data." Ex. SJA 1 at 49.

While AmerGen's experts reasonably show that corrosion at a rate of 0.017 inches per year has not occurred over large areas of the drywell shell between 1992 and 2006, they do not state that such a rate could not occur if the protective coating fails. They also fail to mention that NRC staff has admitted that it is possible that some corrosion could occur from the inside. SER

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[1] In fact, inspection of the results shows that the thinnest measurement at this location was 0.663 inches, not the 0.681 inches reported. Using the thinnest point measured at this location, as was apparently done in 1992, would therefore yield a corrosion rate of 0.04 inches per year. Applying this rate and a single point uncertainty of 0.04 inches to the thinnest measured result in Bay 13 of 0.602 inches would mean that the very acceptance criterion for areas of less than 2 inches in diameter could be violated in just under 2 years.

at 4-51. Indeed, it was this possibility that led AmerGen to commit to further external UT monitoring in 2008. *Id.* at 3-138.

To illustrate the potential for corrosion from the outside, using a set of assumptions that included a corrosion rate of 0.039 inches per year, Mr. Gordon estimated that if the coating failed and moisture got to the metal surface, metal loss could be up to 0.042 inches in the 56 weeks following an outage. Affidavit of Barry Gordon, dated March 26 2007 at ¶ 18. Thus, Mr. Gordon appears to believe that additional corrosion at an appreciable rate could occur if the coating fails and wet conditions are present. This concurs with Citizens' belief. The difference is that because Citizens believe that that the margins are, at best, less than 0.042 inches, Citizens conclude that a monitoring frequency of every 4 years is too long. Indeed, even if Mr. Tamburro were correct that the minimum margin is 0.064 inches, a possibility that 0.042 inches could be lost each outage if coating decay commences would still indicate that monitoring should be undertaken every outage.

Mr. Cavallo in his affidavit does not dispute that deterioration of the coating could occur, indeed he admits that it is possible that repair of the coating might be necessary at some point. Affidavit of Jon R. Cavallo, dated March 26, 2007 at ¶ 22. He also states that the inspection frequency is once every four years. *Id.* at ¶ 20. In addition, Citizens have previously alleged that enough moisture to cause corrosion could be present at the surface of the drywell shell without water running in the drains. Finally, AmerGen has never been able to definitively trace the source of all the water in the drywell to the refueling cavity and has admitted that it has not yet been able devise a way to ensure that the refueling cavity does not leak. Transcript from ACRS Meeting on Feb. 1, 2007 at 217-222. In addition to the refueling cavity, water on the exterior of

the drywell could come from condensation during an outage and from the equipment pool. Thus, AmerGen has not ruled out the possibility of corrosion developing between inspections.

ARGUMENT

I. Legal Standards For Summary Disposition

Summary disposition is only possible "if the filings in the proceeding, depositions, answers to interrogatories and admissions on file, together with the statements of the parties and the affidavits, if any, show that there is no genuine issue as to any material fact and the moving party is entitled to a decision as a matter of law." 10 C.F.R. §§ 2.1205(c), 2.710(d)(2). Prior NRC opinion has held that summary disposition motions under 10 C.F.R. § 2.749 (the equivalent rule prior to the revision of 2004) should be evaluated under the same standards as motions made under Federal Rules of Civil Procedure, Rule 56. *Advanced Med. Sys., Inc*, CLI-93-22, 38 N.R.C. 98, 102 (1993).

Under this rule, the moving party bears the burden of proving the absence of a genuine issue of material fact. *Adickes v. Kress & Co.*, 398 U.S. 144, 157 (1970). Because the burden of proof is on the movant, the evidence submitted "must be viewed in the light most favorable to the opposing party." *Id.* Where a moving party shows a lack of a material dispute, the party opposing summary disposition must respond by setting forth specific facts showing there is a genuine issue. 10 C.F.R. § 2.710(b). A genuine issue is one in which "the factual record, considered in its entirety, must be enough in doubt so that there is a reason to hold a hearing to resolve the issue." *Cleveland Elec. Illuminating Co.* (Perry Nuclear Power Plant, Units 1 and 2), LBP–83-46, 18 N.R.C. 218, 223 (1983).

Generally, under Rule 56, summary dispositions may not rest on credibility determinations. *Leonard v. Dixie Well Service and Supply, Inc.*, 828 F. 2d 291, 294 (5th Cir. 1987). Thus, conflicting opinions from experts generally preclude summary disposition.

However, such a conflict may be illusory, if the opinion of one expert would not be admissible at trial. Therefore, if the opinions of two experts appear to conflict with each other and there is no dispute that could be raised without the expert testimony, Federal Rule of Evidence 702 may be used to help decide whether summary disposition is appropriate. *Duke Cogema Stone & Webster (Savanna River Mixed Oxide Fuel Fabrication Facility)*, LBP-05-04, 61 N.R.C. 71, 80-81, (2005) ("DCS"). This rule permits a witness, qualified as an expert, to testify to assist the trier of fact to understand the evidence if 1) the testimony is based upon sufficient facts or data, 2) the testimony is the product of reliable principles and methods, and 3) the witness has applied the principles and methods reliably to the facts of the case. Fed. R. Evid. 702.

Generally, testimony that is based on a "reliable foundation and is relevant to the task at hand" will be admitted. *Daubert v. Merrill Dow Pharm.*, 509 U.S. 579, 597 (1973). Evidence based upon "scientifically valid principles" will meet this burden. *Id.* Federal courts have applied Rule 702 liberally, favoring the admission of expert testimony to assist the trier of fact. DCS at 15, citing *Kannankeril v. Terminix Int'l*, 128 F. 3d 802, 806 (3rd Cir. 1997).

Thus, where there are material disputes based on sound expert opinion summary disposition in unavailable as the Commission has stated:

> Where there is disagreement among competing experts over material facts, summary judgment may not be appropriate if it would require the trier of fact to untangle the expert affidavits and decide which experts are more correct. In that case, a hearing, if permitted by the applicable procedures, is the appropriate forum for the trier of fact to weigh the competing expert opinions on material facts.

DCS at 15; *see also Schering Corp v. Geneva Pharm.* 339 F. 3d 1373, 1377 (Fed. Cir. 2003) *citing Continental Can v. Montsanto*, 948 F. 2d 1264, 1269 (Fed. Cir. 1991) (resolution of disputed fact requiring expert opinion is improper on summary judgment); *Spirit Airlines v. Northwest*, 431 F. 3d 917, 931 (6th Cir. 2005) ("Our precedents hold that if the opposing party's

expert provides a reliable and reasonable opinion with factual support, summary judgment is inappropriate."); *Scharf v. U.S. Atty Gen.*, 597 F. 2d 1240, 1243 (9th Cir. 1979) ("The affidavit in support of this theory was hardly convincing, but it required the court to resolve an issue of fact based on conflicting expert testimony. This is not the court's function on summary judgment."); *Sierra v. El Paso Gold Mines*, 421 F. 3d 1133, 1150 (10th Cir. 2005) ("There is a genuine issue of material fact regarding the source of pollutants discharged at the portal, and summary judgment was not appropriate.")

As discussed in more detail below, summary disposition at this stage is inappropriate because AmerGen's motion for summary disposition does not meet the movant's burden to show that there are no material issues in dispute. Moreover, the contention was supported by the record and by Dr. Rudolf Hausler's affidavit, which was based upon the facts in the record and use scientifically valid methods to assess the evidence available. Sine the contention was admitted, the evidence showing that the contention raised multiple genuine disputes of material fact has only increased.

II. Summary Disposition Is Inappropriate As A Matter Of Law

AmerGen, as the moving party, bears the burden of proving that there is no genuine issue of material fact, even when the facts are viewed in the light most favorable to Citizens. *Adickes v. Kress & Co.*, 398 U.S. 144, 157 (1970). It has failed to do so. This contention was admitted by the ALSB because sufficiently reliable evidence was presented in the form of references to the record and an expert affidavit to prove that genuine disputes of material facts existed. *Memorandum and Order*, ASLB, LBP-06-07, Feb. 27, 2006 and *Memorandum and Order*, ASLB, LBP-06-22, Oct. 10, 2006. Although AmerGen attempted to proffer new facts concerning the local area acceptance criterion and the potential for future corrosion, its assertions about the formed are contradicted by the record, while its critical assertion about the latter was

made by someone who is not qualified to provide an expert option on the issue, was unsupported by the record, and contradicted AmerGen's other experts. Thus, AmerGen's current motion does not contain sufficient new information to eliminate the need for a hearing and to allow the contention to be adjudicated by summary disposition.

In particular, AmerGen relies upon the affidavit of Mr. Peter Tamburro to attempt to show that there is no material dispute regarding the current margin available. However, his affidavit is inadequate for this purpose because, as shown in detail in the Statement of Facts, pp 5-7, Mr. Tamburro's testimony regarding the local area acceptance criterion is contradicted by the record.

Furthermore, AmerGen relies upon Mr. Tamburro's affidavit to assert that a corrosion rate of 0.017 inches could not occur in the future, Tamburro Aff. at ¶ 38, but Mr. Tamburro's opinion regarding future corrosion rates is not admissible because AmerGen has failed to show that Mr. Tamburro is a corrosion expert. He cannot therefore offer hypothetical opinions about future corrosion. Moreover, Mr. Tamburro's opinion in this regard is inconsistent with the documents he has prepared that are in the record. While he denies that a corrosion rate of 0.017 inches is possible, he asserts that another round of external UT measurements would be prudent within two years to "provide additional data," because he calculated that the maximum localized historic corrosion rate was 0.0335 inches per year. Ex. SJA 1 at 49.

In contrast to Mr. Tamburro, AmerGen's corrosion experts, Mr. Barry Gordon and Mr. Jon R. Cavallo, fail to foreclose the potential for future corrosion. Mr. Gordon estimated that if the external coating failed and moisture reached the metal surface, metal loss could be up to 0.042 inches in 56 weeks. Affidavit of Barry Gordon, dated Mar. 26, 2007 at ¶ 18. Thus, Mr. Gordon's opinion admits the possibility of additional corrosion at an appreciable rate.

Mr. Cavallo also admits that deterioration of the outer coating could occur and that repair of the coating might be required in the future. Affidavit of Jon R. Cavallo, dated Mar. 26, 2007 at ¶ 22. Mr. Cavallo also admits that the current inspection frequency is once every four years. Id. at ¶ 20.

In conclusion, summary disposition is inappropriate as a matter of law. Even without any new opinion from Dr. Hausler, summary disposition would be inappropriate because the Board has already decided that Citizens have properly raised the contention and AmerGen has not shown that Dr. Hausler's opinion in support of the contention is no longer supported by the record. Thus, AmerGen's argument for summary disposition does not even properly allege that there are no genuine material issues to be adjudicated.

In particular, AmerGen has failed to produce any admissible testimony to explain why it has selected the current monitoring frequency of every four years and AmerGen has also failed to properly address the issues of the local acceptance criterion and the potential corrosion rate. Instead of clarifying the inconsistencies in the record concerning the local area acceptance criterion, AmerGen has actually added to the dispute by proffering a version of this criterion that is contradicted by the record. Without resolving this dispute, it is impossible to calculate the current margin.

Furthermore, while only one of AmerGen's affiants, Mr. Tamburro, attempted to raise a dispute with Dr. Hausler regarding the potential future corrosion rate under corrosive conditions, his opinion on this issue failed to provide any support and was outside the scope of his expertise. In contrast, Mr. Gordon and Mr. Cavallo, AmerGen's other experts, failed to foreclose the possibility that significant corrosion could occur between inspections. Indeed, AmerGen's decision to put in place an ongoing monitoring program illustrates that it also believes that future

corrosion could occur. Thus, as a matter of law, AmerGen has failed to meet its burden to show that corrosion to beyond safety requirements could not occur within the 4 year interval between inspections. Therefore, the Atomic Safety and Licensing Board ("ASLB" or "Board") should dismiss AmerGen's motion for summary disposition as inadequate as a matter of law.

III. The Contention Continues To Be Soundly Based On The Record And The Opinions of Dr. Hausler

Having shown that AmerGen has failed even properly allege a lack of material dispute, this Section shows that the evidence supporting the contention has in fact strengthened during this proceeding. Thus, even if AmerGen had met its burden of properly alleging a lack of material dispute, AmerGen's motion for summary disposition would still need to be dismissed because the material disputes that the Board identified when it admitted the contention have not been resolved. Citizens' assertions about the disputed issues continue to be soundly based on the record in this proceeding and on the opinions of Dr. Rudolf H. Hausler.

The ASLB in its opinions admitting the contention currently in dispute and the previous admitted contention, accepted Dr. Hausler as a qualified expert. (See *Memorandum and Order*, ASLB, LBP-06-07, p. 44, FN 33, Feb. 27, 2006 and Memorandum and Order, ASLB, LBP-06-22, p. 21, FN 14, Oct. 10, 2006). In admitting the contentions, the Board found Dr. Hausler's opinions to be sufficiently reliable and supported by the record. Thus, there is now no question about his qualifications and it is clear that his memoranda were based squarely on the record.

The only way in which AmerGen could obtain summary judgment at this time would be to show that further discovery has shown that the factual support previously offered for the contention has become inadequate. This Answer and Dr. Hausler's new opinion provide specific citations to the record illustrating that far from contradicting the opinions contained in Dr. Hausler's June 23, 2006, Memorandum, the additional discovery shows that that opinion was

entirely reasonable and reliable, and the contention continues to be fully supported by the record and Dr. Hausler's opinion.

In fact, as discussed on pp 5-12 above, far from weakening the factual foundations of the contention, further discovery has actually strengthened its basis. Since Citizens filed their motion to add the current contention, AmerGen has made the local area acceptance criterion more stringent. In addition, the latest results, taken in October 2006, show that the drywell shell is now thinner than the 1992 measurements indicated. Thus, margins are now even narrower than they were when Citizens filed the contention.

AmerGen's motion for summary disposition actually reads more like an attack on the basis of the contention, which is somewhat quixotic, because that basis has already been accepted by the Board and is therefore *res judicata*. The only way that such an approach could be successful is if record evidence had emerged after the contention was admitted that eliminated the original basis. Here, this approach must fail, because the opposite has happened. As the Statement of Facts shows, the record evidence is now even more favorable to Citizens than it was when the contention was admitted. Thus, to be consistent with its prior decision to admit the contention, this Board must dismiss the Motion for Summary Disposition.

IV. Summary Disposition Is Inappropriate Because Many Material Issues Are In Dispute

The Statement of Facts illustrated that many material issues are in dispute. Strangely, instead of showing a lack of material disputes, through its Motion for Summary Disposition AmerGen has actually attempted to create a material dispute about the local area acceptance criterion that must be met by the thickness results from the UT testing in the sandbed region of the drywell. Furthermore, the minimum margin available when the UT testing results are compared to the acceptance criteria remains in dispute, as does the potential extent and rate of

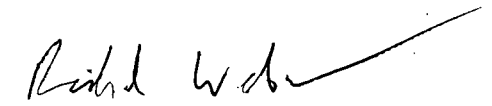
future corrosion. As a consequence, the frequency of UT testing to ensure that the thickness of the drywell does not fall below safety requirements during any extended license renewal period is in dispute. Adding together the potential for corrosion to occur in the future from both the outside and the inside, Citizens continue to assert that a four year interval between UT measurements is too long. If and when Citizens are able to ascertain how AmerGen has computed the margins for all the areas that are thinner than 0.736 inches, but larger than 2 inches in diameter, they will be able to provide a more accurate estimate of the appropriate monitoring frequency.

As the Board has already found, and this pleading further illustrates, Citizens' arguments about these disputes are soundly based upon the record and admissible scientific testimony. On a motion for summary disposition, the Board should view the facts in the light that is most favorable for Citizens. Therefore, as a matter of fact, because there are genuine disputes about many material issues, summary disposition is inappropriate.

CONCLUSION

For the foregoing reasons, the ASLB should dismiss AmerGen's Motion for Summary Disposition.

Respectfully submitted



Richard Webster, Esq
RUTGERS ENVIRONMENTAL LAW CLINIC
Attorneys for Citizens

Dated: April 26, 2007

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)	)	April 26, 2007
	)	

CERTIFICATE OF SERVICE

I, Karen Hughes, of full age, certify as follows:

1. I am a paralegal at the Rutgers Environmental Law Center (RELC). The RELC represents Citizens in this matter.

2. I hereby certify that on April 26, 2007, I caused Citizens response to a summary disposition to be served via email and U.S. Postal Service on the following:

Secretary of the Commission (Email and original and 2 copies via U.S Postal Service)
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Signed: Karen Hughes
Karen Hughes

Dated: April 26, 2007

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
OFFICE OF THE SECRETARY

ATOMIC SAFETY AND LICENSING BOARD

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

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

AFFIDAVIT OF DR. RUDOLF H. HAUSLER

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

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

2. The attached memorandum dated April 25, 2007 represents my current opinion on the topics it covers.

3. I believe that the currently proposed UT monitoring frequency of every four years is inadequate for the reasons stated in the attached memorandum.

4. I do not believe that the affidavits presented by AmerGen, which I have reviewed in detail, show that there are no outstanding issues left to be resolved in this proceeding.

5. I declare under penalty of perjury that this affidavit and the attached memorandum are factually accurate to the best of my knowledge, information and belief.

Dr. Rudolf H. Hausler

Sworn to me this 25th day of April, 2007

Notary Public

AMBER NICOLE DOTSON
NOTARY PUBLIC
State of Texas
Comm. Exp. 04-03-2010

CORRO-CONSULTA

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MEMORANDUM

To: Richard Webster, ESQ
Rutgers Environmental Law Clinic
123 Washington Street
Newark, NJ, 07102

April 25, 2007

From: Rudolf H. Hausler

Subject: **Update of Current Knowledge Regarding the State of Integrity of OCNGS Drywell Liner and Comments Pertaining to Aging Management Thereof**

Summary

- The proposed aging management plan for the Oyster Creek Drywell Liner, as proposed by AmerGen, is being discussed. It is shown that the UT monitoring locations (6 by 6 inch grids inside the drywell) as defined in 1989 are not representative of the corrosion, which had occurred in the sandbed region.
- Furthermore, since the outside of the drywell in the sandbed region had been coated in 1992, corrosion in the upper regions of the sandbed (i.e. where monitoring is being proposed) has become less relevant because water accumulations (the primary causes for corrosion) will now more likely occur towards the bottom of the former sandbed region.
- The primary cause for additional damage to the drywell by continued corrosion will be the formation of defects in the epoxy coating.
- Since there is no way to assess the **rate** of deterioration of a coating, which for all intents and purposes is already past its useful life, the frequency of inspections must be increased because the coating could fail at any time.
- These changes represent a completely new paradigm for the drywell aging management. The entire program, which had been in use since1987 or 1998, needs rethinking. The best approach would be to make use of continuous moisture monitors and possible online corrosion monitors (it is possible to monitor electrochemical potentials as indications of the onset of corrosion) to supplement the UT testing.
- Frequency of monitoring depends on the remaining safety margins. It is therefore important to gain understanding of the areal extent of the existing corrosion

damage. Based on the limited understanding of the extent of locally thin areas, the drywell shell could already be in unacceptable condition. Averages from point measurements (UT measurements) are not the best measure to define average thickness of the whole sandbed region, because the mean itself has uncertainty attached. At minimum, the lower 95% confidence limit of the mean of a number of UT measurements over that area should be employed. A comparison between these values with the safety criteria shows that the margins have become very thin in the areas where an assessment is possible, and that therefore frequent monitoring needs to be instituted to ensure significant further corrosion is prevented.

I. Background

Since severe corrosion had been found in the late 1980's in the "sand bed area" of the drywell liner containing the nuclear reactor at the Oyster Creek power generating station, much work has gone into assessing the degree of the damage and modeling the effects of the damage on the integrity of the vessel. Since the drywell liner is a vital safety component, and in light of the pending application for re-licensing reactor operations for another 20 years, the questions surrounding the integrity of the drywell liner have come to the front and center of the stage once again.

There is no question that deterioration of the surface of the drywell shell will continue at some rate over time. Thus, at some point in the future the liner may no longer serve its intended function. This memorandum discusses how to estimate the residual life of the liner and plan an appropriate aging management program around such an estimate.

The bases for such considerations must necessarily be:

- The current state of deterioration of the liner, i.e. the extent of corrosion and how well has it been estimated in the past.
- The criteria by means of which serviceability is ascertained and the remaining margins to condemning the vessel
- The estimated potential future corrosion rate
- And finally the combination of remaining margin and potential rate of deterioration defines the minimum frequency of inspection.

While all of the above items have been estimated and hard numbers have been proffered and written in granite, there is, as will be shown below, great uncertainty surrounding all of the assertions, which have been used by Exelon/AmerGen to support its current approach of taking UT measurements once every four years in the sandbed region.

II. Current Knowledge Regarding the True State of Deterioration.

After corrosion had been found in the sandbed area a concerted effort was made to assess the corrosion rate in order to project the life of the structure. The tools in this effort were ultrasonic measurements (UT) at well-defined locations. In order to assure repeatability of the measurements, a template was constructed containing 49 openings for placement of the UT transducer. The 49 openings were spaced 1 inch apart over a 6 by 6 inch square. This 6 by 6 inch grid was placed repetitively at the inside of the drywell liner just below the vent pipe where the inside curb was lowered from about 2 feet to just over 9 inches (see Figure 1). In this manner, every bay was monitored systematically at intervals over the past 20^{+} years.[1)] In 1992 the sand was removed from the sandbed, and all steel surfaces as well as the sandbed floor were coated with an epoxy resin. UT measurements using the 6 by 6 inch grid performed in 1992, 1994, 1996 and 2006, always at exactly the same position, indicated that within the accuracy of the test (measuring procedure) the continued corrosion was at most small. That should not be surprising because a) the outside steel surface was now coated, b) water would not accumulate against the vessel at the location were the measurements were made because of the drains in the sandbed floor, and c) if corrosion were to commence it would most likely be at imperfections in the coating near the sandbed floor where indeed, standing water could be present (see discussion below).[2]

There are however a number of additional monitoring techniques that were used. In 1986 trenches were dug in the reactor floor in bays 17 and 5 to a depth about equal to the sandbed floor on the outside. It is noted that these trenches were not dug in the bays where the most severe corrosion had been observed. These trenches enabled the operator to perform UT measurements below the sandbed surface (prior to removal) from the inside. Additionally, after the sandbed had been removed, and upon visual inspection of the corroded areas, UT and other thickness measurements were made from on the outside of the drywell in the sandbed area. It was believed at that point that the most corroded areas had been selected visually for these measurements. As a consequence of all these measurements the operator AmerGen assured the NRC that the locations where the "grid measurements" had been performed were quite representative of the corrosion that had occurred on the outside of the drywell in the sandbed area (Ref. 4).

We take issue with this statement. In support of this contention, an effort was made to show graphically the remaining wall thickness observed in all of these various locations. Thus Figure 2 shows, by way of example, the remaining wall thickness from the 2006 UT measurements made with the help of 6 by 6 inch grids as a function of elevation in the **trench of Bay 17**. It is understood, as is described in Ref. 3 that 6 such grids were placed one on top of the other in the trench in order to capture the corrosion from the bottom to the top of the sandbed. Hence, if the bottom of the trench had the elevation about 9 feet, then the top of the 6 grids would have had an elevation of about 12 feet, which according to Figure 1 corresponds to the top of

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[1)] 7 Bays were monitored only with 1 by 6 inch templates – probably placed in the horizontal direction – Bay 1 was among those, even though Bay 1 was one of the most corroded Bays.

[2] Note that this region is above the concrete floor but just above or below the epoxy coating above the concrete and so is part of the sandbed region, not the embedded region.

the sandbed and is at least 9 inches higher than the top of the grid used for UT measurements from the inside. (Note, none of these elevations is terribly accurate, however, the top of the trench measurements were definitely lower (deeper pits) by a good margin than the inside grid measurements). Figure 2 plots all individual 2006 measurements from the trench in bay 17. The 6 traces represent the variation of the wall thickness in the horizontal direction while the traces themselves extend from the bottom of the trench (left hand side) to the top of the trench (right hand side). The undulations of the 6 traces, which are at times (at the same elevation) in synch and at other times out of phase clearly depict the nature of the "golf ball type" surface described in AmerGen literature (Ref. 1 pg. 4). Where the undulations are in synch one can estimate that the extent of the pit at that location extends over an area larger than just one inch in diameter [3)]. It should also be noted that the average amplitude of the undulations in Fig. 2 are of the order of 0.1 inch, i.e. the roughness of the surface at this point is only of that order of magnitude. AmerGen estimated the "roughness" of the surface to be rather of the order of 0.2 inches (Ref. 5 pg. 5).

The most striking observation is that the corrosion is most severe at the top, almost uniform in severity over most of the depth of the sandbed and again somewhat more severe at the very bottom. **In other words, one sees already in this presentation that it would be difficult to single out one small area by means of a 6 by 6 inch grid and claim it to be representative of the corrosion having occurred in the sandbed area.**

In Figure 3 an effort is being made to compare the average remaining wall thickness from trench measurements (averaged over the horizontal direction) with the average of the 6 by 6 grid measurement from the inside and the direct UT measurements from the outside. Also graphed in this figure are the averages of the outside measurements for the three zones for which data are reported (Ref. 5). What one can see is that the averages for the grid and the trench data overlap quite well at the same elevation. However, the average outside measurements are significantly lower at comparable elevations.[4)] This is probably because the choice of location for the external measurements was deliberately biased towards thin spots.

Finally in Figure 4 we see the spread of the 6 by 6 inch inside grid measurements superimposed on the averages of the other measurements.

<u>Conclusion:</u> What the superposition of the UT measurements in Bay 17 demonstrates is that wall loss ranges from zero to 33 percent, however, only the trench and outside measurements come close to represent the most severe corrosion at the highest elevations. The inside grid measurements give a distorted picture. It should also be remembered that the grid measurements at the inside curb cutout as well as those in the trench are only 6 inches wide. One

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[3)] AmerGen suggested that the "dimples" are about 0.5 inches in diameter (Ref. 1 pg. 4)

[4)] For the outside measurement averages had to be used in the graphical representations because exact elevations (or coordinates) of each point were not known. We only had the classifications into Zones as had been described in Ref. 5.

does not have, therefore any indications as to how far serious corrosion may have spread laterally around the circumference of the bay.

Figure 5 shows an analysis of the available 2006 data for Bay 13. Bay 13 is probably the second worst corroded bay apart from Bay 1. The averages for the external measurements for each zone are fairly similar, as are the 95% limits for the data spread. There is a 95% percent probability for the deepest penetration to be of the order of 48% of the original wall thickness. The superposition of the internal grid data shows a higher average and a narrower distribution of the data spread. Again one recognizes that the internal 6 by 6 inch grid measurements do not represent the worst corrosion degradation.

Finally in Figure 6 we show the distribution of the external measurements for Bay 1. One observes that the 95% lower limit of the data spread is around 40% of the original wall thickness, or indeed at a remaining wall thickness of 450 mils, which is 0.04 inches below the required sandbed thickness for the Design Pressure and Temperature. Because the external sampling in Bay 1 was designed to capture the thinnest points, this is a conservative estimate of the minimum wall thickness. However, given the need for a very high degree of confidence that the drywell shell is ready to withstand accident pressures and the uncertainty created by the sparse data set, I believe that a conservative approach is required in this case.

Conclusion: The deterioration of the drywell liner at Oyster Creek has been examined in various ways by UT measurements. These were in part systematic thickness measurements in predetermined locations (6 by 6 inch grids placed on the inside of the drywell at curb cut-outs –see Fig. 1, and in trenches dug below the inside floor to a depth roughly equal to the outside sandbed floor). These measurements were supplemented by residual wall thickness measurements performed on the outside of the drywell in locations where "visually" it had been determined that the deepest pits were located. (It must be interjected at this point that a pit of 600 mils cannot be distinguished visually from a pit of 500 mils). The location of these measurements is therefore rather arbitrary, but was presumed repeatable for the measurements in question.

All external UT measurements had been summarized by AmerGen (Ref. 7) for the purpose of determining the minimum safety margin still available. In order to better understand the prevailing corrosion mechanism the data had been separated in "zones" corresponding to increasing elevation above the sandbed floor (zone 1: < 9'4", zone 2: 9'4" to 10-'3", zone 3: 10'3" to 12'3", and zone 4 > 10'3"). The data obtained in 1992 and 2006 were combined and statistically analyzed for the following three effects: a) the two sets of measurements separated by time (and probably methodology or instrumentation), b) the effect of the elevation, and c) differences in the bays.

It was found that there is no significant effect of the time (Fig.7a). While there is a decrease of 19 mils between 1992 and 2006, this difference is not statistically

significant within the variability of the data. The differences between the zones, however are significant. Zone 2 is by far the most corrosive zone. When the bays are compared, one finds as expected that some bays have experienced little corrosion in contrast to others. The importance of these observations is obvious: they point again to the fact that the intensity of corrosion is a clear function of elevation and bay. Hence, averaging data and generalization may lead to doubtful conclusions.

In 2006 the validity of some of the external UT measurements was explored by measuring around the nominal original locations. These data were statistically evaluated in Figures 8, 9, 10 for Bays 15, 1 and Bay 19. The additional data collected in Bays 19 and 15 had been identified as "up" or "down", hence additional data sets identified as 2006 up and 2006 down were compared with the original 2006 data. It turns out for Bay 19 for instance that the UT penetrations identified as 2006 up were significantly lower than the measurements of 1992 with a probability of better than 95%. The difference between the 1992 and 2006 up data is 0.1 inch. Similarly for Bay 15 one finds that the 2006 up data are significantly lower than the original 1992 data by about 0.06 inches, although this difference is not significant at the 5% level. For Bay 1 there is practically no difference between the 2006 and the 1992 data sets, because of the two or three measurements in the non-corroded areas. Summarizing these results in Table 1, one finds that the lower 95% confidence limits for Bays 1, 15 are marginally within the 0.736-inch limit. Since one does not know exactly how extensive the "cancer of corrosion" in the sand bed area really is, it is very difficult to put this interpretation in perspective with the assessments made by AmerGen relative to areal criteria for thinned areas (see discussion below).

Two points must be made with regards to the evaluation of these measurements. All measurements are point measurements, and even though they are closely spaced it is nevertheless difficult to estimate the area over which the measured corrosion penetration may have occurred. This is all the more so for the external measurements. Furthermore, the pit distribution has been assumed to be random or Gaussian. AmerGen chose to disregard "outliers" which were two standard deviations from the mean (of 49 points) as erroneous or atypical measurements (Ref. 6 pg 16). However, the distribution of pit depth is not necessarily normal but can be exponential, depending on the sensitivity of the measuring technique. It is therefore totally inadmissible from a statistical point of view to discard, or disregard outliers <u>for which there is no physical explanation.</u>

It has been observed in the oil field for instance that wall penetration may occur in pipelines as single events totally unpredicted and unpredictable by statistical means; one single event within 18 miles after 6 months surrounded by practically virgin surface.

Pitting on metal surfaces may be considered random if the surrounding environment is uniform, homogenous, and clearly identifiable, because the imperfections in the metal are most likely randomly distributed. (There are of course many well-known arguments against this, such as oriented inclusions due to metalworking, however the assumptions simplify the argument without distorting it). In case of the sandbed there is no randomness because of the predictable decrease in oxygen availability with

increasing depth and very likely uneven water content as well. This inhomogeneity is illustrated in Figure 2, where one can see greater corrosion attack toward the top of the sandbed. Similarly, the data show that in Bay 1 the corrosion below the ventpipe occurred more or less in a band of increased corrosion. This band appears to be about 6 to 7 feet long and perhaps a foot wide, although the lowest residual wall thickness (0.669) is found much deeper in the sandbed (Ref. 3). These data shown numerously in various discussions and appendices clearly demonstrate how difficult it is to assess the extent of the damaged areas as is necessary for comparison with the integrity criteria. For instance, the data gathered in Bay 1 in 2006 (and previous years) represent but a small fraction of the overall drywell liner surface exposed to the sandbed environment, and no amount of statistics can predict the pit distribution seen in Bay 1 (Fig. 5). Furthermore, again, the measurements which assess the corrosion in Bay 1 are all point measurements, and one has no way of assessing whether the pits are as local as the representation suggests or whether in fact the thin areas extend from one measurement to the next. I believe that when assessing the extent of severe corrosion, reviewers should assume that the measured points connect unless other measurements show this not to be the case.

III. The Fitness for Use Criteria

GE's original calculations stipulated that "if all UT wall thickness measurements in one Bay were above 736 mils, the bay would be evaluated as acceptable. In bays where measurements were below 736 mils, more detailed evaluation had to be performed" (Ref. 4, pg. 11 and Ref. 1 pg.4).

Subsequent calculations determined that if a 1 sq. ft. area were found with a thickness of 536 mils the theoretical load factor/eigenvalue would be reduced by 9.5%. The model stipulated that the1 sq. ft. area was surrounded by a tapering to 0.736 inches (Ref. 1 pg. 6) over a further one foot area. This additional area of reduced thickness contributed to the reduced load factor, hence also the stipulated safety factor. Similar calculations were performed for a reduction of the 1 sq. ft. area to 636 mils in which case the theoretical load factor and buckling stress would be reduced by 3.9%.

There are a number of questions that do arise in the context of these calculations and their application to the present situation of the OC drywell liner. We would like to make it clear from the outset that we are in no position to verify these calculations and are readily disposed to accept their veracity and results. We would, however, like to note the limitations of these results to put them in proper perspective.

1. AmerGenAmerGen states that GE established these criteria as acceptance criteria for the minimum thickness for the drywell to perform its intended function. That is incorrect, GE modeled the drywell, but the operator then derived acceptance criteria. For example, GE calculated both the 536 inch local thickness and the 636 local thickness with the same assumptions and both led to a reduced load factor. AmerGen and the previous operator then interpreted these results into the current local area acceptance criteria.

2. It is also not clear how the criteria deal with areas that are below 736 mils thick, but are not square.

While the acceptance criteria, whatever they may be, have been developed for certain well-defined geometries, one cannot immediately relate these to other geometries as they occur in real life.

Now, a new criterion has crept in which would render all previous criteria obsolete. Ref. 4 (pg 11 of 55) states that *if an area is less than 0.736 inches then that area shall be greater than 0.693 inches thick and shall be no larger than 6 inch by 6 inch wide. C-1302-187-5320-024 has previously positioned an area of the magnitude in bay 13, and within the uncertainties of measurement, such an area also exists in Bay 1.*

It is furthermore stated if an area is less than 0.693 inches thick then that area shall be greater than 0.490 inches thick and shall be no larger than 2 inches in diameter.

At present, if we assume that the external points measured in Bay 13 represent the surface, it appears that around 2 sq. ft. clustered around points 7, 15, 6, and 11 is less than 0.693 inches in thickness. In addition, over 4 sq. ft. containing points 12, 16, 7, 8, 11, 6, 15, and 5 appears to be less than 0.736 inches in average thickness. Similarly, in Bay 1 around 4 sq ft emcompassing points 12, 5, 13, 4, 12, 3, and 11 appear to be than less than 0.736 inches in average thickness. It is unclear how AmerGen decided that these results were acceptable, given the latest statement of the local area acceptance criterion.

IV. Statistics

Statistics have been used all through this discussion for different purposes. I think it is important to put the use of statistics in perspective as well. Basically there are three kinds of variabilities in the UT measurements as they have been used. First there is the variability of the instrument. The manufacturer usually specifies the "instrument error", in the case of modern UT instruments of the order of 1% of the thickness to be measured. The error usually is given as a standard deviation which means that the 95% confidence limits for the "naked" UT measurement is +/- 2% of wall thickness, in the present case about +/- 20 mils. This is the variability one would find if a calibration block was measured say 100 times. The next variability is a lot more difficult to define: It has to do with the placement of the sensor in the matrix, finding the same spot over again, holding the sensor in the same direction (vertical to the surface) each time etc. This variability (or variance) is additive to the instrumental variability. Finally the thing to be measured varies in thickness as well. This last variability is precisely the response that is desired. Because there have been no planned duplicate measurements (unless one were to assume that since 1992 no corrosion occurred) one cannot assess either the variability of the instrument nor the variability of the measuring technique. However, it is fair to say that the variability of a single measurement overall (i.e. the combination of the instrumental variance and the variance of the technique) are larger than the manufacturer's stated standard

deviation, probably double. With that assumption one might expect say 100 measurements of a single location to be distributed about their mean with a 95% confidence interval of +/- 40 mils. Hence a single measurement of a true value of 800 mils might lie anywhere between 760 and 840 mils, and this is probably an optimistic estimate.

Now, it has been assumed that the pitting phenomenon observed at the Oyster Creek drywell liner in the sandbed region was occurring in a truly random manner. It has been pointed out that this is very likely not the case. Nevertheless, lets just assume that Gaussian statistics might be applicable, simply because they are easy to calculate and are the most easily understood. If one measures with single measurements, as was done in all UT measurements, a number of locations say by means of a grid (template), one obtains a series of data reflecting the variation of metal thickness over a given area. At this point it is important to understand that these measurements are not members of a common universe which can be averaged to obtain an average measurement more truly characteristic of the universe than an individual measurement. Rather each measurement is a representative of a different universe – i.e. representing different pitting (corrosion) characteristics, or kinetics. Hence it really does not make much sense to average these measurements and say that on average "this is the corrosion rate". Rather on needs to characterize the variability of the results and superimpose onto them the instrument error. Hence if a specific measurement is, say 756 mils, it is with 95% probability somewhere between 716 and 796 mils. **Therefore, in order to be on the conservative side one would compare the 716 mils to the single point acceptance criteria, rather than the reported measurement.**

Furthermore, using the average of the grids to represent the entire surface is problematic for many reasons. First, suppose all the sensors had been placed at the low points in the pits. In that case the estimated average would be lower than the true average surface. More importantly, if in fact the corroded surface is like a golf ball surface, how does one average the thickness over the surface area when in fact one only has point measurements within the spherical depressions?

Clearly the entire approach is problematic and perhaps the saving grace is that the design codes require large safety margins. Nevertheless, in this case, when it has been shown that in some situations thickness measurements have been observed well below 693 mils (+/- 40 mils) and below to the 490-mil boundary (with 95% certainty), more detailed measurements are needed.

It has also been shown that the 6 by 6 grid measurements (let alone the 1 by 6 inch matrix measurements) do not represent the entire corroded areas. (Ref. 4: *A review of the 2006 inspection data of 106 external locations shows all the measured local thicknesses meet the established design criteria.* ***Comparison of this new data to the existing 19 locations used for corrosion monitoring leads to the conclusion that the 19 monitoring locations provide a representative sample population of drywell vessel in the sandbed.)*** This statement is patently wrong. However, it is not only

wrong because the measurements in the trenches and the external measurements do not agree with the grid measurements (19 monitoring locations), it is also wrong because corrosion, if it were to accelerate significantly, would now more likely occur near the bottom of the sand bed rather than the top as was the case with the sandbed in place.

All this not withstanding, it is also recognized that safety codes exist and that safety criteria have been developed. These codes and criteria specify the minimum thickness for *areas* while the corrosion measurements (UT) are highly localized **(points)**, and are said not to capture more than about 0.5 inches in diameter. One now has to confront the problem of translating point measurements to (average) area characteristics. This has been done by making a limited number of measurements in locations, which have been chosen by accessibility and convenience (grid locations). The measured data are then translated by averaging and assuming that the average represents the entire surface even though only 1% of the total may have been measured and even though it has been shown that the assumption won't hold.

It had for these reasons been suggested that the entire surface should be scanned in place of point measurements in selected areas. However, in the absence of scans it would seem prudent to maybe accept the notion that failures do not happen because of averages, but rather where there are extremes, in this case extremely thin areas. In this sense it is suggested that to use the variability of the corrosion data (spread of pit depths) and calculate the likely deepest pit or the most likely thinnest areas. Hence if an average of 10 measurements over a specific area results in a thickness of .750 inches with a variability (standard deviation) for the average of 0.03 inches, the lower 95% confidence limit for this average would be 0.69 (0.75 – 0.06).

In this sense the external measurements of Bays 1, 15, and 19 have been reexamined, and as Table 1 shows, at least in Bay 15 there is no additional margin for continued corrosion in the areas that have been monitored to this point.

V. Corrosion Underneath Coating

It is pretty well established that corrosion underneath an intact epoxy coating, especially a two-layer coating, will be immeasurably small. If it were to occur it would be of the rate of either oxygen or water diffusion through the coating, and either process is very slow. Furthermore, as we have said before, corrosion is more likely to occur near the concrete floor of the sandbed above and below the epoxy coating on the floor as we have pointed out before. For this reason alone the current monitoring program could miss significant corrosion, no matter how often UT measurements are being performed.

The entire paradigm of the drywell aging management program needs to be changed, as we have also pointed out before.

What is clear is that any defects in the coating will lead to corrosion damage, provided that there is water present. Hence, the first line of defense is to make sure that there is no water present. This is easier said than done since leaks have occurred before and condensation has also been an issue. Since one still is not sure where the water may be coming from one can safely assume that water could be present at some time in the future and at least during each outage.

The second line of defense is to make sure that the coating is intact. Originally the coating life was quoted as being 10 years. Then AmerGen increased the coating life to 15 years, since the 10 years have already elapsed. However, a 15 year coating life will bring its end of service up to September of this year, hence the coating life has to be 20 years, or at least into the next twenty years of service. All of this has been documented in AmerGen literature. Now, we know that the coating on the floor has suffered damage. The most recent inspection has shown that the coating on the floor was cracked in some bays along with the concrete of the former sandbed floor (Ref. 6) [5]. The cause was attributed to the concrete "shifting and breaking up". However, the other possibility that the coating failed (it was applied too thick to begin with) whereupon water entered the cracks in the concrete, which were there dating back to construction, was not considered. Nevertheless, it has been established in the 2006 inspection that the floor had broken up and that water had entered the cracks underneath the coating. This is a dangerous situation, because now water can migrate in the concrete underneath the coating to the concrete – steel interface. As a consequence corrosion can occur either above or below the floor level where it had been established previously by means of measurements from the trenches that considerable corrosion had already occurred. Hence monitoring has to occur frequently in those areas. It is doubtful that UT measurements in the trenches in Bays 5 and 17 would provide enough coverage for the entire system since essentially every other bay presents worse problems.

Coatings are never 100 % perfect. There are always holidays present, albeit perhaps few. AmerGen has chosen to discount that possibility on the grounds that two layers of coatings had been applied. While extensive qualification of the coating had occurred in 1992 in a mock-up outside the system, and while test coatings were extensively tested for holidays, such tests, albeit standardized and very easy to perform, were never performed once the coating had been applied in the sandbed area. Rather AmerGen insists that relying on visual observations is sufficient. Well, visual observation did not for the past 14 years reveal the defects in the coating on the floor until 2006 and there is no telling just how much damage may have occurred as a consequence. (The coating had been found in perfect conditions in 1994, 1996, 2000 and so on until 2006 when it was found broken up).

The coating is apparently colored gray. It is said that visual inspection will reveal damage and rust if it occurs. That is true after the deterioration has become

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[5] "During visual inspection of the drywell vessel's exterior coating in the sandbed region (Bays 1, 7, 9, 15) areas were observed to have voids. ... To prevent water from seeping underneath the epoxy, an expandable (?) sealer is required for the seams/voids.

noticeable, however, the question is not whether the coating has already failed, it is how much damage might occur between inspections after the coating fails.

For that reason it is held that a four-year inspection cycle is not enough by a long shot. First, one needs to monitor for water continuously. As experience has shown on the interior, water can easily percolate through the concrete, as has indeed happened and the operator still does not know where it comes from.

Second, defects in the coating need to be established where subsequent damage is most likely to occur, i.e. on the former sand bed floor and in the crease between the floor and the outside of the liner.

I don't want to go into the mechanism of corrosion once a defect has occurred other than to say the following: Once a defect (crack, pinhole, holiday etc) provides access for water to the steel surface underneath, corrosion begins slowly, hardly noticeable from the surface. However, as corrosion progresses the coating will start to crack, opening up a larger defect. (Thick coatings crack more easily than thin ones). Corrosion will progress underneath the coating and cause larger blisters, which may or may not be seen visually, but can be detected with simple test methods referenced earlier. The question of course is how rapidly will corrosion occur, and what is a reasonable time interval for inspection. I venture to say that nobody knows the answer to the first question with any certainty. It is therefore a matter of making a reasonable assumption, as I did previously. Overall, the applicant must now deal with the uncertainty is has created by taking very few UT measurements over space and time and relying on ad hoc methods for detection of moisture and coating degradation. Because we are dealing with a primary safety containment for a nuclear reactor, the uncertainties must be resolved against the applicant to ensure that a reasonable assurance of safety is maintained.

Kaufman, April 25, 2007

Rudolf H. Hausler

References

1. GPU Nuclear Calculation Sheet C-1302-187-5320-024, 1993, page 7 of 117
2. Affidavit of Peter Tamburro before the Atomic Safety and Licensing Board, Docket No 50-219, March 26, 2007
3. AmerGen Passport Document 005546049 07 (AR A2152754 E09), page 5, November 11, 2006
4. AmerGen Calculation sheet C-1302-187-E310-041, 2006, page 4 of 55
5. AmerGen Calculation Sheet C-1302-187-5300-01
6. OCLR R00014655

Schematic Cross Section through Sandbed Area
(not to size)

Figure 1

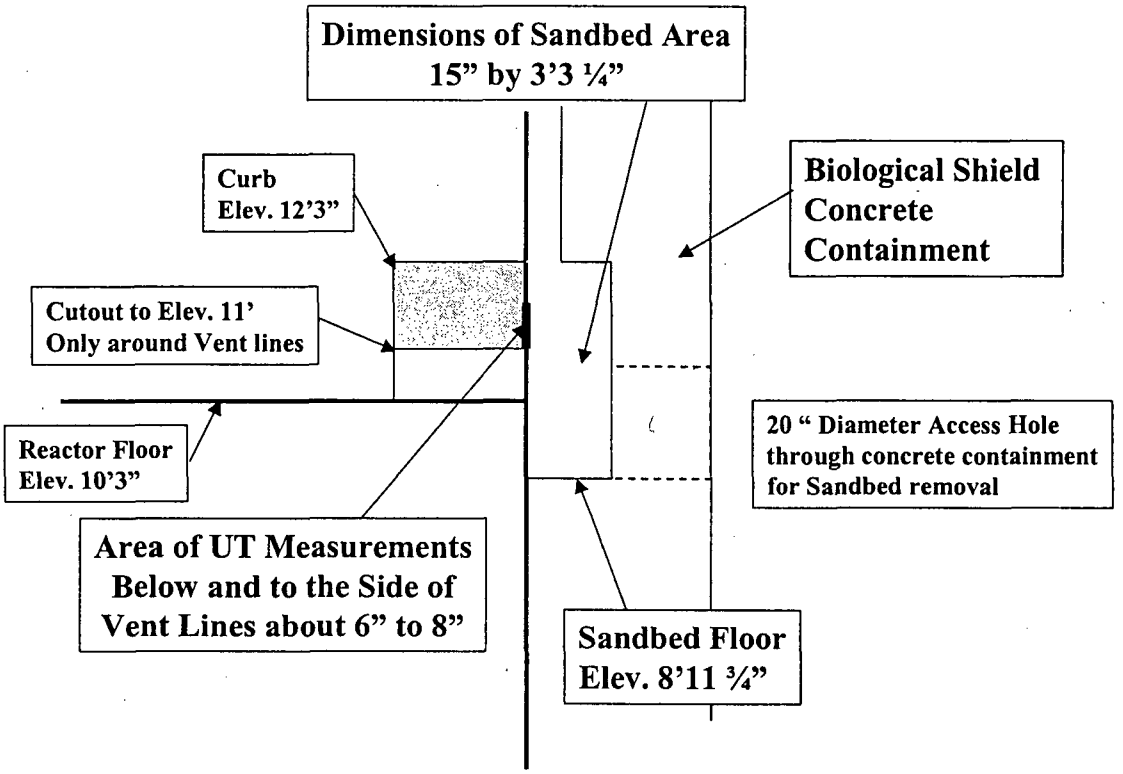


Figure 2

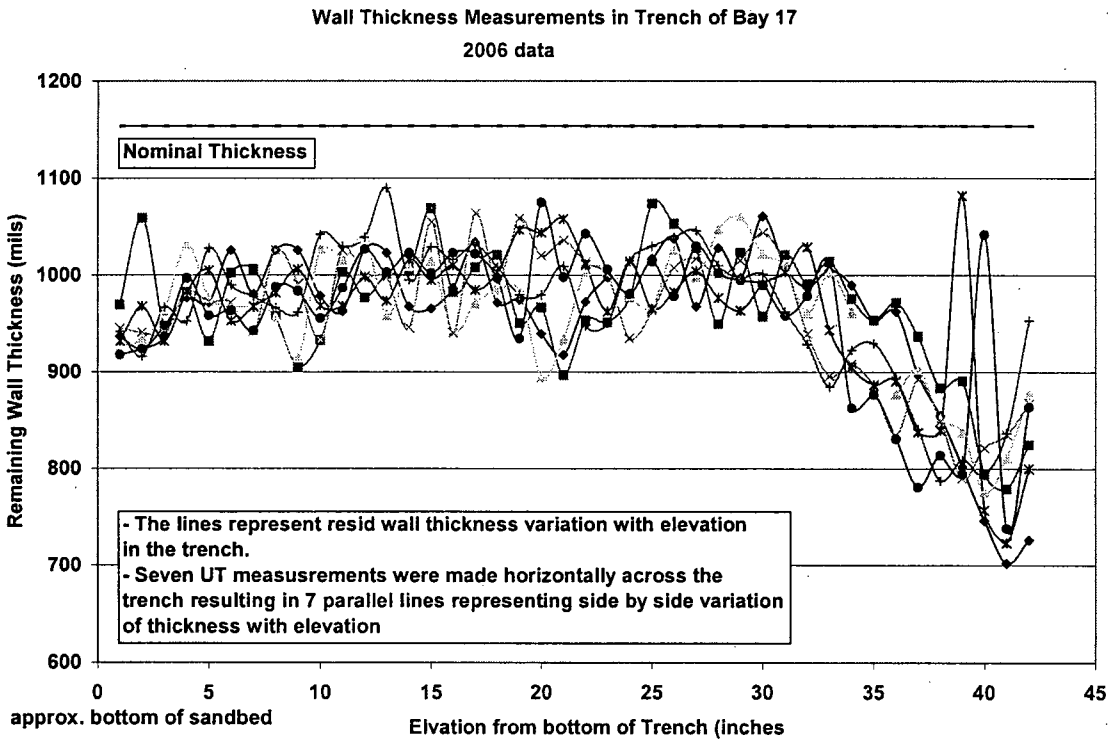

Wall Thickness Measurements in Trench of Bay 17
2006 data
Nominal Thickness
- The lines represent resid wall thickness variation with elevation in the trench.
- Seven UT measusrements were made horizontally across the trench resulting in 7 parallel lines representing side by side variation of thickness with elevation
Remaining Wall Thickness (mils)
1200
1100
1000
900
800
700
600
0
5
10
15
20
25
30
35
40
45
approx. bottom of sandbed
Elvation from bottom of Trench (inches

Figure 3

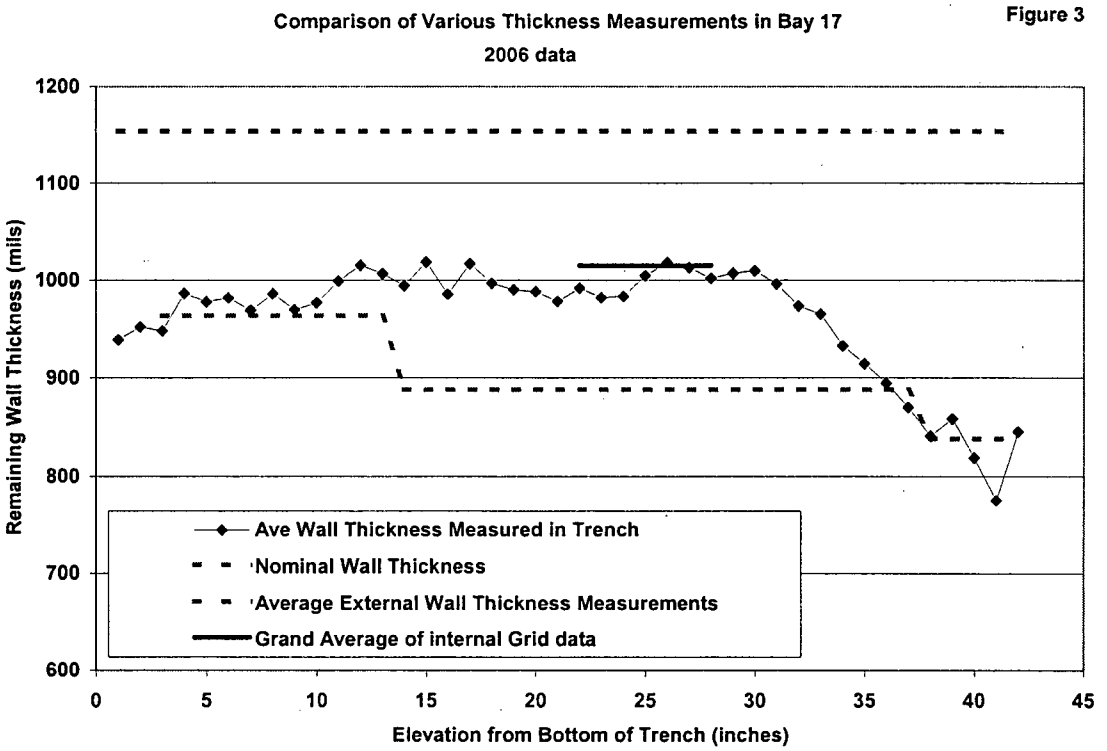

Comparison of Various Thickness Measurements in Bay 17
2006 data
Remaining Wall Thickness (mils)
1200
1100
1000
900
800
700
600
0
5
10
15
20
25
30
35
40
45
Elevation from Bottom of Trench (inches)
Ave Wall Thickness Measured in Trench
Nominal Wall Thickness
Average External Wall Thickness Measurements
Grand Average of internal Grid data

Figure 4

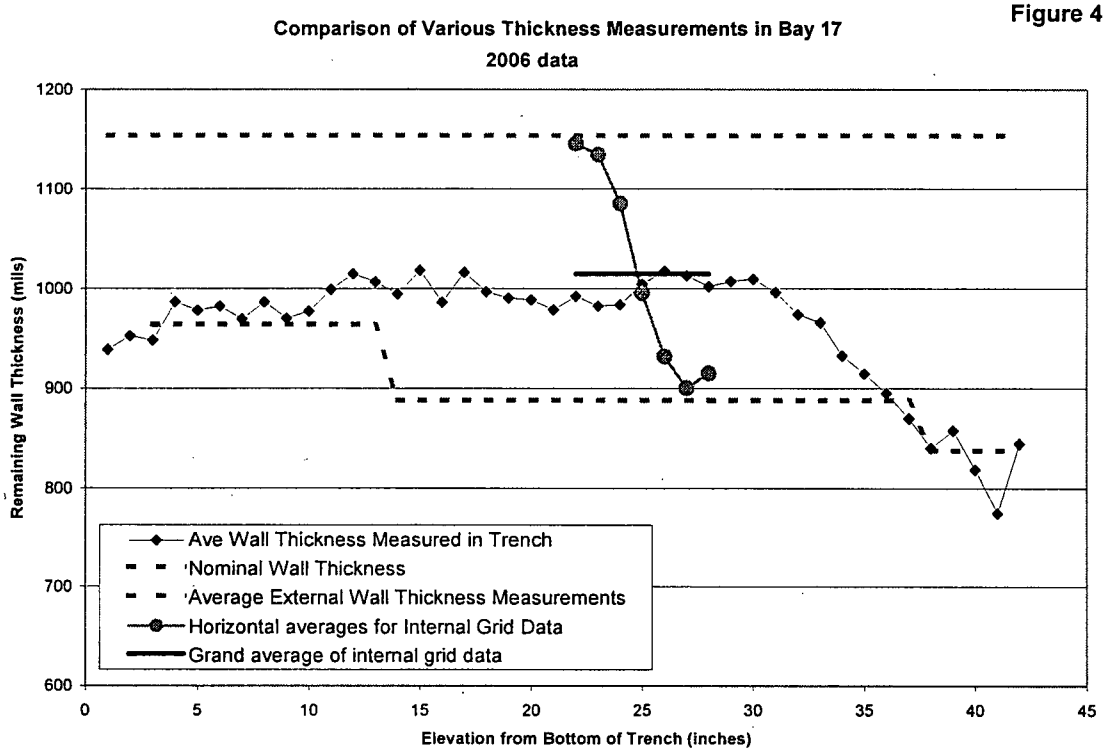
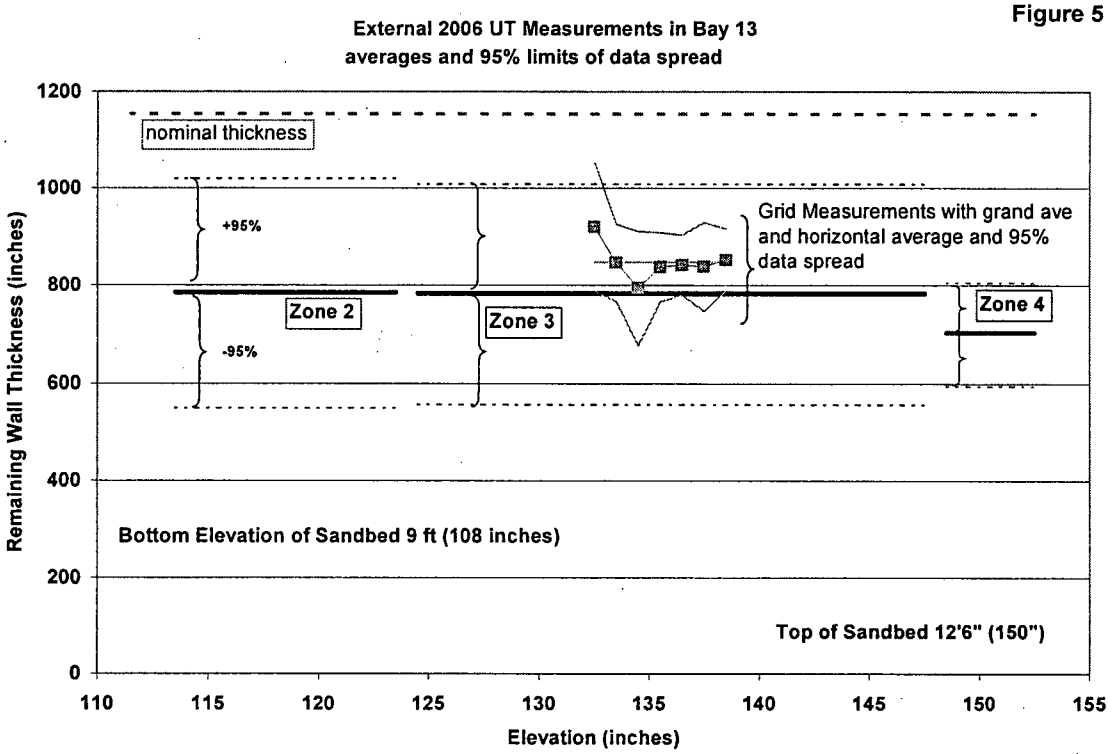


Figure 5



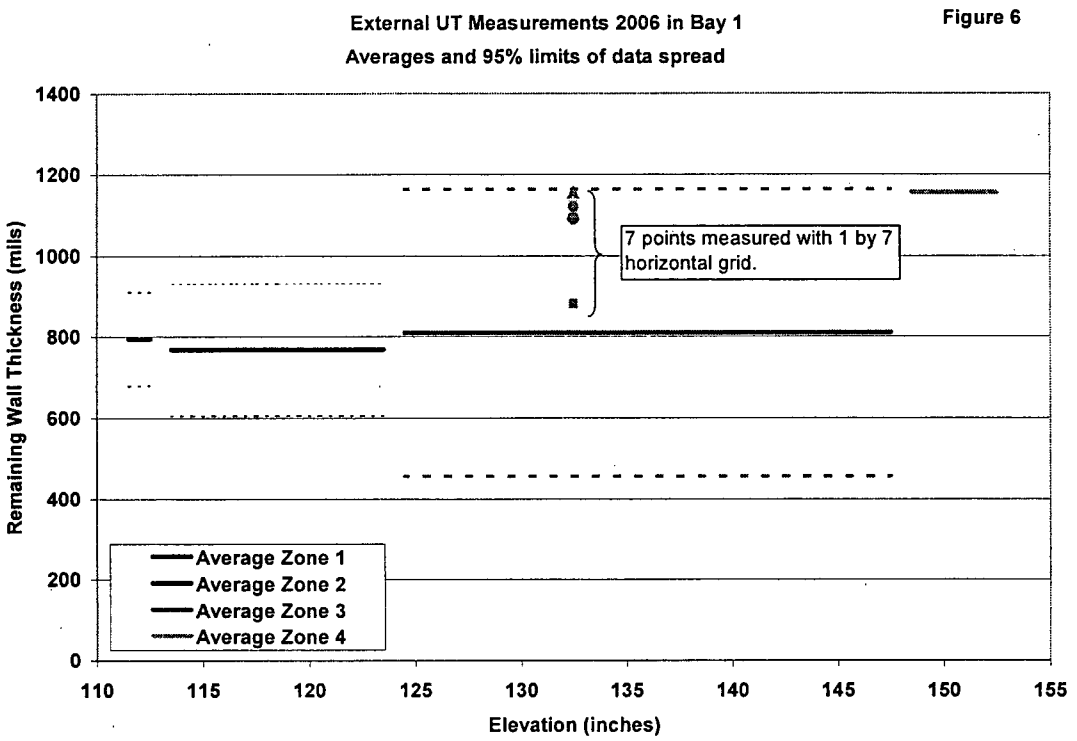

External UT Measurements 2006 in Bay 1
Averages and 95% limits of data spread
Figure 6
Remaining Wall Thickness (mils)
1400
1200
1000
800
600
400
200
0
110
115
120
125
130
135
140
145
150
155
Elevation (inches)
7 points measured with 1 by 7 horizontal grid.
Average Zone 1
Average Zone 2
Average Zone 3
Average Zone 4

Figure 7

Statistical Analysis of all External UT Measurements

Fig 7 a

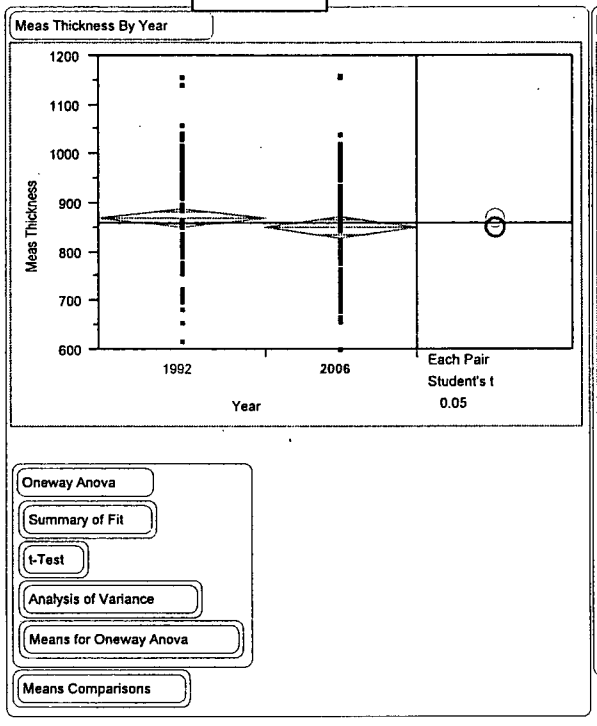


Figure 7b

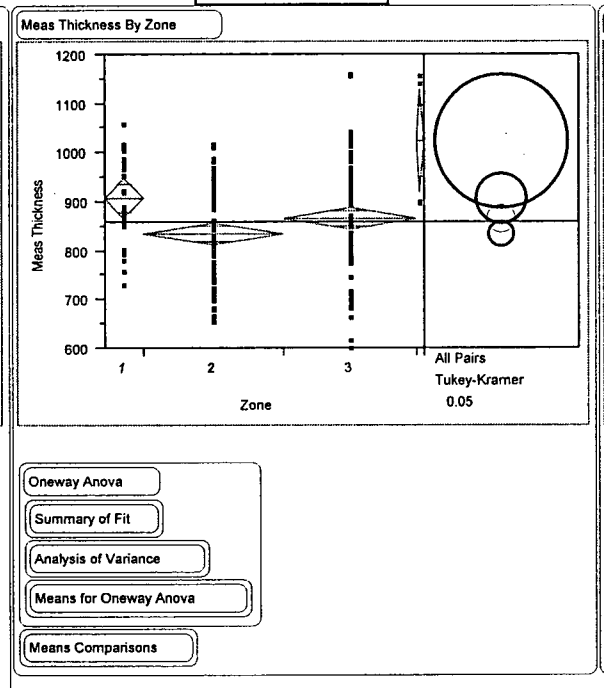
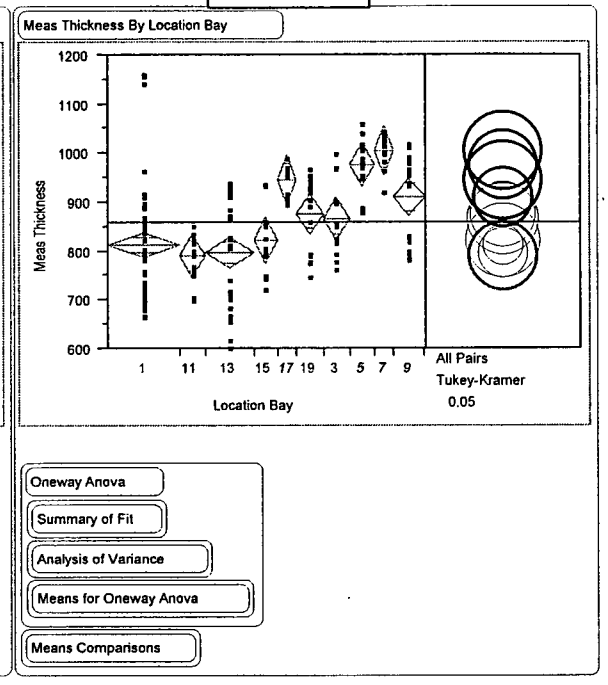
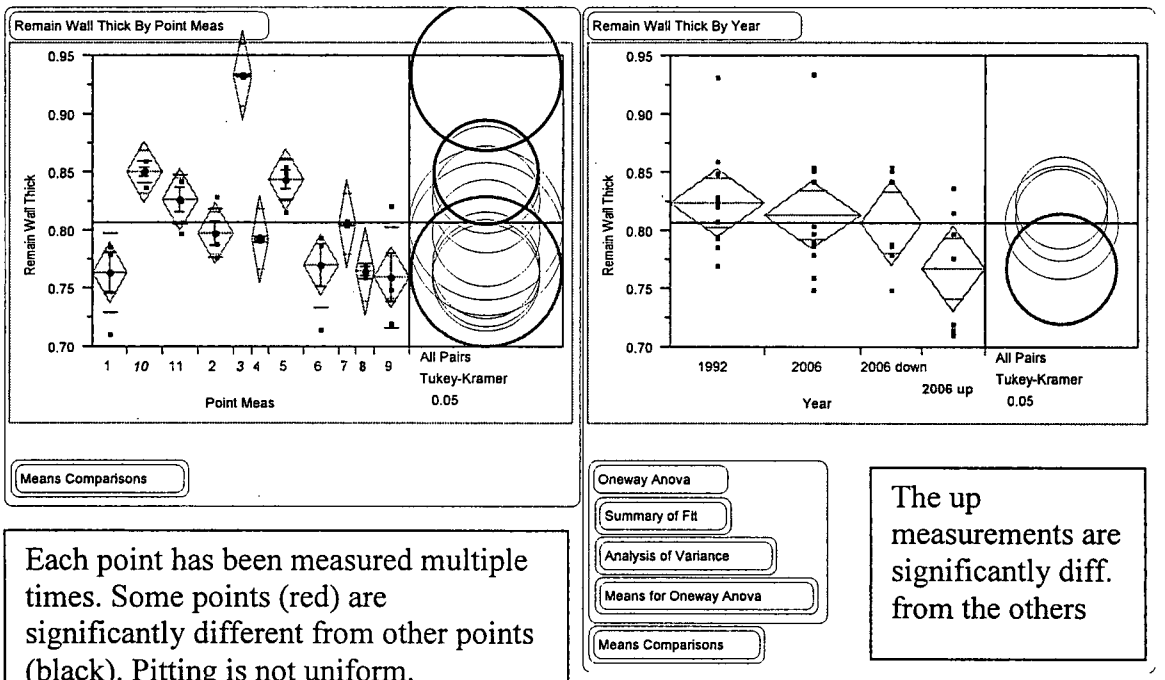


Figure 7c



Comments: Figure 7a: Comparison between measurements I 1992 and 2006 show no significant difference. The means from 1992 and 2006 show a bias of 0.018 inches, but the bias is statistically not significant despite of the many data points. Fig. 7b: The comparison between the "zones" (elevations) is significant. Zones 1 is significantly different from zones 2 and 3. For zone 4 there are not enough data for statistical significance. Fig. 7c: Some bays, red ones, are significantly different from the black ones.

Figure 8: External UT Measurements in Bay 15



Each point has been measured multiple times. Some points (red) are significantly different from other points (black). Pitting is not uniform.

The up measurements are significantly diff. from the others

Figure 9: External UT Measurements in Bay 1.

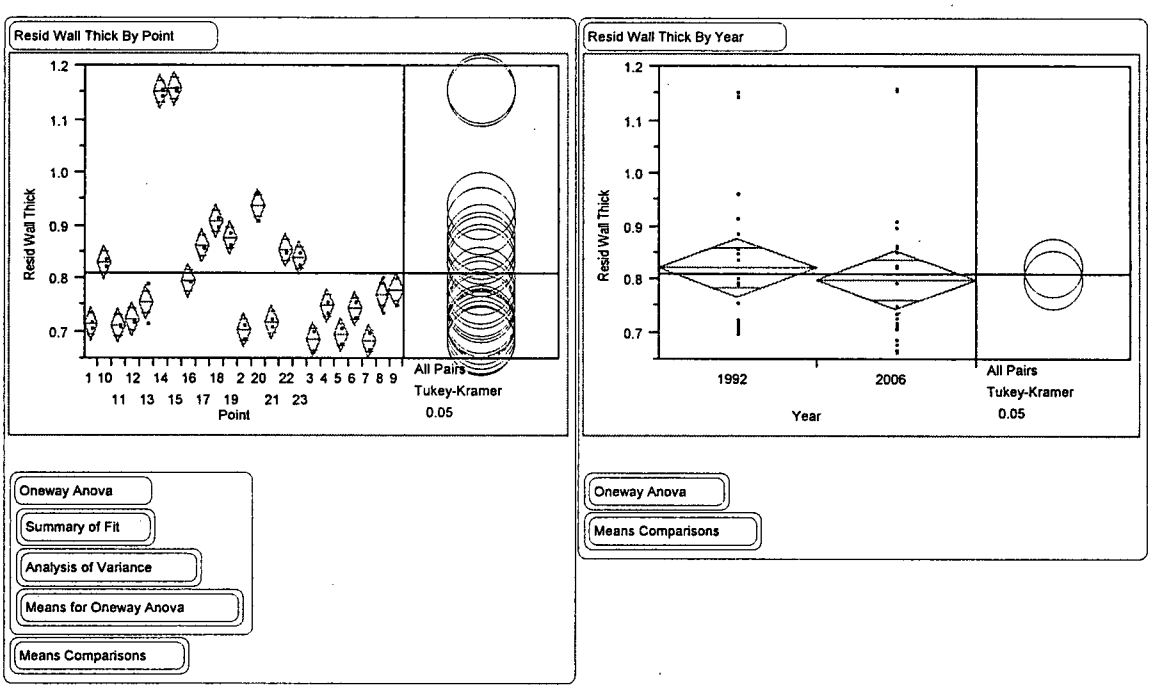
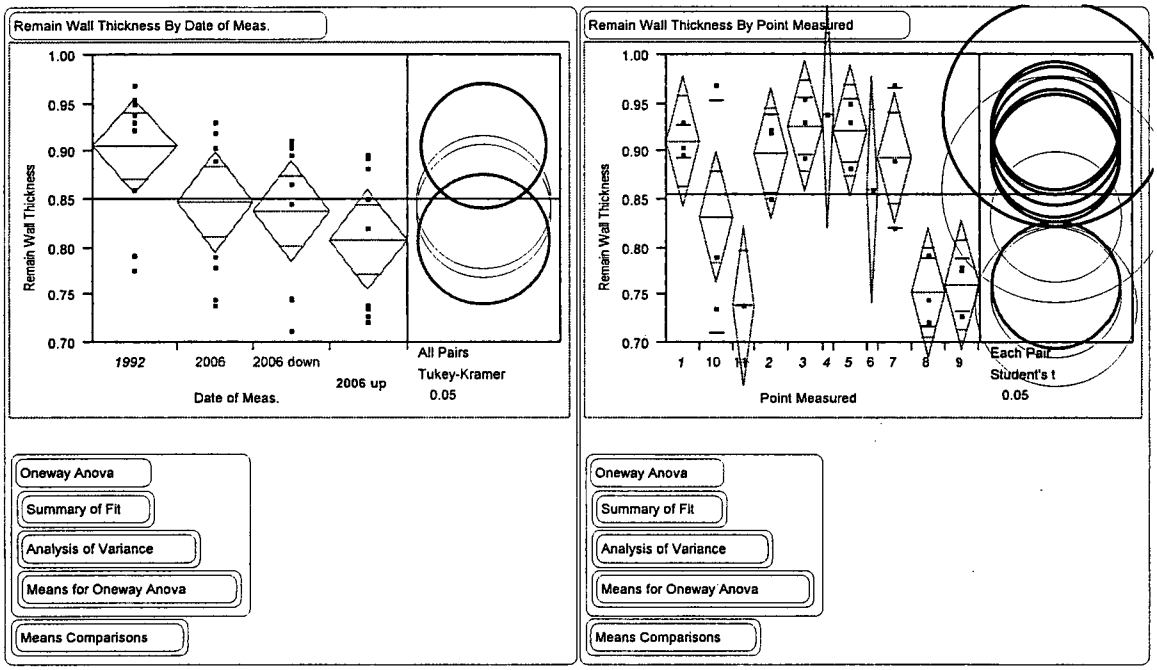


Figure 10: External UT measurements in Bay 19



Again one finds that the "up" measurements are significantly lower from the 1992 measurements.

Table 1

Average Remaining Wall Thickness Measured Externally in the Sandbed Region by UT

Bay	1992		2006		2006-up		2006 down	
	Average	Std Dev	Average	Std Dev	Average	Std Dev	Average	Std Dev
1	0.822	0.027	0.8	0.027				
15	0.825	0.014	0.814	0.014	0.808	0.018	0.768	0.0184
19	0.907	0.025	0.848	0.026	0.837	0.26	0.807	0.026

95 % Confidence Limits of lowest significant measusrements

Bay 1	**0.746**
Bay 15	**0.731**
Bay 19	**0.755**

EXHIBIT SJA 1

Exhibit SJA 1

Sandbed Corrosion Rate Assessments

ATTACHMENT 1
Design Analysis Cover Sheet

Design Analysis (Major Revision) | **Last Page No.** Attachment 5 page 20 of 20

Analysis No.: [1] C-1302-187-E310-041 **Revision:** [2] 0

Title: [3] Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006

EC/ECR No.: [4] 06-01078 **Revision:** [5] 0

		Component(s): [14]	
Station(s): [7]	Oyster Creek		
Unit No.: [8]	1		
Discipline: [9]	Mechanical		
Descrip. Code/Keyword: [10]			
Safety/QA Class: [11]	Q		
System Code: [12]	187		
Structure: [13]	Drywell Vessel		

CONTROLLED DOCUMENT REFERENCES [16]

Document No.:	From/To	Document No.:	From/To
C-1302187-5300-030 Rev. 0	From		
SE-000243-002, Rev. 14	From		
ECR 02-01441, Rev. 0	From		
C-1302187-5300-024 Rev. 1	From		

Is this Design Analysis Safeguards Information? [18] Yes ☐ No X If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] Yes ☐ No X If yes, ATI/AR#:

This Design Analysis SUPERCEDES: [18] **In its entirety.**

Description of Revision (list affected pages for partials): [19] See Summary of Change page (attached).

Preparer: [20] Peter Tamburro (Print Name) PATL (Sign Name) 12/11/06 (Date)

Method of Review: [21] **Detailed Review** ☒ **Alternate Calculations (attached)** ☐ **Testing** ☐

Reviewer: [22] Stephen Leshnoff (Print Name) Stephen Leshnoff (Sign Name) 12/11/06 (Date)

Review Notes: [23] Independent review ☒ Peer review ☐

The statistical analysis methods are comprehensive, thorough, and correct. The data was correctly captured. The analysis results are reasonable. The conclusions are correctly derived.

Checker: Kevin Muggleston Kevin Muggleston 12/11/06

(For External Analyses Only)
External Approver: [24] (Print Name) (Sign Name) (Date)

Exelon Reviewer: [25] (Print Name) (Sign Name) (Date)

Is a Supplemental Review Required? [26] Yes ☒ No ☒ * If yes, complete Attachment 3

Exelon Approver: [27] F. H. RAY (Print Name) F. Harry Ray (Sign Name) 12/15/06 (Date)

* See APPENDIX 23 FOR HU-AA-1212 REVIEWS.

	DOCUMENT NO.
	C-1302-187-E310-041

TITLE Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006

REV	SUMMARY OF CHANGE	APPROVAL	DATE
0			

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1.0 Purpose

The purpose of this calculation is to analyze the UT Inspection, which have been taken of the Drywell Vessel in the Sandbed Region for 1992, 1994, 1996, and 2006.

Specific objectives of this calculation are:

1) Determine the 1992, 1994, 1996, and 2006 mean thickness at each monitored location and compare them to acceptance criteria.
2) Determine the 1992, 1994, 1996, and 2006 thinnest recorded value at each monitored location and compare them to the appropriate acceptance criteria.
3) Statistically analyze measured thicknesses from 1992, 1994, 1996, and 2006 to determine if a statistically significant corrosion rate exists at each location,
4) If a statistically significant corrosion rate exists, provide a conservative projection to ensure future inspections are performed at conservative frequencies.
5) In addition this calculation will analyze the 106 UT data points collected in 1992 and again in 2006.

The conclusion of this calculation pertains to the Sandbed Region of the Drywell Vessel located above elevation 8' 11 1/4"which is not embedded in concrete on both sides.

Background

The inspections were performed at 19 separate locations (grids) located through-out the sandbed region. These inspections are performed from inside the drywell and are located at an elevation that corresponds to the sandbed region of the Drywell. These locations have been periodically inspected over time to determine corrosion rates. At least one grid is located in each of the 10 Drywell Sandbed Bays.

Twelve locations are each on a 6" by 6" area in which 49 separate UT readings are performed in a grid pattern on 1" centers. The grid pattern is located in the same location each time the inspection is performed within plus or minus 1/8 inch. Seven locations are each on a 1" by 6" area in which 7 separate UT readings are performed in a row pattern on 1" centers. The row pattern is located in the same location each time the inspection is performed within plus or minus 1/8 inch.

The grids with 49 readings correspond to bays that experienced the most identified corrosion prior to the repair in 1992.

In 1992, following the removal of the sand and corrosion byproducts from the sandbed region, the exterior of the Drywell Vessel was visually inspected from inside the sandbed. This inspection identified the thinnest local points in each of the 10 sandbed bays. These thinnest locations (approximately 115) were then UT inspected and documented with a single thickness value. These locations do not correspond with the 19 locations that were periodically monitored from inside the Drywell. These locations had not been re-inspected until 2006 when 106 were located and again UT inspected. These points were located using the 1992 NDE inspection data sheet maps. These UT readings were originally intended to provide a comparison to the acceptance criteria.

2.0 Summary of Results

Review of the 1992, 1994, 1996, and 2006 UT inspection data for all grids show that these monitored locations are experiencing no observable corrosion. These locations correspond to areas of the Sandbed Region of the Drywell Vessel that were coated in 1992 and are above the internal concrete curb and floor.

This conclusion is based on statistical testing of the mean thicknesses measured in 1992, 1994, 1996, and 2006 at each location; a point-to-point comparison of the thinnest reading measured in 2006 at each location, and sensitivity studies which have identified the minimum statistically observable rate of corrosion that would have to be present in order to have 95 percent confidence.

All measured mean and local thicknesses meet the established design basis criteria.

Sensitivity studies have identified the rates, which would be statistically observable given the limited number of inspections (four since the sandbed has been coated) and the variance of the data at the most critical location (19A).

Projections based on assumed corrosion rates corresponding to the calculated minimum statistically observable rates are used to determine the required inspection frequencies to ensure that all locations will continue to meet design basis requirements until the next scheduled inspection.

A review of the 2006 UT inspection data of 106 external locations shows all the measured local thicknesses meet the established design basis criteria. Comparison of this new data to the existing 19 locations used for corrosion monitoring leads to the conclusion that the 19 monitoring locations provide a representative sample population of Drywell Vessel in the Sandbed (see section 7.3).

The term "No Observable Corrosion" is being defined as: having "No Statistically Significant Rate of Corrosion". The actual margins remaining have considered rates based on actual differences between UT readings, which represent insignificant changes to shell thicknesses. However, to take a much more conservative approach in determining acceptable inspection frequencies for each of the locations, a sensitivity study has been performed to develop the minimum rate of corrosion that would have to exist in order to conclude with a high confidence level that in fact corrosion does exist. For the sandbed region, this approach is conservative since it includes the large standard error associated with the pre-existing surface irregularities due to corrosion of the exterior shell prior to 1992. This minimum observable rate that is defined is not indicative of an actual corrosion rate. It should also be noted that the results of this approach are significantly influenced by the amount of data used, and that additional inspection will reduce the minimum observable rate. This has been proven based on the upper drywell analysis that proved that as additional data and time were considered the actual rate (which was less than 1 mil per year) became observable.

The following table provides a breakdown of the location with the least amount of margin to the general criteria.

Table 1

Location ID	2006 Mean	Uniform Criteria	Delta	Margin Remaining
	(Inches)	(Inches)	(Inches)	Percentage
19A	0.8066	0.736	0.0706	9.6%

Evaluation of the mean thickness values of this location measured 1992, 1994, 1996 and 2006 shows that this location is experiencing negligible corrosion, approaching a rate of zero. However due to the limited amount of inspections this conclusion cannot be statistically confirmed with 95% confidence. Therefore the next inspection of this location shall be performed prior to the date in which the minimum statistically observable rate would drive the thickness to the minimum required thickness.

Table 2 - The following table provides a breakdown of the locations with the least amount of margin to local criteria.

Location ID	2006 Local Reading	Local Criteria	Delta	Margin Remaining
	(Inches)	(Inches)	(Inches)	Percentage
17D/13	0.648	0.490	0.158	32%
19A/4	0.648	0.490	0.158	32%

Evaluation of these individual values measured 1992, 1994, 1996 and 2006 shows that these points are experiencing negligible corrosion, approaching a rate of zero. However due to the limited amount of inspections this conclusion cannot be statistically confirmed with 95% confidence. Therefore the next inspection of this location shall be performed prior to the date in which the minimum statistically observable rate would drive the thickness to the minimum required thickness.

2.1 Twelve Internal Locations with 49 Readings

Twelve, 49 point grid inspections have been performed in 1992, 1994, 1996 and 2006 after the sand was removed and the coating was applied in 1992. Analysis of the mean values and the thinnest 2006 reading at these locations indicate no observable corrosion during this period.

Table 3 Compilation of the 49 Point Grid Means Over Time

Location ID		Mean Thickness based on 1992 Inspections	Mean Thickness based on 1994 Inspections	Mean Thickness based on 1996 Inspections	2006 Mean	Uniform Criteria	Conclusions
		(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	
9D		1.004	0.992	1.008	0.993		No observable corrosion
11A		0.825	0.820	0.830	0.822		No observable corrosion
11C	All	0.909	0.894	0.951	0.898		No observable corrosion
	Top	0.970	0.982	1.042	0.958		No observable corrosion
	Bottom	0.860	0.850	0.883	0.855		No observable corrosion
13A		0.858	0.837	0.853	0.846		No observable corrosion
13D	All	0.973	0.959	0.990	0.968		No observable corrosion
	Top	1.055	1.037	1.059	1.047		No observable corrosion
	Bottom	0.906	0.895	0.933	0.904		No observable corrosion
15D		1.058	1.053	1.066	1.053	0.736	No observable corrosion
17A	All	1.022	1.017	1.058	1.015		No observable corrosion
	Top	1.125	1.129	1.144	1.122		No observable corrosion
	Bottom	0.942	0.934	0.997	0.935		No observable corrosion
17D		0.817	0.810	0.848	0.818		No observable corrosion
17/19	All	0.983	0.970	0.980	0.969		No observable corrosion
	Top	0.976	0.963	0.967	0.964		No observable corrosion
	Bottom	0.989	0.975	0.990	0.972		No observable corrosion
19A		0.800	0.806	0.815	0.807		No observable corrosion
19B		0.840	0.824	0.837	0.847		No observable corrosion
19C		0.819	0.820	0.854	0.824		No observable corrosion

Locations that were previously split in two groups are shown for consistency with previous calculations.

Table 4 Compilation of the Lowest 2006 Reading in Each 49 Point Grid Over Time

Location ID/ Point	1992 Reading	1994 Reading	1996 Reading	Lowest 2006 Reading	Local Criteria	Conclusions
	(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	
9D/ 15	0.763	0.770	0.776	0.751	0.490	No observable corrosion
11A/20	0.677	0.677	0.668	0.669		No observable corrosion
11C/5	0.776	NA	1.14	0.767		No observable corrosion
13A/18	0.761	0.752	0.774	0.746		No observable corrosion
13D/49	0.824	0.811	0.822	0.821		No observable corrosion
15D/42	0.980	0.903	0.940	0.922		No observable corrosion
17A/40	0.804	0.809	0.983	0.802		No observable corrosion
17D/13	0.648	0.646	0.693	0.648		No observable corrosion
17-19/35	0.914	0.906	0.935	0.901		No observable corrosion
19A/4	0.659	0.650	0.680	0.648		No observable corrosion
19B/34	0.743	0.716	0.745	0.731		No observable corrosion
19C/21	0.650	0.666	0.771	0.660		No observable corrosion

2.2 Seven Locations With 7 Readings

Seven, 7 point grid inspections have been performed in 1994, 1996 and 2006 after the sand was removed and the coating was applied in 1992.

Analysis of the mean values and the thinnest 2006 reading at these locations indicate no on going corrosion during this period. This conclusion is based on the statistical "F" test of the data over time.

Table 5 Compilation of the 7 Point Grid Means Over Time

Location ID	Average Thickness based on 1992 Inspections	Average Thickness based on 1994 Inspections	Average Thickness based on 1996 Inspections	2006 Mean	Uniform Criteria	Conclusions
	(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	
1D	1.121	1.101	1.151	1.122	0.736	No observable corrosion
3D	1.182	1.184	1.175	1.180		No observable corrosion
5D	1.182	1.168	1.173	1.185		No observable corrosion
7D	1.137	1.136	1.138	1.133		No observable corrosion
9A	1.157	1.157	1.155	1.154		No observable corrosion
13C	1.149	1.140	1.154	1.142		No observable corrosion
15A	1.133	1.114	1.127	1.121		No observable corrosion

Table 6 Compilation of the Lowest 2006 Reading in Each 7 Point Grid Over Time

Location ID/ Point	1992 Reading	1994 Reading	1996 Reading	Lowest 2006 Reading	Local Criteria	Corrosion
	(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	
1D/1	0.889	0.879	0.881	0.881	0.490	No observable corrosion
3D/5	1.159	1.164	1.158	1.156		No observable corrosion
5D/1	1.164	1.163	1.163	1.174		No observable corrosion
7D/5	1.111	1.135	1.113	1.102		No observable corrosion
9A/7	1.133	1.132	1.127	1.130		No observable corrosion
13C/6	1.138	1.123	1.147	1.128		No observable corrosion
15A/7	1.083	1.040	1.100	1.049		No observable corrosion

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 13, "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"

3.23 Practical Statistics – "Mathcad Software Version 7.0 Reference Library, Published by Mathsoft, Inc. Cambridge

3.24 AmerGen Calculation C-1302-187-E310-037, Rev. 1 Statistical Analysis of Drywell Vessel Data.

3.25 AmerGen Calculation C-1302-187-5320-024, Rev. 1 OC Drywell Ext. UT Evaluation in Sandbed"

4.0 Assumptions

The statistical evaluation of the UT 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 grid is such that the thickness measurements are normally distributed. If the data is not normally distributed the grid is subdivided 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 Drywell Vessel Thickness criteria has been previously established (reference C-1302-187-5320-024) as follows:

1) General Uniform Thickness - 0.736 inches or greater.

2) If an area is less than 0.736" thick then that area shall be greater than 0.693 inches thick and shall be no larger than 6" by 6" wide. C-1302-187-5320-024 has previously dispositioned an area of this magnitude in Bay 13.

3) If an area is less than 0.693" thick then that area shall be greater than 0.490" thick and shall be no larger then 2" in diameter. C-1302-187-5320-024 calculated an acceptance criterion of .479 inches however; this evaluation is conservatively using .490 inches, which is the original GE acceptance criterion. In addition, this calculation applied this acceptance criteria over an area up to 2 1/2" in diameter. Since the UT readings were taken on 1 inch centers and the transducer size is less than 0.5 inch these readings can be characterized as less than 2 inches in diameter.

5.2 Seven core samples approximately 2" in diameter were removed from the drywell vessel shell for analysis (reference 3.1). In these locations replacement plugs were installed. Four of these removed cores are in grid locations that are part of the sandbed monitoring program. Therefore the UT data from these points are not included in the calculation.

The following specific location/grid points have core bore plugs.

Bay Area	Points
11A	23, 24, 30, 31
17D	15, 16, 22, 23
19A	24, 25, 31, 32
19C	20, 26, 27, 33

5.3 Historical data sets for 1992, 1994, 1996, and 2006 have been collected and are provided in attachments 1, 2, 3, and 4.

5.4 The 106 UT data for 2006 and 1992 external inspections are provided in attachment 5.

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. Values with +/- 1.0 are indicative that the distribution is normally skewed.

6.6.9 Kurtosis measures the heaviness of a distribution tails. A normal distribution has a kurtosis, which approaches zero. Values with +/- 1.0 indicate that the distribution is normal.

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 is the ratio of explained variance to unexplained variance. The mean square regression (MSR) value provides an estimate of the variance explained by regression (a line with a slope). The mean square error (MSE) provides an estimate of the variance that is not explained by a straight line with a slope.

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 high probability that the actual corrosion rate is the computed corrosion rate. The greater the F-Ratio then 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).

If the F-Ratio is less than 1 then no conclusions can be made that the means are best explained by a line with a slope.

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 this range.

6.2 Methodology Background

In the mid 1980's a survey was performed of the Drywell Vessel at the Sandbed elevation. As a minimum at least one inspection location (also referred to as a grid) was selected for repeat inspection in each of the 10 Drywell Bays and permanently marked. This became the basis for the Dyrwell Thickness Monitoring Program in the Sandbed Region.

UT Inspection of locations with the most thinning (known at the time) consisted of 49 individual UT thickness readings in a 7 by 7 pattern spaced on 1 inch centers over a 6" by 6" area. These measurements were taken using a stainless steel template. The template was designed to ensure that the 7 by 7 grid is located in the same area with repeatability of a 1/16". The template has a grid pattern of 49 holes on 1 inches center that are large enough to fit the UT transducer. The sides of the template are notched to that it can be aligned with permanent field markings made at each inspection location.

Forty nine evenly spaced individual readings over a 6" be 6" area were originally selected in the mid 1980's based on statistical proof that a minimum number of 30 samples are necessary to characterize a entire population (the 6 " by 6" area) assuming the entire population is normally distributed (ref 3.7 and 3.8).

The program then performed UT inspections over time at these same locations. The corrosion rates were developed using a standard regression analysis and establishment of the 95% confidence intervals enhanced to capture increasing variance depending on the projection of ongoing corrosion and the number of inspections. This methodology is based on the following references:

1) Applied Regression Analysis, Second Edition, N.R. Draper & H. Smith, John Wiley and Sons 1981
2) Statistical Concept and Methods, G.K. Bhattacharyya & R.A. Johnson, John Wiley and Sons 1977,
3) Experimental Statistics, Mary Gobbons Natrella, John Wiley and Sons 1966 (Reprint National Bureau of Standards Handbook 91)
4) Fundamental Concepts in the Design of Experiments, Charles C Hicks, Saunders College Publishing, Fort Worth, 1982

6.3 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 or in 7 locations, 7 holes in one row laid on 1" centers. All 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 The thinnest single location in each of the grids will be trended and compared to acceptance criteria.

6.4 Data that is not normally distributed will be compared to previous calculations. In several cases the data has shown significant wear patterns. For example the top 3 rows of grid 11C are much thicker than the bottom 4 rows. Past calculations has sub divided these grids into thicker and thinner subsets based on the patterns and determined if each subset is normally distributed. Normally distributed subsets are then analyzed separately. In this calculation the same grids are subdivided into subsets to ensure consistency to past calculations. In some cases (past and present) grids are not normally distributed due a few "outlying" thinner and thicker points. In these cases the outlying points are trended separately.

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

$$\text{Skewness} := \frac{\left(\text{No}_{\text{DataCells}}\right) \cdot \overrightarrow{\Sigma\left(\text{Cells} - \mu_{\text{actual}}\right)^3}}{\left(\text{No}_{\text{DataCells}} - 1\right) \cdot \left(\text{No}_{\text{DataCells}} - 2\right) \cdot \left(\sigma_{\text{actual}}\right)^3} \qquad \text{Skewness} = 0.354$$

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

$$\text{Kurtosis} := \frac{\text{No}_{\text{DataCells}} \cdot \left(\text{No}_{\text{DataCells}} + 1\right) \cdot \overrightarrow{\Sigma\left(\text{Cells} - \mu_{\text{actual}}\right)^4}}{\left(\text{No}_{\text{DataCells}} - 1\right) \cdot \left(\text{No}_{\text{DataCells}} - 2\right) \cdot \left(\text{No}_{\text{DataCells}} - 3\right) \cdot \left(\sigma_{\text{actual}}\right)^4} \ldots + - \frac{3 \cdot \left(\text{No}_{\text{DataCells}} - 1\right)^2}{\left(\text{No}_{\text{DataCells}} - 2\right) \cdot \left(\text{No}_{\text{DataCells}} - 3\right)}$$

$$\text{Kurtosis} = 0.262$$

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 distributio is by a normal probability plot(reference 3.22 and 3.23). In a normal plot, each data value is plottec against what its value would be if it actually came from a normal distributiThe expected normal values, callednormal scores, and can be estimated by first calculating the rank scores of the sorted data. The Mathcad function "sorts" sorts the "Cells" array

$j := 0..\ last(Cells)$ $\qquad srt := sort(Cells)$

Then each data point is ranked. The array "rank" captures these rankings

$$r_j := j + 1 \qquad rank_j := \frac{\overrightarrow{\sum\left(\overrightarrow{srt = srt_j}\right) \cdot r}}{\overrightarrow{\sum srt = srt_j}}$$

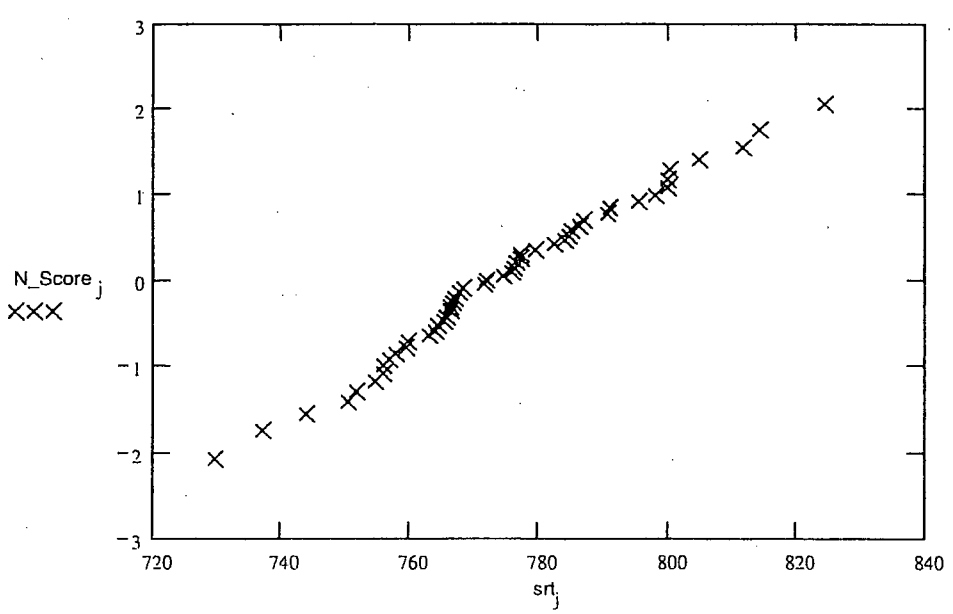
Each rank is proportioned into the "p" array. Then based on the proportion an estimate is is calculated for the data point. TheVan der Waerden's formula is used

$$p_j := \frac{rank_j}{rows(Cells) + 1}$$

The normal scores are the corresponding$p$th percentile points from the standard normal distribution:

$$x := 1 \qquad N_Score_j := root\left[cnorm(x) - \left(p_j\right), x\right]$$

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.

$$Bins := Make_{bins}(\mu_{actual}, \sigma_{actual})$$

$$Distribution := hist(Bins, Cells)$$

$$Distribution = \begin{pmatrix} 0 \\ 0 \\ 3 \\ 4 \\ 6 \\ 13 \\ 7 \\ 8 \\ 4 \\ 3 \\ 0 \\ 1 \end{pmatrix}$$

The mid points of the Bins are calculated

$$k := 0..11 \qquad Midpoints_k := \frac{(Bins_k + Bins_{k+1})}{2}$$

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.

$$normal_{curve_0} := pnorm(Bins_1, \mu_{actual}, \sigma_{actual})$$

$$normal_{curve_k} := pnorm(Bins_{k+1}, \mu_{actual}, \sigma_{actual}) - pnorm(Bins_k, \mu_{actual}, \sigma_{actual})$$

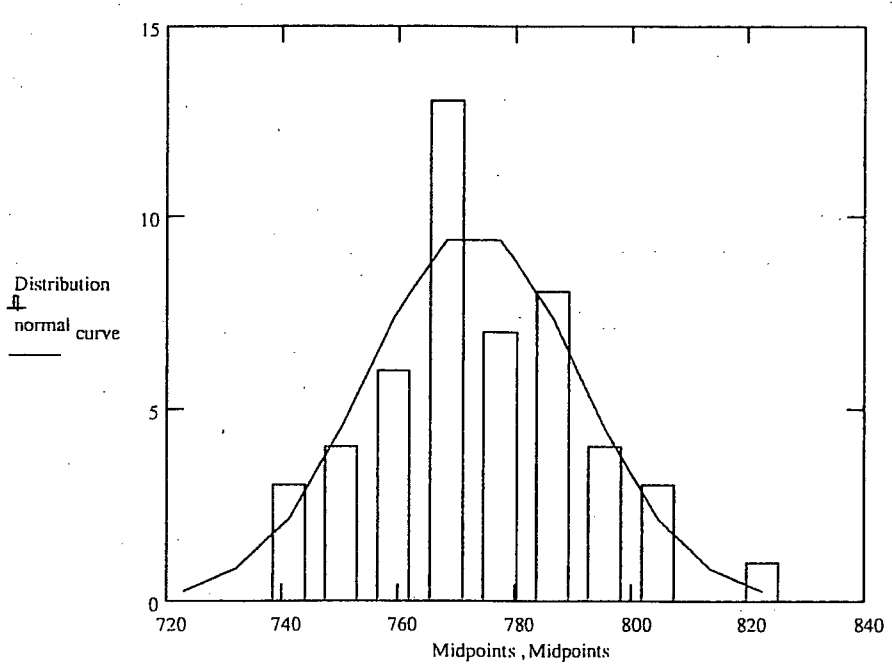
The normal curve is simply a proportion, which is multiplied by the number of "Cells" (49)

$$normal_{curve} := No_{DataCells} \cdot normal_{curve}$$

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 General Summary of Corrosion Rate Assessment Methodology

This methodology develops a test to assess whether the trend of the means or individual points over time is indicative of corrosion. The statistical test consists of two parts. The first part is to determine if the data (either the means or individual points) is well characterized by a straight line determined by using standard linear regression modeling. The second part is a comparison of the linear regression through the data with a line defined by a prescribed slope and intercept. The slope represents the rate corrosion, and it is chosen to reflect acceptable limits. The intercept is determined by the thickness in 1992 (baseline) as the sand removal. The confidence level for the test will be 95%. The test will be referred to as the *F test for Corrosion*. If the *F test for Corrosion* shows that the prescribed line for corrosion is within the 95% confidence bounds determined by the linear regression on the data, then a statistical projection can be made to the year 2029.

If the F test for Corrosion shows that the prescribed line for corrosion is not acceptable within the 95% confidence bounds determined by the linear regression on the data, then a conservative approach will be used, and the regression will be utilized to determine an apparent corrosion rate to establish the next inspection frequency for that location.

Two sensitivity studies will be performed. The first will determine the minimum observable corrosion rate that may exist in the 49 point grid, given the observed standard deviations of the averages and the number of observations, which are 4 in this case. For this analysis, location 19A was chosen since it is the thinnest location of the 19 grids. The second study will determine the minimum observable corrosion rate that may exist at one point within a grid, given the observed standard error for the individual points and the number of observations, which is, again, 4 in this case. For this analysis, point 4 in grid 19A was chosen since it is one of the two individual points, which are the thinnest out of the 19 grids.

6.5.9.1 Appropriateness of the Regression Model for Corrosion

General corrosion rates of a carbon steel plate over long periods of time (i.e. years) can be approximated by a straight line with a slope over time (see assumptions 4.3, 4.4 and 4.4).

This assumption has been shown to be reasonable over the life of the monitoring program. Prior to 1992 sand removal from the sandbed, the regression model was shown to accurately calculate the actual corrosion rates (reference 3.7, 3.11 through 3.21) of the vessel in the sandbed and to provide reliable projections that were used to schedule the ultimate repair (the sand removal). In addition the regression model has been shown to detect very small corrosion rates of less than 1 mil per year in the upper elevations of the drywell. In this case it took up to ten inspections over an approximate 10 years to detect these minor rates (reference 3.2. 24).

6.5.9.2 "F" Test Results for Corrosion

To illustrate a case in which the location is corroding, nine 49 point matrixes will be generated with input means which are descending over time at a rate of 2 mils per year. This will illustrate the case where the population is corroding at 2 mils per year with a 20 mil standard deviation.

The nine means, standard deviations of the following simulated dates are shown below

$Dates_i :=$

1993
1995
1996.5
1997
1999.4
2002
2004
2006
2008

$d := 0..8$ "d" is used as an index for the arrays

$Rate := 2.0$

$\mu_{input_d} := 775 - (Rate)\cdot(Dates_d - Dates_0)$

$\sigma_{input_d} := 20$ $Cells_d := rnorm(No\ DataCells, \mu_{input_d}, \sigma_{input_d})$

$\mu_{actual_d} := mean(Cells_d)$ $\sigma_{actual_d} := Stdev(Cells_d)$

The resulting simulated means are

$$\mu_{actual} = \begin{bmatrix} 770.163 \\ 769.826 \\ 773.738 \\ 767.08 \\ 752.938 \\ 754.346 \\ 750.331 \\ 744.589 \\ 742.622 \end{bmatrix} \quad \sigma_{actual} = \begin{bmatrix} 20.964 \\ 20.197 \\ 19.8 \\ 19.57 \\ 17.368 \\ 20.289 \\ 16.007 \\ 24.804 \\ 20.188 \end{bmatrix} \quad Dates = \begin{bmatrix} 1.993\cdot10^3 \\ 1.995\cdot10^3 \\ 1.997\cdot10^3 \\ 1.997\cdot10^3 \\ 1.999\cdot10^3 \\ 2.002\cdot10^3 \\ 2.004\cdot10^3 \\ 2.006\cdot10^3 \\ 2.008\cdot10^3 \end{bmatrix}$$

The following function simply returns the number of means (No_of_{means}) which will be used later

$$No_of_{means} := rows(\mu_{actual}) \qquad No_of_{means} = 9$$

The curve fit equation and model equation is defined for the function "yhat"

$$yhat(x, y) := intercept(x, y) + slope(x, y) \cdot x$$

The curve fit equation in which the date ($Dates$) 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 makes 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.

The Sum of Squared Error (SSE) is calculated as follows (reference 3.23). This is the variance between each actual value (mean or individual point) and what the value should be if it met the regression model.

$$SSE := \sum_{i=0}^{last(Dates)} \left(\mu_{actual_i} - yhat(Dates, \mu_{actual})_i\right)^2 \qquad SSE = 125.623$$

The Sum of Squared Residuals (SSR) is then calculated as follows (reference 3.23). This is the difference between what the value should be if it met the regression model and what the value should be if it met the grandmean model.

$$SSR := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, \mu_{actual})_i - mean(\mu_{actual})\right)^2 \qquad SSR = 1.005 \cdot 10^3$$

Degrees of freedom associated with the sum of squares for residual error.

$$DegreeFree_{SS} := No_of_{means} - 2$$

The degrees of freedom for the sum of squares due to regression,

$$DegreeFree_{reg} := 1$$

$$MSE := \frac{SSE}{DegreeFree_{ss}} \qquad MSE = 7.519$$

$$Standard_{error} := \sqrt{MSE} \qquad Standard_{error} = 2.742$$

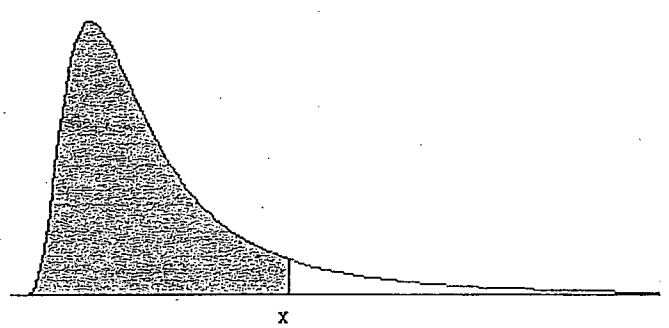
$$MSR := \frac{SSR}{DegreeFree_{reg}} \qquad MSR = 741.797$$

The MSE is the variance estimate to the regression model. The MSR is an estimate for the difference between the regression model and the grandmean. The ratio of the two gives a measure of how well the data approaches a line with slope. The larger the ratio then the better the data is represented by the regression model. For example if the MSE was very large indicating that the values significantly vary from the regression model, then the ratio would approach zero and the hypothesis that there is slope is not satisfied. Another example would be if the MSE was very small indicating that the values are very close to the regression model, then the ratio would be very large and the hypothesis that there is slope is satisfied.

$$F_{actaul} := \frac{MSR}{MSE}$$

This ratio F_{actaul}) is then compared to the "F" Distribution with the appropriate confidence factor. The Mathcad functi qF computes cumulative probabilities for "a F distribution" with d1, d2 degrees of freedom at x confidence

Pictorially, pF(x, d1, d2) computes the area of the region shaded below:



The confidence factor is set at 95% Confidence := .95

$\alpha := 0.05$ $\quad F_{critical} := qF(Confidence, DegreeFree_{reg}, DegreeFree_{ss})$ $\quad F_{critical} = 5.591$

The "F" ratio for 95% confidence is calculated:

$F_{ratio} := \frac{F_{actaul}}{F_{critical}}$ $\quad F_{ratio} = 10.015$ $\quad Standard_{error} = 4.236$

The "F" ratio is greater than 1.0, therefore the regression model holds for the data. The curve fit for the nine means is best explained by a curve fit with a slope.

If the F ratio is less than 1.0 then no conclusions can be made with respect to how well the data satisfies a line without slope.

6.9.3 Linear Regression with 95% Confidence Intervals

Using data generated in section 6.9.2 the curve fit for linear regression is calculated by the Mathcad functions " slope " and "intercept".

$$m_s := \text{slope}\left(\text{Dates}, \mu_{\text{actual}}\right) \qquad y_b := \text{intercept}\left(\text{Dates}, \mu_{\text{actual}}\right)$$

$$m_s = -2.159 \qquad y_b = 5.077 \cdot 10^3$$

The predicted curve is calculated over time where " $\text{year}_{\text{predict}}$ " is time (independent variable), and "$\text{Thick}_{\text{predict}}$" is thickness (dependent variable).

$$\text{Remaining}_{\text{Pl_life}} := 23 \qquad f := 0 .. \text{Remaining}_{\text{Pl_life}} - 1 \qquad \text{year}_{\text{predict}_f} := 1993 + f \cdot 2$$

$$\text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$$

The 95% Confidence ("1- α_t") curves are calculated as follows (reference 3.3)

$$\alpha_t := 0.05$$

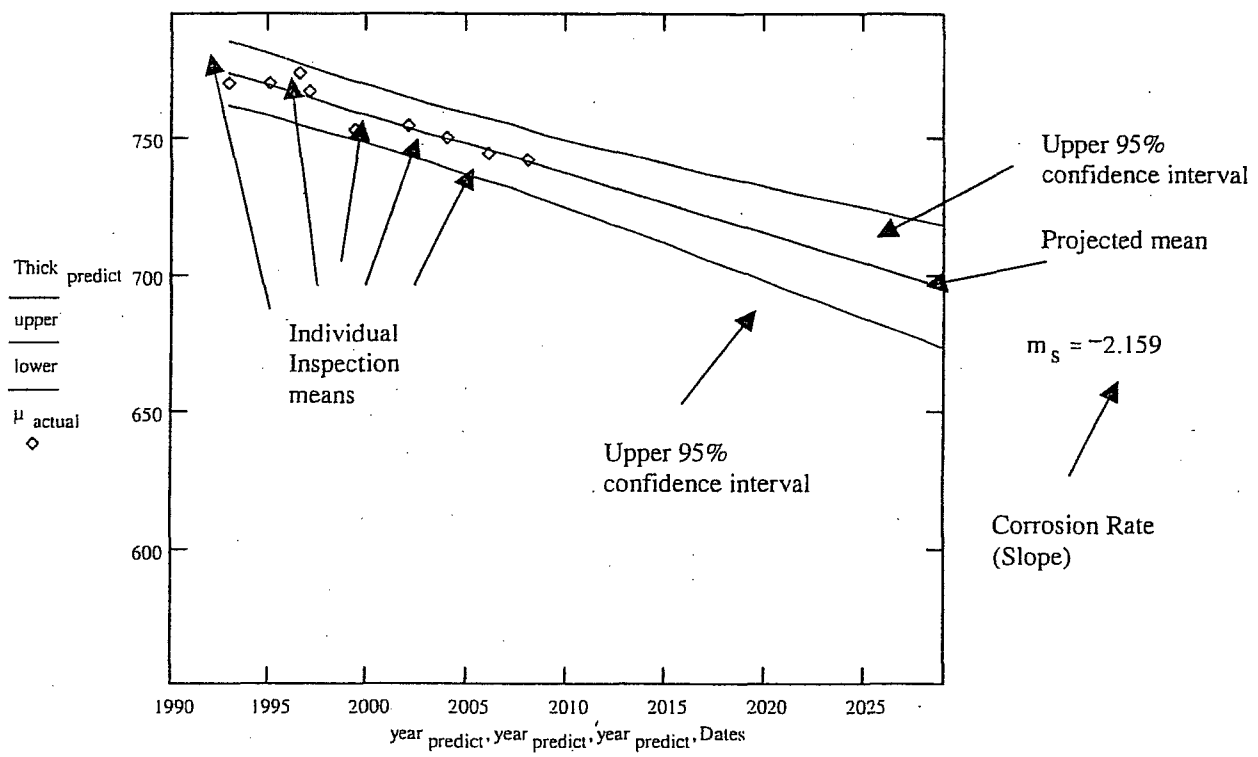
$$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates})$$

$$\text{sum} := \sum_d \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$$

$$\text{upper}_f := \text{Thick}_{\text{predict}_f} \cdots + \text{qt}\left(1 - \frac{\alpha_t}{2}, \text{No_of}_{\text{means}} - 2\right) \cdot \text{Standard}_{\text{error}} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{\text{predict}_f} - \text{Thick}_{\text{actualmean}}\right)^2}{\text{sum}}}$$

$$\text{lower}_f := \text{Thick}_{\text{predict}_f} \cdots + -\left[\text{qt}\left(1 - \frac{\alpha_t}{2}, \text{No_of}_{\text{means}} - 2\right) \cdot \text{Standard}_{\text{error}} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{\text{predict}_f} - \text{Thick}_{\text{actualmean}}\right)^2}{\text{sum}}}\right]$$

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.



6.9.4 Sensitivity Studies to Determine Observable Corrosion Rates

This sensitivity study will determine the minimum statistically observable corrosion rate that can exist in the 49 points grid given the observed standard deviations of the means and the number of observations which in this case is 4. This will be performed by running a series of simulations based on the results from the grid at location 19A.

This study will perform 10, 100 iteration runs for varying corrosions rates of 5, 6, 7, 8, and 9 mils per year.

The simulation will generate 49 points arrays using the Mathcad function "rnorm".
The function "norm (m, u, SD)" - returns an array of "m" random numbers generated from a normal distribution with mean of "u" and a standard deviation of "SD".

Each iteration will generate 49 point arrays for the years 1992, 1994, 1996 and 2006.

The input to the 1992 array will be 49, the actual mean (800 mils) which was determined from the actual 1992, 19A data (reference appendix 10 page 10). and a standard deviation of 65 mils. This standard deviation is the average of the calculated standard deviations from the 1992, 1994, 1996 and 2006 data (see appendix 10 page 10). A simulated mean (for 1992) will then be calculated from the simulated 49 point array.

The input to the 1994 array will be 49, the value 800 minus the simulated rate (in mils per year) times 2 years (1994-1992) and a standard deviation of 65 mils. A simulated mean (for 1994) will then be calculated from the simulated 49 point array.

The input to the 1996 array will be 49, the value 800 minus the simulated rate (in mils per year) times 4 years (1996-1992) and a standard deviation of 65 mils. A simulated mean (for 1996) will then be calculated from the simulated 49 point array.

The input to the 2006 array will be 49, the value 800 minus the simulated rate (in mils per year) times 14 years (2006-1992) and a standard deviation of 65 mils. A simulated mean (for 2006) will then be calculated from the simulated 49 point array.

The four simulated means will then be tested for corrosion based on the methodology in section 6.5.9.2. The confidence factor for the test will be 95%. If the corrosion test is successful (the F Ratio is great than 1) then that iteration is considered a successful valid iteration.

100 iterations will be run 10 times at each of the input rates of 1, 2, 3, 4, and 5 mils per year. The resulting number of successful iterations (passes the corrosion test) will then be considered as probability of observing that rate given the 19A data.

For this case location 19A was chosen since it is the thinnest of the 19 grids.

Appendix 10 shows the following data for location 19A

Year	Mean (mils)	Standard Deviation (mils)
1992	800	58.6
1994	806	69.3
1996	815	67.3
2006	807	62.4

7.0 Calculation

7.1 Sandbed Locations with 49 Readings

7.1.1. Bay 9 location 9D December 1992 through Oct 2006

Refer to Appendix #1 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data collected in October 2006 is normally distributed. The mean of the 2006 data is 0.9825 inches, which meets the design basis uniform thickness requirements of 0.736". In order to be consistent with past calculations (ref. 3.20 3.21 and 3.22) this mean does not include point 15, which is thinnest point in the set.

The "F" Test results for Corrosion on the means shows as ratio of 0.029. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 15 is the thinnest reading of the 2006 data at 0.751 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 15 shows a ratio of 0.03. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 10.8 mils per year which is not considered credible and would be observable.

7.1.2 Bay 11 location 11A December 1992 through Oct 2006

Refer to Appendix #2 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. A plug lies within this location. Four points lie over the plug (see section 5.2). Therefore points 23, 24, 30, and 31 are eliminated from the corrosion rate evaluation.

The data collected in October 2006 is normally distributed after the four points that lie over the plug are eliminated. The mean of the 2006 data is 0.8215 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test for Corrosion on the means shows a ratio of 0.01. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2018. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 20 is the thinnest reading of the 2006 data at 0.669 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 20 shows a ratio of 0.09. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 7.5 mils per year which is not considered credible and would be observable.

7.1.3 Bay 11 location 11C December 1992 through Oct 2006

Refer to Appendix #3 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data collected in October 2006 is not normally distributed Removal of point number 5, which is much thinner, will results in a normal distribution,

although slightly skewed. However past calculations (ref. 3.20, 3.21, and 3.22) have split this data and analyzed the top 3 rows and the bottom 4 row separately. This summary will only describe the evaluation of the entire 7 rows. Appendix 3 provides the results of the top 3 rows and the bottom 4 rows, which are consistent to the following conclusions. Point 1 was not collected due to an obstruction with the vent attachment weld.

The mean of the 2006 data is 0.8982 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test for Corrosion on the means shows a ratio of 0.02. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 43 was discounted from the 1992 data in the previous calculations (reference 3.20, 3.21 and 3.22) since it was 4.3 sigma from the mean in 1992. This same point was recorded as 0.860 inches in 1994, 0.917 inches in 1996 and 0.861 inches in 2006. Therefore it was also discounted from the 1992 mean in this calculation for consistency.

Point 5 is the thinnest reading of the 2006 data at 0.767 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 5 shows a ratio of 0.005. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 11.5 mils per year which is not considered credible and would be observable.

7.1.4 Bay 13 location 13A December 1992 through Oct 2006

Refer to Appendix #4 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data collected in October 2006 is approximately normally distributed. The Kurtosis indicates the distribution is slightly heavy around the mean. Point 5 is much thicker (1.046 inches) than the mean of grid. Therefore the conclusion was made that this distribution approaches normality.

The mean of the 2006 data is 0.8458 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.004. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2020.

Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

The calculated 1994 mean (837mils) in this calculation is different than the same mean calculated in 1994 (827.5 mils). This is because the 1994 mean calculation eliminated four points (4, 5, 6 and 7) from in the 1994 data (reference 3.21) since they were much thicker than the remaining 1994 data points. However the 1992 and 1996 calculation did not eliminate the same four points even though some of the four points were thicker then the 1992 and 1996 data sets. Review of the 2006 data show that these points are also thicker than the remaining points. Also the 2006 data with the four points included is normally distributed. Therefore the 1994 mean was recalculated in this calculation with the 4 points included.

The calculated 1996 mean (853 mils) in this calculation is different than the same mean calculated in 1996 (843.4 mils). Thorough review of the 1996 calculation ref (3.22) and the 1996 data indicates that the correct mean for the 1996 data is actually 853 mils and not 843.4 mils. Therefore it is concluded that the 1996 calculation mistakenly documented this value. Therefore this calculation uses 853 mils for the 1996 mean.

Point 19 is the thinnest reading of the 2006 data at 0.746 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 19 shows a ratio of 0.044. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 10.7 mils per year which is not considered credible and would be observable.

7.1.5 Bay 13 location 13D December 1992 through Oct 2006

Refer to Appendix #5 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data collected in October 2006 is normally distributed. However past calculations (ref 3.20, 3.21, and 3.22) have split this data and analyzed the top 3 rows and the bottom 4 row separately. This summary will only describe the evaluation of the entire 7 rows. Appendix 5 provides the results of the top 3 rows and the bottom 4 rows, which are consistent to the following conclusions.

The mean of the 2006 data is 0.9682 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.0005. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 49 is the thinnest reading of the 2006 data at 0.821 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for No Corrosion on point 49 shows a ratio of 1.64. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made

that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 13.8 mils per year which is not considered credible and would be observable.

7.1.6 Bay 15 location 15D December 1992 through Oct 2006

Refer to Appendix #6 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data collected in October 2006 is normally distributed. The mean of the 2006 data is 1.0531 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.012. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 42 is the thinnest reading of the 2006 data at 0.922 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 42 shows a ratio of 0.02. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 18 mils per year which is not considered credible and would be observable.

7.6.9 Bay 17 location 17A December 1992 through Oct 2006

Refer to Appendix #7 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data collected in October 2006 is not normally distributed. However past calculations (ref 3.20, 3.21, and 3.22) have split this data and analyzed the top 3 rows and the bottom 4 rows separately. These two sub sets are normally distributed. This summary will only describe the evaluation of the entire 7 rows. Appendix 7 provides the results of the top 3 rows and the bottom 4 rows, which are consistent to the following conclusions.

The mean of the 2006 data is 1.015 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.006. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 3 was discounted from the 1996 data in the 1996 calculation (reference 3.22) since it was significantly thinner (0.672 inches) than the remaining 1996 points. This same point was recorded as 1.158 inches in 1992, 1.158 inches in 1996, and 1.154 inches in 2006. Therefore it was discounted from the 1996 mean in this calculation for consistency.

Point 40 is the thinnest reading of the 2006 data at 0.802 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 40 shows a ratio of 0.002. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 13.0 mils per year which is not considered credible and would be observable.

7.1.8 Bay 17 location 17D December 1992 through Oct 2006

Refer to Appendix #8 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. A plug lies within this location. Four points lie over the plug (see section 5.2). Therefore points 15, 16, 22, and 23 are eliminated from the corrosion rate evaluation.

The data collected in October 2006 is normally distributed after the four points that lie over the plug are eliminated. The mean of the 2006 data is 0.8187 inches, which meets the design basis uniform thickness requirements of 0.736".

The calculated 1996 mean (848 mils) in this calculation is different than the same mean calculated in 1996 (845 mils). Thorough review of the 1996 calculation ref (3.22) and the 1996 data indicates that the correct mean for the 1996 data, when excluding points 15, 16, 22 and 23, is actually 848 mils and not 845 mils. Therefore it is concluded that the 1996 calculation mistakenly documented this value. Therefore this calculation uses 848 mils for the 1996 mean.

The "F" Test result for Corrosion on the means shows a ratio of 0.000007. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2016. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 14 is the thinnest reading of the 2006 data at 0.648 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for No Corrosion on point 14 shows a ratio of 3.3. The "F" Test result for Corrosion on point 14 shows a ratio of 0.001. Sensitivity studies show that given only

four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this individual point would not reach the minimum required thickness prior to the 2016. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 6.6 mils per year which is not considered credible and would be observable.

7.1.9 Bay 17 location 17-19 December 1992 through Oct 2006

Refer to Appendix #9 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data collected in October 2006 is normally distributed. However past calculations (ref 3.20, 3.21, and 3.22) have split this data and analyzed the top 3 rows and the bottom 4 rows separately. This summary will only describe the evaluation of the entire 7 rows. Appendix 9 provides the results of the top 3 rows and the bottom 4 rows, which are consistent to the following conclusions.

The mean of the 2006 data is 0.969 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.068. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

The calculated 1996 mean (990.14 mils) in this calculation is different that the same mean calculated in 1996 (991.4 mils). Thorough review of the 1996 calculation ref (3.22) and the 1996 data indicates that the correct mean for the 1996 data is actually 990.14 mils and not 991.4 mils. Therefore it is concluded that the 1996 calculation mistakenly documented this value. Therefore this calculation uses 990.14 mils for the 1996 mean.

Point 35 is the thinnest reading of the 2006 data at 0.901 inches. Which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 35 shows a ratio of 0.02. The "F" Test result for Corrosion on point 14 shows a ratio of 0.001. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 17 mils per year which is not considered credible and would be observable.

7.1.10 Bay 19 location 19A December 1992 through Oct 2006

Refer to Appendix #10 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. A plug lies within this location. Four points lie over the plug (see section 5.2). Therefore points 24, 25, 31, and 32 are eliminated from the corrosion rate evaluation.

The data collected in October 2006 is normally distributed after the four points that lie over the plug are eliminated. The mean of the 2006 data is 0.8066 inches, which meets the design basis uniform thickness requirements of 0.736". This mean is the thinnest of the 19 locations.

Evaluation of the mean thickness values of this location measured 1992, 1994, 1996 and 2006 shows that this location is experiencing negligible corrosion, approaching a rate of zero. However due to the limited amount of inspections this conclusion cannot be statistically confirmed with 95% confidence. Therefore the next inspection of this location shall be performed prior to the date in which the minimum statistically the statistically observable rate would drive the thickness to the minimum required thickness.

The "F" Test result for Corrosion on the means shows a ratio of 0.004. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2016. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to

reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate (which approaches zero) the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 4 is the thinnest reading of the 2006 data at 0.648 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 4 shows a ratio of 0.02. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this point would not reach the minimum required thickness prior to the 2016. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 6.6 mils per year which is not considered credible and would be observable.

7.1.11 Bay 19 location 19B December 1992 through Oct 2006

Refer to Appendix #11 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and the coating was applied in 1992. The data collected in October 2006 is normally distributed. The mean of the 2006 data is 0.8475 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.088. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2022. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 34 is the thinnest reading of the 2006 data at 0.731 inches. Which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 34 shows a ratio of 0.001. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 10.0 mils per year which is not considered credible and would be observable.

7.1.12 Bay 19 location 19C December 1992 through Oct 2006

Refer to Appendix #11 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. A plug lies within this location. Four points lie over the plug. Therefore points 20, 26, 27, and 33 are eliminated from the corrosion rate evaluation (see section 5.2).

The data collected in October 2006 is normally distributed after the four points that lie over the plug are eliminated. The mean of the 2006 data is 0.8238 inches, which meets the design basis uniform thickness requirements of 0.736".

The calculated 1996 mean (854 mils) in this calculation is different that the same mean calculated in 1996 (848 mils). Thorough review of the 1996 calculation ref (3.22) and the 1996 data indicates that the correct mean for the 1996 data is actually 854 mils and not 848 mils. Therefore it is concluded that the 1996 calculation mistakenly documented this value. Therefore this calculation uses 854 mils for the 1996 mean.

The "F" Test result for Corrosion on the means shows a ratio of 0.000007. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2018. Additional

inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 4 is the thinnest reading of the 2006 data at 0.660 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 4 shows a ratio of 0.00007. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 6.7 mils per year which is not considered credible and would be observable.

7.2 Sandbed Locations with 7 Readings

7.2.1 Bay 1 location 1D December 1992 through Oct 2006

Refer to Appendix #13 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data is not normally distributed. Eliminating point 1 which is significantly thinner than the remaining points results in a distribution, which is almost normal. This is consistent with previous data. Past calculations discounted the thinner point and calculated a mean of the remaining 6 points. The mean of the 2006 data is 1.122 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.001. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

The 1996 calculation (ref. 3.22) also eliminated point 7 from the mean calculation since it was significantly thinner then the values in for the same point in other years.

Point 1 is the thinnest reading of the 2006 data at 0.881 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 1 shows a ratio of 0.02. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 16.3 mils per year which is not considered credible and would be observable.

7.2.2 Bay 3 location 3D December 1992 through Oct 2006

Refer to Appendix #14 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data is not normally distributed. The mean of the 2006 data is 1.18 inches. Which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.008. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

The calculated 1996 mean (1175 mils) in this calculation is different that the same mean calculated in 1996 (1181 mils). This is because the 1996 mean calculation eliminated point 5 from in the 1996 data (reference 3.22). However the 1992 and 1996 calculation

did not eliminate this point. Review of the 2006 data shows that the point 5 value is within 2 sigma of the grandmean. Therefore the 1996 mean was recalculated in this calculation with the point 5 included.

Point 5 is the thinnest reading of the 2006 data at 1.156 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for No Corrosion on point 5 shows a ratio of 0.08. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 27.8 mils per year which is not considered credible and would be observable.

7.2.3 Bay 5 location 5D December 1992 through Oct 2006

Refer to Appendix #15 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data is not normally distributed. This is most likely due to the low number of data points. The mean of the 2006 data is 1.185 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.048. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 1 is the thinnest reading of the 2006 data at 1.174 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test for No Corrosion for point 1 shows a ratio of 0.037. The "F" test results of the 1992, 1994, 1996 and 2006 point 1 value show an "F" ratio of 0.925, which is an

indication that a slope might exist for this point. Review of the individual readings for each year shows the following values in each year.

Year	Point 1 Value (inches)
1992	1.164
1994	1.163
1996	1.163
2006	1.174

The variance of 10 mils between 1992 and 2006 is well within the uncertainties of the instrumentation. The curve fit of the data indicates a slightly positive slope, which is not credible. Therefore it is concluded that this individual location, which was the thinnest location recorded in 2006 is not experiencing corrosion.

Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 28.5 mils per year which is not considered credible and would be observable.

7.2.4 Bay 7 location 7D December 1992 through Oct 2006

Refer to Appendix #16 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data is normally distributed. The mean of the 2006 data is 1.113 inches. Which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.384. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 5 is the thinnest reading of the 2006 data at 1.102 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 5 shows a ratio of 0.06. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 25.5 mils per year which is not considered credible and would be observable.

7.2.5 Bay 9 location 9A December 1992 through Oct 2006

Refer to Appendix #17 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data is not normally distributed. This is most likely due to the low number of data points. The mean of the 2006 data is 1.154 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.231. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 7 is the thinnest reading of the 2006 data at 1.13 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for No Corrosion on point 7 shows a ratio of 0.26. The "F" Test result for Corrosion on point 7 shows a ratio of 0.02. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection

based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 26.7 mils per year which is not considered credible and would be observable.

7.2.6. Bay 13 location 13 C December 1992 through Oct 2006

Refer to Appendix 18 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data is normally distributed but skewed. The mean of the 2006 data is 1.142 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.01. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 6 is the thinnest reading of the 2006 data at 1.128 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for Corrosion on point 6 shows a ratio of 0.00000087. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 26.6 mils per year which is not considered credible and would be observable.

7.2.7 Bay 15 location 15A December 1992 through Oct 2006

Refer to Appendix 19 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data is normally distributed. The mean of the 2006 data is 1.121 inches, which meets the design basis uniform thickness requirements of 0.736".

The "F" Test result for Corrosion on the means shows a ratio of 0.01. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on an assumed rate of 6.9 mils per year shows that this location would not reach the minimum required thickness prior to the 2029.

In addition the apparent corrosion rate was determined using the regression model (even though it does not meet the F test for Corrosion). Based on the apparent rate the conclusion can be made that the location will not corrode to less then the minimum required thickness prior to 2029.

Point 7 is the thinnest reading of the 2006 data at 1.049 inches, which meets the design basis local thickness requirements of 0.490".

The "F" Test result for No Corrosion on point 7 shows a ratio of 0.25. The "F" Test result for Corrosion on point 7 shows a ratio of 0.02. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

Additional calculation shows that for this point to corrode to less than the minimum required thickness by 2029 it would have to corrode at a rate of 23.3 mils per year which is not considered credible and would be observable.

7.3 External Inspections

7.3.1 Background

In 1992, following the removal of the sand from the sandbed region and the removal of corrosion byproducts, the Drywell Vessel was visually inspected from the sandbed, which is outside the Drywell Vessel. This inspection identified the thinnest locations in each of the 10 sandbed bays. These thinnest locations were then UT inspected. In many cases the areas had to be slightly grounded so that the UT probe could rest flat against the surface of the vessel. The thickness values and the locations of each reading, referenced from existing welds, were recorded on a series of NDE data sheets. At each location one UT reading was performed.

In 2006, 106 readings were taken of the external portion of the Drywell Vessel from within the former sandbed region. These locations were located using the 1992 NDE Inspection Data Sheet maps. These UT readings were compared to acceptance criteria. The data is provided in Attachment 5.

7.3.2 Results

(Refer to Appendix 20)

All 106 readings were greater than the acceptance criteria of 0.49 inches even when allowing for 20 mils tolerance in uncertainty. The minimum recorded value was 0.602 inches measured at point 7 in bay 13. This point was also the thinnest point recorded in 1992.

These readings were not intended for corrosion rate trending due to uncertainties and inconsistencies between the 1992 and 2006 UT readings. These include:

a) The roughness of the inspected surfaces due to the previously corroded surface of the shell in the sandbed regions
b) The different UT technologies between 1992 and 2006
c) UT Equipment Instrument Uncertainties and
d) The poor repeatability in attempting to inspect the exact same unmarked locations over time

The 2006 and 1992 data cannot be used for developing corrosion rates by performing regression analysis, which requires at least three similar inspections over time to develop acceptable confidence factors.

7.3.3 Worst Case
(Refer to Appendix 20)

To ensure a formal conservative evaluation, point to point comparisons were performed on all 106 points as follows.

For each reading the 2006 value was subtracted from the 1992 value and divided by 14 years (time between 1992 and 2006). Values that resulted in positive changes in metal thickness were discounted from the computation to maintain conservative results.

The resulting differences in UT readings based on point-to-point comparison vary between 0 and .0335 inches per year.

The minimum 2006 reading of all the areas was 0.602 (point 7 Bay 13) inches.

The maximum worst case localized difference between readings was found in a point-to point comparison of point 2 in bay 17. The difference in thickness at this point equates to a rate of 0.0335 inches per year, which is not considered credible given the physical limitations of the UT inspections taken from the exterior surface. These limitations include the roughness of the inspected surfaces, the different UT technologies between the 1992 and 2006, UT Equipment Instrument Uncertainties, and the repeatability due to trying to locate the exact same location over time. In addition, this point is at an elevation where the inside surface is coated and accessible for visual inspection. During the 2006 visual inspections, no degraded coating or indication of corrosion has been identified on the exterior or interior drywell shell at this point location.

However even when considering a 0.0335 inches per year rate of change (recorded on a location that is 0.681 inches thick in 2006) and applying it on the thinnest location recorded in 2006 (0.602 inches in Bay 13 point 7) and applying 0.020 inch deduction for instrumentation uncertainty this location would only reduce to 0.515 inches by 2008, which still demonstrates margin compared to the acceptance criteria of 0.49 inches.

Repeat inspection of this location in 2008 will provide additional data to confirm the very conservative nature of the above evaluation.

7.3.4 Comparison of the 2006 external data to the Bounding Internal Grid 19A

Inspection of internal grid 19A has concluded it to be the most critical of the monitored sandbed locations since it has the thinnest mean. This grid has a mean 0.8066 inches with a standard deviation of 0.0623 inches. The grid is normally distributed.

A normally distributed sample allows conclusion of the entire normally distributed population from which the sample is taken. For example, in a normally distributed population, approximately 95% of the population lies within approximately plus or minus two standard deviations of the mean; and approximately 99% of the population lies within approximately plus or minus three standard deviations of the mean.

The thinnest location of the entire sandbed region was found during the exterior inspections in 1992 and 2006. This spot (0.602" in 2006) was not in an area corresponding to the internal monitored locations. However comparison of this thinnest value to the mean, standard deviation, and thinnest individual reading (0.648 inches) for location 19A shows that the monitoring program provides a representative sample population of the thicknesses of the entire sand bed region.

For example the UT transducer head is approximately 0.428 inches in diameter. The Drywell Vessel in the sandbed has approximately 700 square feet of surface area. Therefore the actual population of the sandbed region available to the transducer is in excess of 70,000, 0.428" diameter areas.

Therefore in theory if one were to sample a population that is normally distributed, with a mean of 0.8066 inches, with a standard deviation of the 0.0623 inches, and the total population was 70,000, approximately 0.5% of the population would be less than 0.648 inches, approximately 0.05% of the population would be less than 0.602 inches, and 1.9*10E-5 % of the population would be less than 0.49 inches.

This theoretical model is very conservative since the majority of the sandbed has been shown to be much thicker than the critical location in 19A. However this discussion bolsters the conclusion that the monitoring of the 19 internal locations, coupled with visual inspection of the sandbed external coating, will ensure the material condition of the Drywell Vessel in the sanded regions is maintained within design basis.

7.4 Sensitivity of the Corrosion Test without the 1996 Data
(Refer to appendix 21).

The mean thickness values for the 1996 data are consistently greater than the 1992 and 1994 data. This has called into the question the accuracy of the 1996 UT Inspections. As result, in 2006, the Oyster Creek NDE Group investigated several potential factors that could have caused the discrepancy. These potential variables included the potential failure by contractor personnel to clean off the inspected surface prior to the inspection and the potential that the UT unit was mistakenly placed on the "High Gain" setting. However the review did not confirm that these factors were the cause.

Never the less the question remains as to whether the 1996 data should be included in the analysis documented by this calculation.

Therefore a sensitivity study of the "Corrosion" test was performed and is documented in Appendix 21. The study selected locations where the 1996 means were at least 20 mils greater than the grandmean of the grid or subset. The grandmean is the mean of the 1992, 1994, 1996 and 2006 means. The "Corrosion" test was then performed on these grids with only the 1992, 1994 and 2006 data excluding the 1996 data. The results of the study are presented in appendix 21 and are summarized in the table below.

Location	Area	"F" Ratio with 1996 data	"F" Ratio without 1996 Data	Results
11C	All	0.004	0.00009	Negligible
	Top	0.012	0.000003	Negligible
	Bottom	0.002	0.01	Negligible
13D	Bottom	0.002	0.000002	Negligible
17A	All	0.006	0.001	Negligible
	Bottom	0.003	0.007	Negligible
17D	All	0.0001	0.002	Negligible
19C	All	0.0001	7.3	See Below
1D	All	0.047	0.02	Negligible

The study showed that for the "Corrosion" test, eliminating of the 1996 data results in negligible change to the "F" ratio (when compared to the criteria of 1.0); except for the 19C grid. In the 19C grid the F ratio increased significantly. However 19C the regression curve fit results in a very small positive slope, which is not credible. Even with the 1996 data the regression curve fit results in a very small positive slope.

Therefore based on these sensitivity studies it is concluded using the 1996 data will results in a negligible impact on the results of the "Corrosions Test" for Regression.

7.5 Sensitivity Study to Determine the Statistically Observable Corrosion Rate with Only Four Inspections
(Refer to appendix 22).

The drywell vessel in the sandbed region is externally coated. The coating was inspected in 2006 and found to be in excellent condition. The surface inside the vessel corresponding to 19 monitored grids is internally coated. In addition, the atmosphere in the drywell is inerted with nitrogen. Therefore the actual corrosion rate on the vessel is expected to be significantly less than 1 mil per year, possibly approaching zero mils per year. However the limited number of inspections (4) and the high variance in the data (standard deviations of 60 to 100 mils) make it impossible to identify rates less than 1 mil per year at this time. The high variance is because the surface of the sandbed region on the exterior is rough due to the aggressive corrosion, which occurred prior to 1992.

For example, for sections of the drywell above the sandbed region, it took approximately 10 inspections over a period greater than 10 years to confirm with 95% confidence that corrosion rates (which were less than 1 mil per year) existed. These locations above the sandbed region have a variance, which is less than that for the sandbed region (a standard deviations of approximately 20 mils). This is because the external surface of the vessel above the sandbed region experienced a much less severe corrosion mechanism resulting in a more uniform surface.

Therefore based on the experience above the sandbed region and the greater variance in the sandbed region (3 to 4 times greater) it is not expected that these inspections will yield the expected rate (significantly less than 1 mil per year) with 95% confidence in only four inspections.

Therefore a sensitivity study was performed to determine the minimum statistically observable rates given the number of sandbed inspections and the calculated variance of the data. The methodology for the study is described in sections 6.9.4.

The study determined the minimum statistically observable corrosion rate based on the variance that can exist in the 49 point grids given the observed standard deviations and the number of observations (4). For this case grid 19A was chosen since it is the thinnest of the 19 grids.

This study performed 10 iterations of of 100 simulations each of varying corrosions rates of 5, 6, 7, 8, and 9 mils per year.

Each simulation generated 49 point arrays for 1992, 1994, 1996, and 2006. The arrays were generated using a random number generator, which simulates a normal distribution. The random number generator requires an input of the target mean value and an input for the target standard deviation.

The mean value input into the random number generator for to the 1992 array was the 1992 actual mean for location 19A (800 mils- reference appendix 10 page 10). The standard deviation

input into the random number generator for all arrays was 65 mils (which is an average of the calculated standard deviations from the 1992, 1994, 1996 and 2006 data (see appendix 10 page 10). The random number generator then generated 49 point arrays based on a mean of 800 mils and a standard deviation of 65 mils.

The 1994 array was generated in the same manner except the input mean was the value of 800 minus the simulated rate (in mils per year) times 2 years (1994-1992). The 1996 array was generated in the same manner except the input mean was the value of 800 minus the simulated rate (in mils per year) times 4 years (1996-1992). The 2006 array was generated in the same manner except the input mean was the value of 800 minus the simulated rate (in mils per year) times 14 years (2006-1992).

These four simulated arrays were then tested for Corrosion per section 6.9.2. This procedure was repeated 100 times for each of the simulated corrosion rates of 5, 6, 7, 8, and 9 mils per year. Corrosion rates that successfully passed the Corrosion test 95 times or more out of 100 iterations are considered the statistically observable rate. Each set of 100 iterations was repeated 10 times. Finally a refined rate of 6.9 mils per year was simulated and passed the test in the ten, 100 iterations with 95% confidence.

Results were that a 49 point grid with a standard deviation of 65 mils experiencing a corrosion rate of 6.9 mils per year can be observed 95 or more times out of 100 simulations with 95% confidence. This is a potential minimum detectable corrosion rate. The actual detectable corrosion rate is analytically indeterminate at this time and, using engineering judgment, is probably close to zero. Applying the potential minimum detectable corrosion rate is conservative and optional. The result is a manageable condition.

8.0 Software

This calculation does not use the same software that was used in earlier calculations (reference 3.20, 3.21, and 3.22). Previous sandbed related calculations utilized the GPUN mainframe computer and the "SAS" mainframe software. The Oyster Creek Plant was sold to AmerGen in the year 2000. The GPUN Main Frame was not available to AmerGen after the year 2002. Also the "SAS" software is mainframe based is difficult to maintain. An alternative PC based software, "MATHCAD", has been chosen to perform this calculation.

Although the software has been changed the overall methodology, with minor exceptions, is the same as in previous calculation. The minor exceptions are the statistical tests that determine whether the data is normally distributed. The Mathcad routines have been successfully used in previous calculations for Upper Drywell Elevations (reference 3.24).

In addition the Excel Software was used to evaluate the 106 external UT inspection data.

9.0 Appendices

Appendix #1 - Bay 9 location 9D December 1992 through Oct 2006
Appendix #2 - Bay 11 location 11A December 1992 through Oct 2006
Appendix #3 - Bay 11 location 11C December 1992 through Oct 2006
Appendix #4 - Bay 13 location 13A December 1992 through Oct 2006
Appendix #5 - Bay 13 location 13D December 1992 through Oct 2006
Appendix #6 - Bay 15 location 15D December 1992 through Oct 2006
Appendix #7 - Bay 17 location 17A December 1992 through Oct 2006
Appendix #8 - Bay 17 location 17D December 1992 through Oct 2006
Appendix #9 - Bay 17 location 17-19 December 1992 through Oct 2006
Appendix #10 - Bay 19 location 19A December 1992 through Oct 2006
Appendix #11 - Bay 19 location 19B December 1992 through Oct 2006
Appendix #12 - Bay 19 location 19C December 1992 through Oct 2006
Appendix #13 - Bay 1 location 1D December 1992 through Oct 2006
Appendix #14 - Bay 3 location 3D December 1992 through Oct 2006
Appendix #15 - Bay 5 location 5D December 1992 through Oct 2006
Appendix #16 - Bay 7 location 7D December 1992 through Oct 2006
Appendix #17 - Bay 9 location 9A December 1992 through Oct 2006
Appendix 18 - Bay 13 location 13 C December 1992 through Oct 2006
Appendix 19 - Bay 15 location 15A December 1992 through Oct 2006
Appendix 20 - Review of the 2006 106 External UT inspections
Appendix 21 - Sensitivity of the Corrosion Test with out the 1996 Data
Appendix 22 - Sensitivity Studies to Determine Minimum Statistically Observable Corrosion Rates
Appendix 23 - Independent Third Party Review of Calculation

Attachment 1- 1992 UT Data
Attachment 2- 1994 UT Data
Attachment 3- 1996 UT Data
Attachment 4- 2006 UT Data
Attachment 5- 1992 UT Data for First Inspections of Transition Elevations 23' 6" and 71' 6".

EXHIBIT SJA 2

Reason For Evaluation: Water Found in Drywell Trench 5 – UT Data Evaluation

During the 1R21 Refueling Outage, standing water was found in the trench at elevation 10' 3" in Bay 5 of the Drywell. The purpose of this technical evaluation is to develop a conservative approach to address the worst case concerns associated with the as-found water in the drywell concrete. This evaluation will assess the condition through comparisons of the original UT data taken in 1986, and the UT data taken during the 1R21 outage. Note that the sand and water corrosive environment was removed from the sandbed region in 1992. This evaluation will evaluate these UT results as they relate to potential corrosion concerns based on the current plant configuration with water existing in the drywell concrete area. This evaluation will address immediate concerns in the as-found wetted area of the drywell shell to demonstrate adequate design margins exist (in a worst-case scenario) to support startup of the plant and operation of the plant through the next cycle of operation. The complete assessment of all UT data taken in 1R21 and establishing the associated margins to support operating through the period of extended operation of the plant will be addressed separately.

This Tech Eval was developed in accordance with CC-AA-309-101 Revision 7.

The development of this Tech Eval was reviewed with Howie Ray in accordance with HU-AA-1212. The risk rank was assessed as a "2". Therefore a third party review will be performed.

Background:

In 1986 concrete was removed in two locations (one each in Bays 5 and 17) from the interior Drywell floor at elevation 10' 3". Approximately a 1 foot wide by 2 foot long section was removed at each location. These areas have been commonly referenced to as the "trenches". The purpose of the "trenches" was to expose the Drywell Vessel below the concrete inside the Drywell at elevation 10' 3" so that UT readings could be performed on the vessel.

The bottom of trenches in Bay 5 and 17 are located at approximately elevation 8' 9" and 9' 3" respectively, which generally correspond to the elevation of the sandbed floor located outside the Drywell. Therefore the UT readings from the original trench areas correspond to sections of the vessel that are not embedded in outside concrete. The results of these UT inspections were documented in TDR 851 and drawing 3E-SK-S-85. UT readings were taken on 1 inch centers. The results of the 1986 UT inspections show drywell thicknesses which are indicative of the vessel embedded on the inside of the Drywell and exposed to the sand environment on the outside, which was eventually eliminated in 1992 when the sand was removed from the sandbed region.

In 1992, following the removal of the sand from the sandbed region and the removal of corrosion byproducts, the Drywell Vessel was visually inspected from inside the sandbed, which is outside the Drywell Vessel. This inspection identified the thinnest locations in each of the 10 sandbed bays. These thinnest locations were then UT inspected. In some

cases the area had to be slightly grinded so that the UT probe could rest flat against the surface of the vessel. The thickness values and the locations of each reading, referenced from existing welds, were recorded on a series of NDE data sheets. At each location one UT reading was performed.

In 2006, UT readings of the interior Drywell shell were again recorded on 1 inch centers in the two trenches. These readings were intended for a comparison with the 1986 readings.

Also in 2006, 106 readings were taken of the external portion of the Drywell Vessel from within the former sandbed region. These locations were located using the 1992 NDE Inspection Data Sheet maps. These readings were intended for a comparison with the 1992 readings.

Additionally, during the 1R21 outage in 2006 more concrete was removed from the bottom of the trench in Bay 5 to expose an additional 6" by 12" section of the drywell vessel. This newly exposed section of the vessel lies below the sandbed floor on the outside of the drywell. Therefore the results of this inspection show drywell thicknesses that are indicative of the vessel that is embedded on both sides by concrete.

Detailed Evaluation:

Assumptions and Clarifications

1) TDR 851 documents that values initially recorded using "D" meter UT instrumentation in the Bay 5 trench in 1986 were much less than nominal.

In order to rule out that these readings did not indicate small or pin-point corrosion cells additional NDE investigations were performed in 1986 by GPUN and EPRI NDE personnel. The investigations revealed that the low readings were due to small inclusions in the steel plate rather than thin steel. This was later confirmed by the removal of a 2" diameter section of the Drywell Vessel, which contained an inclusion. Lab analysis of the inclusion characterized it as an "aluminide stringer" at the mid-wall plane of the plate parallel to the rolling direction (reference TDR 854). The conclusions of this investigation were also reviewed by the NRC in an SER (dated December 29, 1986, Docket No.50-219) and found to be acceptable.

However the actual readings were captured in Drawing 3E-SK-S-85.

Inclusions of this nature and size are acceptable in the manufacturing process of carbon steel plates and do not effect the ultimate strength of the plates,

If Oyster Creek were to perform an inspection of this plate for unacceptable indications then ASME Section III sub-section NB 2532 (2004) would provide acceptance criteria for indications as identified by UT inspection.

Subsection NB 2532 provides acceptance criteria as follows:

1) Any area where one or more imperfection produce continuous total loss of back reflection accompanied by continuous indications on the same plane that cannot be encompassed with a circle whose diameter is 3 inches or one half the plate thicknesses, which ever is greater is unacceptable.
2) In addition two or more imperfections smaller than described in 1 above shall be unacceptable unless separated by a minimum distance equal to the greatest diameter of the largest imperfection, or unless they may be collectively encompassed by the circle described in (1) above

The ultrasonic equipment (Panametrics 37DL) used during 1R21 displays both a "digital thickness readout" and an "A" scan presentation. Small inclusions whether gas or non-metallic that are flattened during the rolling process create perfect sound reflectors in plate. The "A" scan presentation gives the operator the ability to distinguish between non-relevant signals and true thickness readings. It also gives the operator the ability to adjust the appropriate signal (the one representing the full thickness) either by increasing or decreasing the gain to change the signal amplitude or by using a feature called "extended blank" which basically tells the machine not to record readings in a certain area. These adjustments are made so the correct reading can be obtained from the controlled storage module of the instrumentation database.

A review of the 1R21 data taken in the Bay 5 trench shows that the operator made several adjustments to both the gain and the extended blank.

In addition, had any of the inclusions been large enough to block the ultrasonic signal a reading would not have been recorded. No such readings were observed in 1R21. The inspection performed on the Bay 5 Trench during 1R21 was for thickness only, however the fact that we were able to get sound to penetrate through the entire thickness demonstrates that no area contained inclusions larger than the diameter of the transducer (0.438"). This would not have been the case due to the different technology used in 1986. Therefore using the ASME Section III guidance for the 1986 and 2006 inspection led to the following conclusions.

In 2006 all readings located on 1 inches center were successfully obtained and back reflection were achieved on all reading. Therefore based on the size of the UT transducer no imperfections were detected, which approach 0.438 inches in diameter.

UT readings were collected on 1 inch centers with a UT transducer with a head size of 0.438 inches in diameter. Therefore the largest linear distance in the inspection area that would not have been scanned is approximately 0.976 inches, which is diagonal distance between two adjoining inspection points. Therefore any potential laminations approaching 1" in diameter would have been identified by the inspection and were not.

However oblong indications of up to 0.562 inches wide and that exceed 3" in length and are parallel to the grid pattern may not have been observed.

The existence of unacceptable indications is not considered credible for the following reasons:

1) The 1986 data shows that no three continuous 1 inch grid locations had indications of inclusions.

2) The indication would have to be oblong and parallel to the grid pattern.

3) Any inclusions or indications would have occurred in the manufacturing process randomly with respect to the location on the plate. Therefore, since 1986 and 2006 thickness readings are normally distributed (see attachment 2), it can be concluded with 95% confidence that the true condition of the plate is known in 2006.

Therefore for the purpose of this evaluation, all readings found to be lower than 0.780 inches were discounted from the 1986 readings for the trench in Bay 17. Also the 2006 data showed no similar readings (less than 0.780) in the lower 5 grids. The discounted readings are circled in attachment 1. Note that this treatment of the 1986 data is actually conservative for computing corrosion rate if they were compared to the 2006 data, because the 1986 values (if included) would have reduced the 1986 average thickness.

2) The uncertainties of the 1986, 1992, and 2006 UT readings can be as great as +/- .020 inches based on:

a) The roughness of the inspected surfaces due to the previously corroded surface of the shell in the sandbed regions
b) The different UT technologies between the 1986, 1992 and 2006
c) UT Equipment Instrument Uncertainties and
d) The uncertainties in attempting to inspect the exact same location over time

3) Row 7 points 6 and 7 in the Bay 17 trench data for 2006 were discounted because they were much thicker than the previous readings. These points are located on a much thicker weld. These readings were re-verified by NDE to be correct, however these values were discounted to maintain conservative results.

4) The sections of drywell vessel that were exposed by the removal of the concrete in trenches in 1986 continued to corrode from the exterior at elevated rates between 1986 and 1992 prior to the removal of the sand and epoxy coating application. For example inspection in 1992 showed that corrosion rates in Bay 17 could have been as great as 0.0211 inches per year, with 95% confidence (ref. C-1302-187-5300-021). The corrosion rates in the Bay 5 were estimated to be as great as 0.0113 inches per year, at 95% confidence (C1302-187-5300-028). Therefore the material loss measured by the 2006 UT inspection would include the corrosion rates that were known to exist from the sandbed side (exterior) between 1986 and 1992.

5) Direct point to point comparison of the 1986 and 2006 trench UT data cannot be preformed since the precise location of the 1986 readings and grids were not marked.

Acceptance Criteria

Drywell Vessel Thickness criteria has been previously established (reference C-1302-187-5320-024) as follows:

1) General Uniform Thickness - 0.736 inches or greater.

2) If an area is less than 0.736" thick then that area shall be greater than 0.693" thick and shall be no larger then 6" by 6" wide. C-1302-187-5320-024 has previously dispositioned an area of this magnitude in Bay 13.

3) If an area is less than 0.693" thick then that area shall be greater than 0.490" thick and shall be no larger then 2" in diameter. C-1302-187-5320-024 calculated an acceptance criterion of .479 inches however; this evaluation is conservatively using .490 inches, which is the original GE acceptance criterion. Since the UT readings were taken on 1 inch centers and the transducer size is less than 0.5 inch these readings can be characterized as less than 2 inches in diameter.

Comparison of the Bay 5 Trench

The 1986 and 2006 data for the Bay 5 trench is located in attachment 1. A Mathcad spreadsheet that computes the average of each data set is provided in attachment 2. Please note that zero values are automatically discounted from the average and standard deviation computation. These are the values that were concluded to be inclusions in the 1986 data (see assumption 1).

The computation shows that a total of 302 readings were considered for 1986 and that the mean was 1.112 inches with a standard deviation of 0.045 inches and a standard error of .00259 inches. This meets the general acceptance criteria of 0.736 inches with a 95% confidence.

The computation shows that a total of 294 readings were considered for 2006 and that the mean is 1.074 inches with a standard deviation of 0.0456 inches and a standard error of .00266 inches. This meets the general acceptance criteria of 0.736 inches with a 95% confidence.

Assuming the material loss occurred continuously from 1986 to 2006 results in an apparent corrosion rate of 0 .0019 inches per year. However when considering the aggressive corrosive environment that existed from 1986 to 1992 on the outside of the vessel, a corrosion rate of 0.0063 inches per year would be expected during this time frame (1986 to 1992). This rate is well within the range (up to 0.0113 inches per year)

measured in bay 5 during this period (see assumption/clarification 4). Therefore, it can be concluded that most of the material loss occurred between 1986 and 1992.

The minimum 2006 reading in this trench was 0.957 inches. This meets the local acceptance criteria of 0.49 inches.

Comparison of the Bay 17 Trench

The 1986 and 2006 data for the Bay 17 trench is located in Attachment 1. A Mathcad spreadsheet that computes the average of each data set is provided in Attachment 3. Note that zero values are automatically discounted from the average and standard deviation computation. These are the 2006 points, which were much thicker than the previous readings (see assumption 3).

The 1986 data consist of five, 7 row by 7 column grids and one additional row. The computation shows that a total of 250 readings were considered for 1986 and that the mean is 1.024 inches, with 95% confidence, a standard deviation of .045 inches, and a standard error of .002847 inches. This meets the general acceptance criteria of 0.736 inches with a 95% confidence.

The 2006 data consist of six 7 row by 7 column grids. The initial 2006 computation of the considered 290 readings resulted in a 0.963 inch mean with a standard deviation of .0713 inches and a standard error of .004184 inches. This meets the general acceptance criteria of 0.736 inches. Statistical review of the data shows that the distribution is skewed and cannot be considered completely normalized. Therefore the calculated mean for these six grids does not have a 95% confidence level. However closer review of the 2006 data shows that the top grid has a mean (0.845 inches) which was significantly less than the mean or the lower 5 grids (0.9852 inches). Statistical review of the 5 lower grids without the top grid shows that the distribution is completely normalized.

The mean of the lower 5 grids (with a total of 243 readings) is 0.9856 inches, a standard deviation of .0412 inches, and a standard error of 0.00266 inches. This meets the general acceptance criteria of 0.736 inches and is consistent with the standard deviation and standard error of 1986 data.

This comparison indicates that it is possible that the lower 5 grids of the six measured in 2006 (with a total of 243 readings) correspond to approximately the same area that 5 grids and 1 row (with 250 reading) measured in 1986. However since the mean of all six 2006 grids (with 290 readings) results in a more conservative rate the 6 grid mean will be used to calculate the maximum potential corrosion rates between 1986 and 1992 and apparent corrosion rates between 1986 and 2006.

Assuming the material loss occurred continuously from 1986 to 2006 results in an apparent corrosion rate of 0.003055 inches per year. However when considering the aggressive corrosive environment that existed from 1986 to 1992 on the outside, a corrosion rate of 0.0102 inches per year would be expected during this time frame (1986

to 1992). This rate is well within the range (up to 0.0211 inches per year) measured in bay 17 during this period (see assumption/clarification 4). Therefore, it is expected that the material loss occurred between 1986 and 1992.

In addition the minimum 2006 individual reading in this trench was 0.702 inches which is estimated to be located in an area no larger than 4" in diameter. This meets the acceptance of criteria 0.693 inches in an area of 6" by 6" or smaller for at least an additional two years.

Comparison of external inspection locations correlating to beneath the interior Drywell floor at elevation 10' 3" but above the wetted area at elevation 9' 2".

The 1992 and 2006 data for 106 external inspections is provided in attachment 4. This attachment includes inspections that were performed above and below the internal concrete floor at elevation 10' 3".

Review of the 106 locations show 18 areas corresponding to elevations of the drywell vessel that are beneath the interior Drywell floor at elevation 10' 3" but above the wetted area at elevation 9' 2" (see attachment 5). The data for the 18 locations is shown in attachment 6. For each of these 18 readings the 2006 value was subtracted from the 1992 value and divided by 14 years (time between 1992 and 2006). Locations with positive rates were re-verified by NDE to be correct during the 2006 inspection. However, since these values would result in positive changes in metal thickness, they were discounted from the computation to maintain conservative results.

The resulting differences in UT readings based on point-to-point comparison in this region vary between 0 and .0065 inches per year. On average the differences for this region, ignoring the described uncertainties, equate to 0.00228 inches per year.

The minimum 2006 reading of all the areas below the concrete floor was 0.669 inches. This meets the local acceptance criteria of 0.49 inches even after deducting the worst case differences including instrument uncertainties.

Comparison of External Inspection Locations correlating to beneath the wetted elevation of 9' 2" (approximate level at which water was discovered in the Bay 5 trench)

The 1992 and 2006 data for 106 external inspections is provided in attachment 4. This attachment includes inspections that were performed above and below the internal concrete floor at elevation 10' 3".

Review of the 106 locations show 22 area corresponding to elevations of the drywell vessel at an elevation below 9' 2"; which is the approximate level that water was discovered in the Bay 5 trench (see attachment 5). The data for the 22 locations is shown in attachment 6. For each of these 22 readings the 2006 value was subtracted from the 1992 value and divided by 14 years (time between 1992 and 2006). Locations with positive rates were re-verified by NDE to be correct during the 2006 inspection.

However, since these values would result in positive changes in metal thickness, they were discounted from the computation to maintain conservative results.

The resulting changes based on point to point comparison varied between 0 and .0061 inches per year. On average the changes for this region would equate to 0.00233 inches per year. These values can be conservatively used to demonstrate that even if the rates are not due to the expected uncertainties, there is sufficient margin existing to account for these uncertainties.

Bounding Worse Case

The maximum worst case point to point difference between 2006 data and 1992 data was found at a single location at an elevation above the wetted region but below the floor at elevation 10' 3". The difference was found at point 5 in Bay 17 from data collected from the external inspection (See attachment 6 sheet 2).

This wall thickness difference was computed be subtracting the 1992 value for this point from the 2006 value without eliminating uncertainties. This point is not located within either of the trench locations. The difference in thickness at this point equates to an apparent rate of 0.0065 inches per year, which is not considered credible given the physical limitations of the UT inspections taken from the exterior surface. These limitations include the roughness of the inspected surfaces, the different UT technologies used between 1992 and 2006, UT Equipment Instrument Uncertainties, and the repeatability due to trying to locate the exact same location over time.

However even when considering this worse case difference which was recorded on a location that is 0.822 inches thick in 2006, and considering it as a loss of wall rate per year at the thinnest location recorded in 2006 for points located below the concrete floor (0.669 inches in Bay 13 point 11), and applying 0.020 inch deduction for instrumentation uncertainty this location would only reduce to 0.636 inches by 2008, which still demonstrates significant margins compared to the acceptance criteria of 0.49 inches. Attachment 6 provides a spreadsheet that illustrates the basis for the above discussion.

Also considering a 0.0065 inches per year rate of change and applying it to the 2006 Bay 17 trench mean value (0.963 inches) and applying .020 inch deduction for instrumentation uncertainty would only reduce this value to 0.930 inches by 2008,

Conclusion:

The UT measurement taken on the plates exposed by the two trenches exhibit signs of material loss. It is concluded that most of the material loss occurred between 1986 and 1992. Assumed corrosion rates for this mechanism between 1986 and 1992 are consistent with as found measured corrosion rates previously established for these bays prior to removing the sand.

Additional concrete was removed from Bay 5 trench and UT readings taken 6 inches below the previous 1986 and 2006 readings. This newly excavated area represents shell thicknesses of the embedded region (on both sides) of the vessel in Bay 5 of sandbed region. The average Drywell shell thickness measured was 1.113 inches and the minimum reading was 1.052 inches. The UT Data Sheet is Attachment 7 to this evaluation. The shell thickness in this area meets the general uniform thickness criteria of 0.736 inches with considerable margin. This area will be used to repeat these UT measurements in 1R22.

Evaluation of the NDE examination results at and below the elevation 10'3" concrete slab concludes that the Drywell shell has sufficient thickness to withstand all design requirements.

Since there is uncertainly associated with the different instrumentation used in 1986 and 1992 and the instrumentation used in 2006, additional inspection of both trenches will be performed during the 2008 refueling outage. .

References:

TDR 851, Rev. 0, "Assessment of Oyster Creek Drywell Shell,

TDR 854, Rev. 0, "Drywell Corrosion Assessment"
Drawing 3E-SK-S-85.
C-1302-187-5320-024, "OC Drywell UT Evaluation in Sandbed"

Attachment 1 – 1986 and 2006 Trench Inspection Data – 10 pages
Attachment 2 – Bay 5 Trench Comparison of 1986 and 2006 data – 17 pages
Attachment 3 – Bay 17 Trench Comparison of 1986 and 2006 data – 20 pages
Attachment 4 – 1986 and 2006 Sandbed External Inspection Data – 20 pages
Attachment 5 – Plan and Elevation locations of the External Inspection locations – 8 pages
Attachment 6 – Comparison of 1986 and 2006 External Data – 2 pages
Attachment 7 – UT Data Sheet 1R21LR-032 – 2 pages
Attachment 8 – Third Party Review Documentation - 3 pages
Attachment 9 – MPR Ass. Independent Review Documentation - 2 pages

Prepared by: Tamburro, P. Pat Tam 11/7/06

This evaluation was Independently Reviewed by Frank Stulb through out its development which took approximately 7 days.

Comment resolution and incorporation of the Independent Third Party Review comments were discussed with Frank Stulb per a telephone conversation on 11/3/06 at 10:12 AM. He provided authorization for documentation and approval of his Independent Review of this document per this telephone conversation.

Independent Reviewer: P. Tamburro for F. Stulb by telecon on 11/7/06
Pat Tam 11/7/06 For F. Stulb per telecon.

Manager Comments:
The preparer and multiple reviewers of this technical evaluation had the appropriate knowledge and experience and are qualified to perform this task. The Independent Third Party Review (ITPR) was performed by MPR who was selected as a subject matter expert based on their expertise and industry experience on this topic. This document has been rigorously challenged and addresses the adequacy of the as-found water conditions and potential impacts to demonstrate the drywell vessel maintains its design and licensing bases requirements to support restart from 1R21.

The ITPR has been completed and comments adequately resolved as documented in Attachment 9.

Manager Approval: F.H. Ray 11/7/2006
F Hoy Ray 11/7/06

Presented at Start-Up PORC Meeting No. 06-18

PORC Chairman Approval: 11/7/06

EXPANDED U.T. AT PT. NO. 5B TRENCH
(6 IN. BY 46 IN. MATRIX)
(DATA SHT. NO. 86-049-47)

1.156	1.166	1.182	1.172	1.225	1.161	1.1[illegible]
1.160	.437	1.184	1.173	1.175	1.171	1.17[illegible]
.165	1.164	1.151	.657	.419	1.170	1.1[illegible]
1.145	1.151	1.158	1.162	1.155	1.159	1.1[illegible]
1.123	1.151	1.148	1.167	.456	1.139	1.15[illegible]
1.128	1.138	1.141	1.157	1.158	1.144	1.15[illegible]
1.123	1.149	1.130	.734	.735	N/A	N/A
1.109	1.121	1.144	1.155	1.156	1.149	1.15[illegible]
1.064	1.066	1.068	1.115	1.1	1.109	1.12[illegible]
1.051	1.096	1.041	1.077	1.162	1.078	.666
1.063	1.100	1.110	1.048	1.101	1.110	1.13[illegible]
1.047	1.109	1.149	1.13	1.176	1.179	1.05[illegible]
1.125	1.123	1.090	1.117	1.182	1.200	1.18[illegible]
1.135	1.091	1.107	1.080	1.084	1.125	1.18[illegible]
1.094	1.064	1.067	1.079	.646	1.169	1.14[illegible]
1.043	1.079	1.052	1.079	1.119	1.164	.444
1.058	1.055	1.082	1.044	1.071	.475	1.137
1.087	1.049	1.058	1.114	1.083	1.053	1.144
1.180	1.118	1.093	1.043	1.062	1.178	1.156
1.138	1.071	1.109	1.137	1.096	N/A	1.194
1.109	1.082	1.158	1.098	1.166	1.134	1.054
1.141	1.128	1.089	1.154	1.144	1.141	1.122
1.159	.758	.759	1.170	.771	1.151	1.10[illegible]
1.166	1.127	1.105	1.174	1.169	1.105	1.131
1.109	1.148	.481	1.166	1.171	1.113	1.141
1.089	1.167	.571	1.188	1.128	1.133	1.106
1.126	1.092	1.178	.718	1.167	1.124	1.072
1.069	1.054	1.112	1.089	1.146	1.119	1.090
1.076	1.056	1.098	.453	1.139	1.098	1.077
1.118	1.054	1.100	1.159	1.060	1.062	1.101
.67	1.073	1.110	1.205	1.149	1.090	1.113
.08	1.106	1.171	1.193	1.041	1.134	1.093
1.094	1.119	1.115	1.148	1.092	1.118	1.109
1.128	1.134	1.125	N/A	1.147	1.145	1.112
1.065	1.077	1.178	1.168	1.077	1.068	1.073
1.062	1.101	.456	1.088	1.069	1.074	1.067
1.100	1.062	1.141	1.059	1.110	1.076	1.078
1.044	1.052	.445	1.045	1.083	1.081	1.076
1.031	.788	1.057	1.073	1.059	1.109	1.062
1.035	.355	1.076	1.060	1.016	1.074	1.037
1.024	1.103	1.030	1.059	1.061	1.062	1.076
.436	1.057	1.021	1.015	1.028	1.089	1.08[illegible]
1.087	1.110	1.027	1.040	1.070	1.079	1.081
.773	1.132	1.049	1.096	1.052	1.093	1.092
1.168	1.112	1.113	1.101	1.056	1.065	1.108
1.271	1.138	1.117	1.103	1.152	1.142	1.108
1.211	1.158	1.099	1.133	1.134	1.145	1.1[illegible]

EL11-3"

Note circled values were discounted because thes value indicate inclusions.

TDR - 851

From 3E-SK-S-85

Bay 5 Trench 90°

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AR# A2152754 E09
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U.T. AT WELD, BAY NO. 5
(DATA SHT NO. 86-049-39)

DOWNCOMER AREA	2.901	2.914
HEAT AFFECTED ZONE	.438	1.206
AREA	1.170	1.175
	.870	.411

EXPANDED U.T. AT PT. NO. 5B
3 IN. ABOVE CURB, 5 IN. FROM
(6 IN. BY 6 IN. MATRIX)
(DATA SHT. NO. 86-049-36)

1.173	1.179	.468	.44	.498	1.2
1.184	1.181	1.174	1.255	1.15	1.1
1.177	1.184	.465	1.213	1.212	1.1
1.212	1.178	1.177	1.209	1.177	1.1
1.194	1.181	.465	1.22	1.135	1.1
1.174	1.209	1.163	1.16	1.157	1.1
1.155	1.161	1.163	1.221	1.173	1.1

WELD

EXPANDED U.T. AT PT.
11 IN. ABOVE CURB. 30
(6 IN. BY 6 IN. M
(DATA SHT. NO. 86-0

EXPANDED U.T. AT PT. NO. 17D TRENCH
(6 IN. BY 35 IN. MATRIX) 55½N FROM WELD
(DATA SHT. NO. 86-049-561)

EL11'-5"

EL11'-0"

.936	.932	.943	.958	.923	.889	.913
1.014	.953	.984	.987	.973	.939	.956
.991	1.085	.951	.968	.939	.945	.958
.995	.995	1.038	1.031	.992	1.083	1.011
1.025	1.011	.968	1.024	1.004	1.002	1.055
1.017	1.036	1.029	1.031	1.084	1.026	1.05
1.041	1.055	1.044	1.047	1.043	2.318	3.46
1.045	1.009	1.024	1.026	1.008	1.070	1.07
.991	1.012	1.041	1.031	1.017	1.076	1.076
1.031	1.101	1.081	1.077	1.040	1.076	1.072
1.087	1.059	1.069	1.057	1.102	1.088	1.047
.998	1.065	1.048	1.004	1.014	1.016	1.016
.964	1.019	.987	1.055	1.045	1.022	1.061
.906	1.040	1.019	.980	1.024	1.010	1.014
.964	1.105	1.083	1.011	1.047	1.016	1.028
1.063	1.012	1.029	1.047	1.056	.972	.987
1.021	1.097	1.071	1.069	1.033	.911	.952
1.068	1.023	1.006	1.063	1.045	1.035	.982
1.052	1.037	1.044	1.078	1.050	1.054	1.038
1.037	1.015	1.026	1.064	1.070	1.056	1.048
1.065	1.059	1.026	1.058	1.047	1.067	1.075
1.088	1.046	1.019	1.103	.993	1.086	1.041
1.056	1.045	.995	1.044	1.042	1.026	1.116
1.102	1.001	1.044	1.082	1.028	1.000	1.08
1.106	1.050	1.002	1.017	1.042	1.034	1.037
.969	.965	.988	1.122	1.034	1.032	1.07
1.097	1.028	1.051	.951	1.059	1.015	1.005
1.135	1.022	1.076	1.058	.952	.981	1.023
1.023	1.049	.987	1.085	1.048	1.072	.98
1.100	1.017	.958	1.044	.991	1.056	1.074
.053	1.030	1.025	.987	1.031	1.057	1.087
.005	1.049	1.006	1.058	1.058	1.011	.992
.972	.985	1.012	1.009	1.067	1.017	.975
.985	.979	.974	.961	1.017	1.008	.982
.999	.987	1.021	.958	.954	1.064	.942
.923	.981	.976	.970	.964	.990	1.004

WELD

From 3E-SK-S-8: Bay 17 Trench.

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ATTACHMENT 1
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EXPANDED U.T. AT PT.NO. 17D
14 IN. ABOVE CURB 59N FROM WELD
(6 IN. BY 6 IN. MATRIX)
(DATA SHT. NO. 86-049-049)

EL12'-2"

N/A	1.139	1.139	1.141	1.142	1.141	1.14
1.141	1.141	1.142	1.144	1.145	1.144	1.146
1.140	1.141	1.140	1.142	1.144	1.143	1.140
1.139	1.140	1.140	1.145	1.142	1.143	1.145
1.139	1.140	1.141	1.142	1.142	1.144	1.152
1.140	1.141	1.129	1.139	1.140	1.139	1.152
1.134	1.125	1.126	1.131	1.142	N/A	N/A

WELD

EL 12'-2"

56
63
57
57
53
33
07

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	Report Number:	1R21LR-
Oyster Creek		Date:	10/21/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification:	IS-328227-004

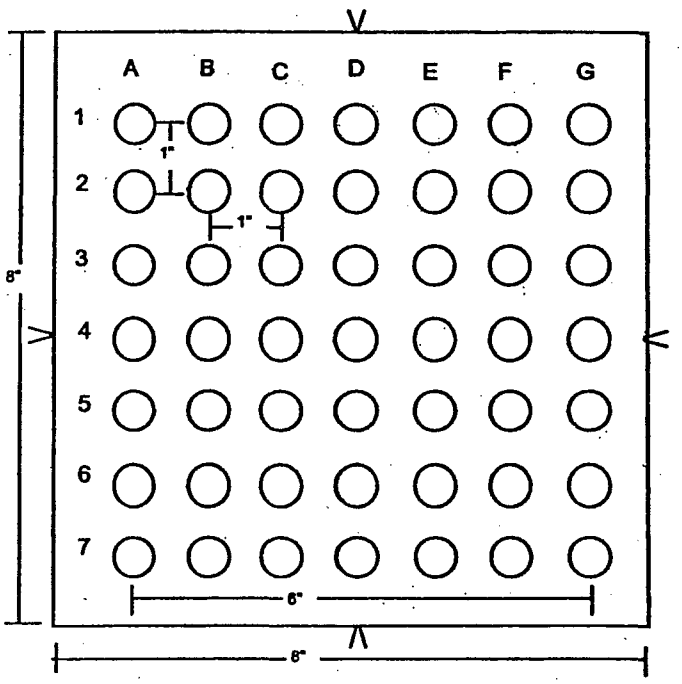
Examiner: Leslie Richter		Level: II	Instrument Type:	Panametrics 37DL Plus	
Examiner: Matt Wilson		Level: II	Instrument No:	031125009	
Transducer Type: DV 506	Serial #: 072561	Size: 0.438"	Freq: 5 Mhz		Angle: 0°
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge		Block Number: CAL-STEP-139			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	2.0"	11:01	11:32	12:05	12:38	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches				
Delay Calib:	N/A	Thermometer: 246647		Comp. Temp: 71°	Block Temp: 68°	
Range Calib:	N/A	W/O Number: C2013479				
Instrument Freq.	N/A	Total Crew Dose	Drywell Containment Vessel Thickness Examination. Internal UT Inspections.			
Gain:	63 db	96 mr				
Damping:	N/A	Trench 1 Bay 5				
Reject:	N/A					
Filter:	N/A					

Thickness readings taken at holes located in template.

The UT transducer was positioned in the same orientation at each grid point.



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AR# A2152754 E09
ATTACHMENT 1
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COMMENTS:

Template was placed at the bottom of the trench and forty-nine (49) points were recorded, then template was relocated above previous location with the centerline of the bottom row 1" +/- 1/16" from previous grid top row.
A "V" was stamped next to each side of each template location and above and below top and bottom.
A total of 294 reading were taken.

General Electric		Ultrasonic Thickness Measurement Data Sheet	File Name:	1R21LR- 25
Oyster Creek			Date:	10/18/2006
Refueling Outage -	1R21		UT Procedure:	ER-AA-335-004
Page 2 of	2		Grid Procedure:	IS-328227-004

Bottom of Trench							
Location ID		Trench 2		Bay	17	Elev.	10' 3"
	A	B	C	D	E	F	G
1	0.937	0.970	0.927	0.946	0.932	0.918	0.942
2	0.924	1.059	0.934	0.941	0.968	0.924	0.916
3	0.948	0.948	0.963	0.941	0.932	0.937	0.967
4	0.977	0.983	1.032	0.982	0.983	0.997	0.953
5	0.972	0.932	0.977	0.973	1.005	0.959	1.028
6	1.026	1.002	0.968	0.972	0.953	0.964	0.990
7	0.981	1.006	0.967	0.945	0.968	0.943	0.978
8	1.026	0.958	0.958	1.026	0.982	0.988	0.967
9	1.026	0.906	0.915	0.991	1.006	0.984	0.962
10	0.979	0.933	1.027	0.934	0.969	0.956	1.042
11	0.963	1.003	1.016	1.062	0.969	0.987	1.030
12	1.027	0.977	1.039	0.999	0.998	1.027	1.039
13	1.023	1.001	0.959	0.997	0.974	1.003	1.090
14	0.986	1.004	1.009	0.946	1.016	1.023	0.995
15	0.966	1.069	1.014	1.055	0.995	1.002	1.029
16	0.987	0.983	0.942	0.941	1.010	1.023	1.016
17	1.034	1.008	0.971	1.064	0.985	1.022	1.032
18	0.972	1.021	0.985	0.992	1.003	0.997	1.008
19	0.975	0.951	0.985	1.059	1.047	0.935	0.980
20	0.940	0.967	0.895	1.020	1.044	1.075	0.980
21	0.918	0.897	0.934	1.036	1.058	0.998	1.009
22	0.973	0.954	1.004	1.013	1.011	1.043	0.948
23	0.998	0.952	1.007	1.000	0.963	1.006	0.951
24	OBST.	0.978	0.979	0.935	1.014	0.981	1.015
25	1.017	1.074	0.968	0.963	0.966	1.014	1.030
26	1.038	1.053	1.026	1.008	0.983	0.979	1.039
27	0.968	1.028	0.998	1.017	1.004	1.030	1.046
28	1.028	0.950	1.047	1.000	0.977	1.002	1.010
29	0.997	1.023	1.060	1.015	0.964	0.995	0.997
30	1.061	0.958	1.022	1.044	0.991	0.990	1.001
31	1.008	1.021	1.010	1.010	1.003	0.959	0.963
32	0.988	0.991	0.961	0.940	1.029	0.979	0.929
33	1.005	1.014	1.003	0.896	0.944	1.013	0.885
34	0.990	0.976	0.962	0.909	0.905	0.863	0.923
35	0.954	0.954	OBST.	0.885	0.887	0.877	0.930
36	0.963	0.972	0.877	0.835	0.891	0.831	0.894
37	0.897	0.937	0.903	0.893	0.838	0.781	0.841
38	0.855	0.884	0.853	0.850	0.840	0.814	0.788
39	0.802	0.891	0.838	0.790	1.082	OBST.	0.809
40	0.746	0.795	0.776	0.822	0.757	1.042	0.794
41	0.702	0.779	0.811	0.835	0.723	0.738	0.837
42	0.726	0.825	0.878	0.868	OBST.	0.864	0.954
Top							

Tscr.	AVG.
0.660	0.963
Min Reading	Max. Reading
0.702	1.090

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Posey

Examined by Jeremy Tuttle *Jeremy Tuttle* 10/21/06 Level II Date 10/21/2006
Examined by N/A Level N/A Date N/A
Reviewed by: Lee Stone Level II Date 10/21/2006

Template layout for Trench UT data.

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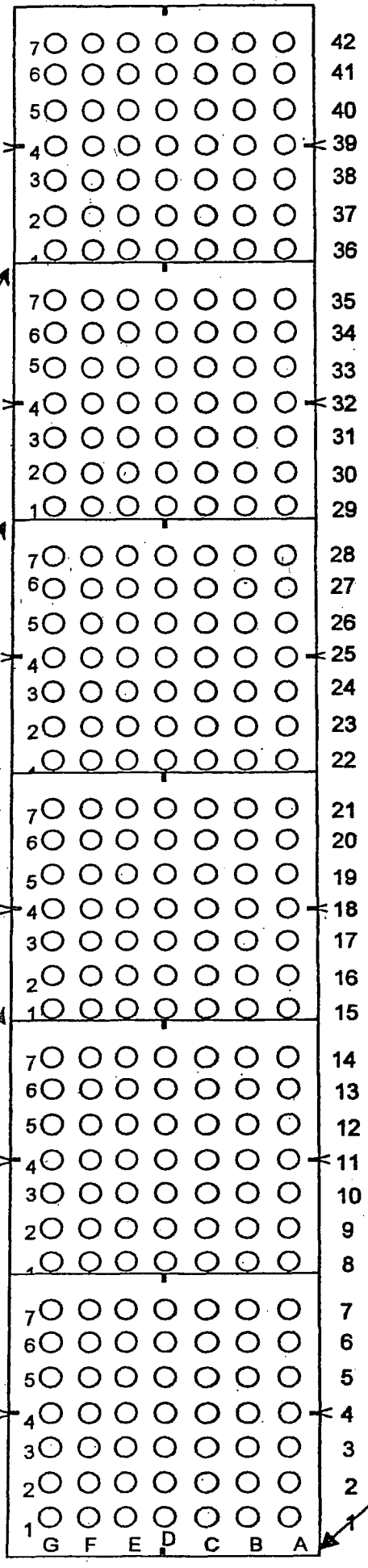
MMC 10-23-06
L III



Centerline of bottom row is 1" +/- 1/16" from previous row

1"

Template placed at Bottom of Trench

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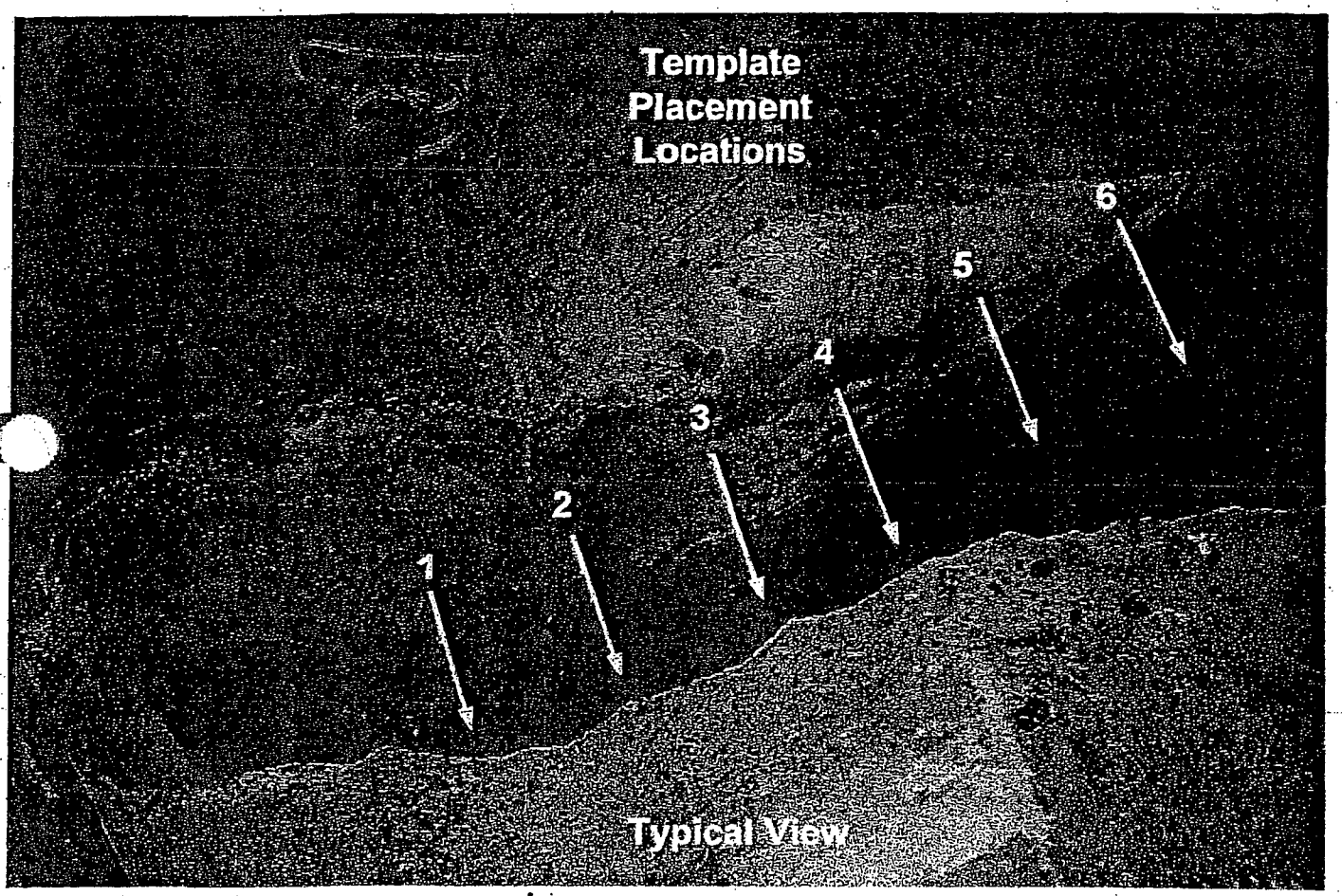
MM' C III
10-23-06



PASSPORT#
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AR# A2152754 E09
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General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	1R21LR- 25
Oyster Creek		Date:	10/21/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification:	IS-328227-004

Examiner: Jeremy Tuttle *Jeremy Tuttle 10/21/06*		Level: II		Instrument Type:	Panametrics 37DL Plus
Examiner: N/A		Level: N/A		Instrument No:	031125009
Transducer Type: DV 506	Serial #: 072362	Size: 0.438"	Freq: 5 Mhz		Angle: 0°
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge		Block Number: CAL-STEP-139			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	2.0"	7:17	8:22	N/A	9:05	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"		Inches to	1.500"	Inches
Delay Calib:	N/A	Thermometer:	246672	Comp. Temp: 73°	Block Temp:	68°
Range Calib:	N/A	W/O Number:	C2013479			
Instrument Freq.	N/A	Total Crew Dose	Drywell Containment Vessel Thickness Examination. Internal UT Inspections.			
Gain:	51 db	223 mr				
Damping:	N/A	Trench 2 Bay 17				
Reject:	N/A					
Filter:	N/A					

Thickness readings taken at holes located in template.

The UT transducer was positioned in the same orientation at each grid point.

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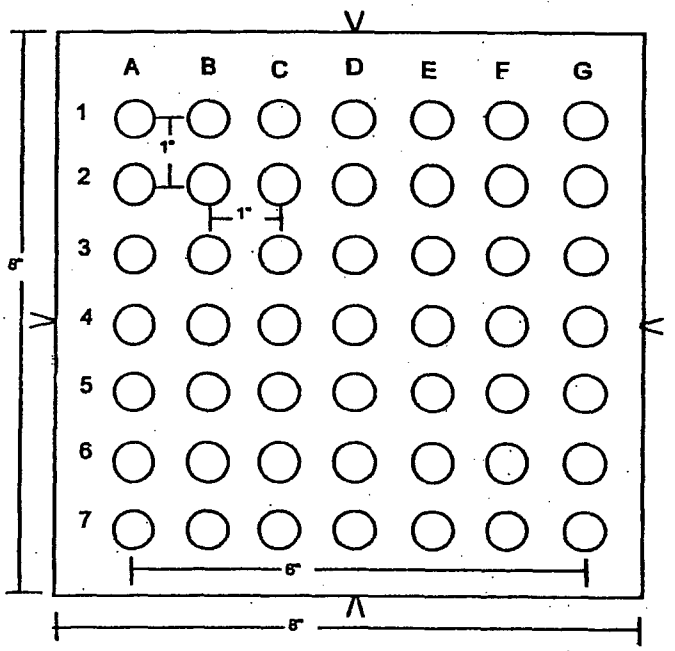

COMMENTS:
Grid Template aligned with V-stamps.
Template was placed at the bottom of the trench and forty-nine (49) points were recorded, then template was relocated above previous location with the centerline of the bottom row 1" +/- 1/16" from previous grid top row.
A total of 290 readings were taken.

All obstructions due to rough surface conditions. Some readings taken as best effort readings due to rough surface conditions.

Reviewed by: Lee Stone *Lee Stone* Level II Date 10/21/2006

General Electric	Ultrasonic Thickness Measurement Data Sheet	File Name:	1R21LR- 24
Oyster Creek		Date:	10/21/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 2 of 2		Grid Procedure:	IS-328227-004

MMC L III 10-23-06

Bottom of Trench							
Location ID		Trench 1		Bay	5	Elev.	10' 3"
	A	B	C	D	E	F	G
1	1.059	1.034	1.036	1.106	1.074	1.131	1.078
2	1.061	1.021	1.008	1.051	1.047	1.049	1.024
3	1.062	1.026	1.047	1.026	0.968	1.049	1.032
4	1.016	1.055	1.026	0.959	1.013	1.061	0.987
5	1.027	1.046	1.001	0.993	1.064	1.070	0.993
6	1.035	1.021	1.004	0.985	1.013	1.150	0.957
7	1.032	1.054	1.023	1.033	0.962	0.962	0.991
8	1.065	1.023	1.069	1.043	1.092	1.028	1.030
9	1.111	1.037	1.086	1.071	1.044	0.996	0.976
10	1.061	1.034	1.009	1.099	1.036	0.988	1.105
11	1.014	1.022	1.028	1.142	1.064	1.040	1.041
12	1.125	1.146	1.145	1.125	1.079	1.087	1.089
13	1.101	1.157	1.127	1.155	1.072	1.130	1.043
14	1.116	1.077	1.108	1.094	1.087	1.056	1.051
15	1.127	1.042	1.119	1.126	1.079	1.102	1.075
16	1.109	1.176	1.169	1.112	1.054	1.131	1.113
17	1.106	1.090	1.096	1.079	1.073	1.083	1.030
18	1.094	1.115	1.073	1.068	1.065	1.073	1.091
19	1.045	1.117	1.049	1.114	1.082	1.090	1.095
20	1.111	1.123	1.117	1.086	1.138	1.090	1.091
21	1.151	1.131	1.145	1.091	1.075	1.116	1.114
22	1.126	1.094	1.159	1.058	1.088	1.109	1.134
23	1.129	1.100	1.162	1.023	1.096	1.112	1.070
24	1.089	1.159	1.137	1.109	1.091	1.165	1.124
25	1.135	1.167	1.099	1.075	1.141	1.122	1.050
26	1.054	1.050	1.036	1.074	1.032	1.078	1.070
27	1.134	1.045	1.026	1.082	1.171	1.145	1.178
28	1.069	1.085	1.102	1.142	1.120	1.061	1.116
29	1.020	1.065	1.068	1.021	1.040	1.001	1.066
30	1.085	1.064	1.045	1.033	1.006	1.033	1.056
31	1.047	1.059	0.997	1.083	1.018	1.065	1.030
32	1.084	1.062	1.063	1.105	1.143	1.089	1.048
33	1.107	1.093	1.057	1.050	1.130	1.061	1.064
34	1.099	1.066	1.005	1.027	1.044	1.018	1.073
35	1.059	1.118	1.045	1.023	1.039	1.068	1.087
36	1.067	1.072	1.041	1.035	1.030	1.015	1.047
37	1.093	1.050	1.099	1.039	1.033	0.992	1.033
38	1.142	1.094	1.099	1.086	1.086	1.039	1.048
39	1.151	1.122	1.112	1.074	1.115	1.073	1.049
40	1.132	1.115	1.103	1.106	1.083	1.052	1.047
41	1.137	1.130	1.139	1.119	1.106	1.084	1.087
42	1.113	1.131	1.097	1.122	1.131	1.104	1.063
Top							

Tscr.	AVG.
0.660	1.074
Min Reading	Max. Reading
0.957	1.178

PASSPORT# 00546049 07
AR# A2152754 E09
ATTACHMENT 1
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MMC L III 10-23-06

Examined by	Leslie Richter	Level	II	Date	10/21/2006
Examined by	Matt Wilson	Level	II	Date	10/21/2006
Reviewed by:	Lee Stone	Level	II	Date	10/21/2006

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MM & JH 10-23-06

PASSPORT#
00546049 07
AR# A2152754 E09
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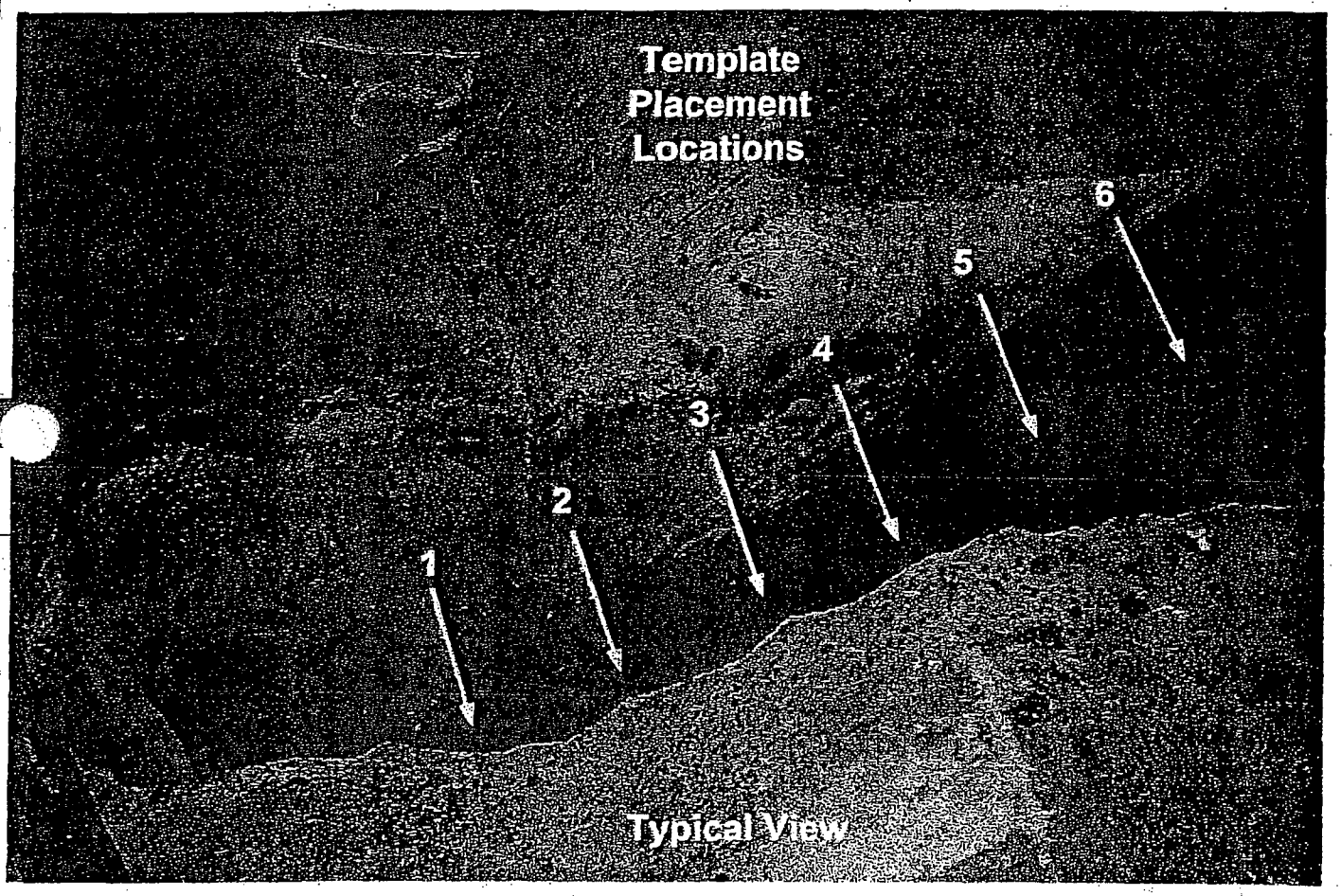
PT



Template layout for Trench UT data.

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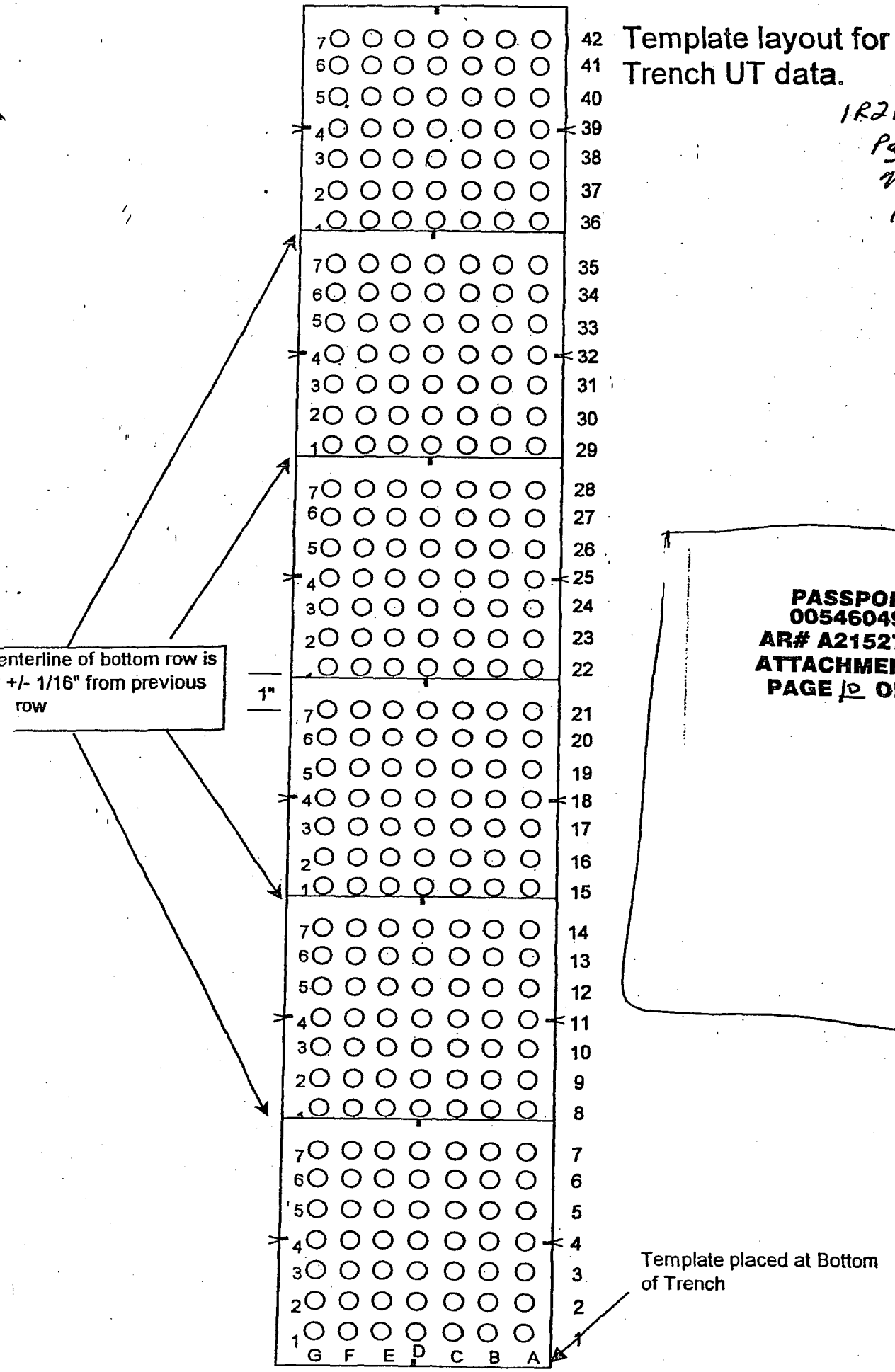

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ATTACHMENT 1
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Attachment 2 - Bay 5 Trench

1986 Data

The data shown below was collected in 1986 in the trench in Bay 5

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench5-1.txt")

$$Points_{49} := showcells(page, 7, 0)$$

$$Points_{49} = \begin{bmatrix} 1.156 & 1.166 & 1.182 & 1.172 & 1.225 & 1.181 & 1.171 \\ 1.16 & 0 & 1.184 & 1.173 & 1.175 & 1.171 & 1.176 \\ 1.165 & 1.164 & 1.151 & 0 & 0 & 1.17 & 1.17 \\ 1.145 & 1.151 & 1.158 & 1.162 & 1.155 & 1.159 & 1.172 \\ 1.123 & 1.151 & 1.148 & 1.167 & 0 & 1.139 & 1.156 \\ 1.128 & 1.138 & 1.141 & 1.157 & 1.158 & 1.144 & 1.159 \\ 1.123 & 1.149 & 1.13 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$XXXS := convert(Points_{49}, 7) \qquad No_{DataCells} := length(XXXS)$$

$$XXXS := deletezero_{cells}(XXXS, No_{DataCells})$$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench5-2.txt")

$$Points_{49} := showcells(page, 7, 0)$$

$$Points_{49} = \begin{bmatrix} 1.109 & 1.121 & 1.144 & 1.155 & 1.156 & 1.149 & 1.155 \\ 1.064 & 1.066 & 1.068 & 1.115 & 1.1 & 1.109 & 1.124 \\ 1.051 & 1.096 & 1.041 & 1.077 & 1.162 & 1.078 & 0 \\ 1.063 & 1.1 & 1.11 & 1.048 & 1.101 & 1.11 & 1.133 \\ 1.047 & 1.109 & 1.149 & 1.13 & 1.176 & 1.179 & 1.058 \\ 1.125 & 1.123 & 1.09 & 1.117 & 1.182 & 1.2 & 1.182 \\ 1.135 & 1.091 & 1.107 & 1.08 & 1.084 & 1.125 & 1.183 \end{bmatrix}$$

$$XXX := convert(Points_{49}, 7) \qquad No_{DataCells} := length(XXX)$$

$$XXX := deletezero_{cells}(XXX, No_{DataCells})$$

$$Cells_{86} := stack(XXX, XXXS) \qquad No_{DataCells} := length(Cells_{86}) \qquad No_{DataCells} = 89$$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench5-3.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.094 & 1.064 & 1.067 & 1.079 & 0 & 1.169 & 1.14 \\ 1.043 & 1.079 & 1.052 & 1.079 & 1.119 & 1.164 & 0 \\ 1.058 & 1.055 & 1.082 & 1.044 & 1.071 & 0 & 1.137 \\ 1.087 & 1.049 & 1.058 & 1.114 & 1.083 & 1.053 & 1.164 \\ 1.18 & 1.118 & 1.093 & 1.043 & 1.062 & 1.178 & 1.156 \\ 1.138 & 1.071 & 1.109 & 1.137 & 1.096 & 0 & 1.194 \\ 1.109 & 1.082 & 1.158 & 1.098 & 1.166 & 1.134 & 1.056 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\qquad$ $No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{86} := stack(Cells_{86}, XXX)$ $\qquad$ $No_{DataCells} := length(Cells_{86})$

$No_{DataCells} = 134$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench5-4.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.141 & 1.128 & 1.089 & 1.154 & 1.164 & 1.141 & 1.122 \\ 1.159 & 0 & 0 & 1.17 & 0 & 1.151 & 1.105 \\ 1.166 & 1.127 & 1.105 & 1.174 & 1.169 & 1.105 & 1.131 \\ 1.109 & 1.148 & 0 & 1.166 & 1.171 & 1.113 & 1.141 \\ 1.089 & 1.167 & 0 & 1.18 & 1.128 & 1.133 & 1.106 \\ 1.126 & 1.092 & 1.178 & 0 & 1.167 & 1.124 & 1.072 \\ 1.069 & 1.054 & 1.112 & 1.089 & 1.146 & 1.119 & 1.098 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\qquad$ $No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{86} := stack(Cells_{86}, XXX)$ $\qquad$ $No_{DataCells} := length(Cells_{86})$

$No_{DataCells} = 177$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench5-5.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.076 & 1.056 & 1.098 & 0 & 1.139 & 1.098 & 1.077 \\ 1.118 & 1.054 & 1.1 & 1.159 & 1.06 & 1.062 & 1.101 \\ 1.067 & 1.073 & 1.11 & 1.205 & 1.149 & 1.09 & 1.113 \\ 1.088 & 1.106 & 1.171 & 1.193 & 1.041 & 1.134 & 1.093 \\ 1.094 & 1.119 & 1.115 & 1.148 & 1.092 & 1.118 & 1.109 \\ 1.128 & 1.134 & 1.125 & 0 & 1.147 & 1.145 & 1.112 \\ 1.065 & 1.077 & 1.179 & 1.168 & 1.077 & 1.068 & 1.073 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\quad No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{86} := stack(Cells_{86}, XXX)$ $\quad No_{DataCells} := length(Cells_{86})$ $\quad No_{DataCells} = 224$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench5-6.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.062 & 1.101 & 0 & 1.088 & 1.069 & 1.074 & 1.067 \\ 1.1 & 1.062 & 1.141 & 1.059 & 1.11 & 1.076 & 1.078 \\ 1.044 & 1.052 & 0 & 1.045 & 1.083 & 1.081 & 1.076 \\ 1.031 & 0 & 1.057 & 1.073 & 1.059 & 1.109 & 1.062 \\ 1.035 & 0 & 1.076 & 1.06 & 1.016 & 1.074 & 1.037 \\ 1.024 & 1.103 & 1.03 & 1.059 & 1.061 & 1.062 & 1.076 \\ 0 & 1.057 & 1.021 & 1.015 & 1.028 & 1.089 & 1.08 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\quad No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{86} := stack(Cells_{86}, XXX)$

$No_{DataCells} := length(Cells_{86})$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench5-7.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.087 & 1.11 & 1.027 & 1.04 & 1.07 & 1.079 & 1.081 \\ 0 & 1.132 & 1.049 & 1.096 & 1.052 & 1.093 & 1.092 \\ 1.168 & 1.112 & 1.113 & 1.101 & 1.056 & 1.065 & 1.108 \\ 1.271 & 1.138 & 1.117 & 1.103 & 1.152 & 1.142 & 1.108 \\ 1.211 & 1.158 & 1.099 & 1.133 & 1.134 & 1.145 & 1.108 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\qquad$ $No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{86} := stack(Cells_{86}, XXX)$ $\qquad$ $No_{DataCells} := length(Cells_{86})$ $\qquad$ $No_{DataCells} = 302$

$No_{DataCells} = 302$

The thinnest point at this location is shown below

$minpoint := min(Cells_{86})$ $\qquad$ $minpoint = 1.015 \cdot 10^{3}$

Mean and Standard Deviation

$\mu 86_{actual} := mean(Cells_{86})$ $\mu 86_{actual} = 1.1123 \cdot 10^3$ $\sigma 86_{actual} := Stdev(Cells_{86})$ $\sigma 86_{actual} = 45.002$

Standard Error

$$Standard_{error} := \frac{\sigma 86_{actual}}{\sqrt{No_{DataCells}}}$$

$Standard_{error} = 2.59$

Skewness

$$Skewness := \frac{(No_{DataCells}) \cdot \overrightarrow{\Sigma(Cells_{86} - \mu 86_{actual})^3}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (\sigma 86_{actual})^3}$$

$Skewness = 0.132$

Kurtosis

$$Kurtosis := \frac{No_{DataCells} \cdot (No_{DataCells} + 1) \cdot \overrightarrow{\Sigma(Cells_{86} - \mu 86_{actual})^4}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (No_{DataCells} - 3) \cdot (\sigma 86_{actual})^4} \ldots + - \frac{3 \cdot (No_{DataCells} - 1)^2}{(No_{DataCells} - 2) \cdot (No_{DataCells} - 3)}$$

$Kurtosis = -0.534$

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.

$$j := 0 .. \mathrm{last}(\mathrm{Cells}_{86}) \qquad srt := \mathrm{sort}(\mathrm{Cells}_{86})$$

Then each data point is ranked. The array rank captures these ranks

$$r_j := j + 1$$

$$rank_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt = srt_j}\right) \cdot r}}{\overrightarrow{\Sigma srt = srt_j}}$$

$$p_j := \frac{rank_j}{\mathrm{rows}(\mathrm{Cells}_{86}) + 1}$$

The normal scores are the corresponding pth percentile points from the standard normal distribution:

$$x := 1 \qquad N_Score_j := \mathrm{root}\left[\mathrm{cnorm}(x) - (p_j), x\right]$$

Upper and Lower Confidence Values

The Upper and Lower confidence values are calculated based on .05 degree of confidence "α"

$No_{DataCells} := length(Cells_{86})$

$\alpha := .05$ $\qquad Tα := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right]$ $\qquad Tα = 1.968$

$Lower_{95\%Con} := \mu 86_{actual} - Tα \cdot \frac{\sigma 86_{actual}}{\sqrt{No_{DataCells}}}$ $\qquad Lower_{95\%Con} = 1.107 \cdot 10^3$

$Upper_{95\%Con} := \mu 86_{actual} + Tα \cdot \frac{\sigma 86_{actual}}{\sqrt{No_{DataCells}}}$ $\qquad Upper_{95\%Con} = 1.117 \cdot 10^3$

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

$Bins := Make_{bins}(\mu 86_{actual}, \sigma 86_{actual})$

$Distribution := hist(Bins, Cells_{86})$

Distribution =

0
3
14
42
45
54
41
43
45
11
2
1

The mid points of the Bins are calculated

$k := 0..11$ $\qquad Midpoints_k := \frac{(Bins_k + Bins_{k+1})}{2}$

The Mathcad function pnorm calculates a portion of normal distribution curve based on a given mean and standard deviation

$normal_{curve_0} := pnorm(Bins_1, \mu 86_{actual}, \sigma 86_{actual})$

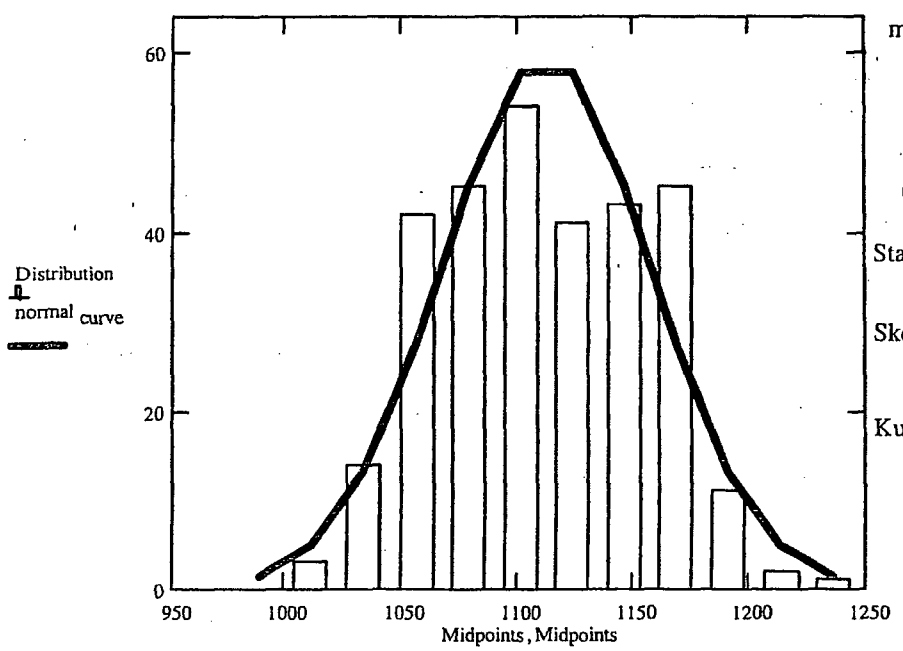
$normal_{curve_k} := pnorm(Bins_{k+1}, \mu 86_{actual}, \sigma 86_{actual}) - pnorm(Bins_k, \mu 86_{actual}, \sigma 86_{actual})$

$normal_{curve} := No_{DataCells} \cdot normal_{curve}$

Results For Elevation Sandbed elevation Locatiobn Oct. 2006

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



minpoint = $1.015 \cdot 10^3$

Standard $_{error}$ = 2.59

Skewness = 0.132

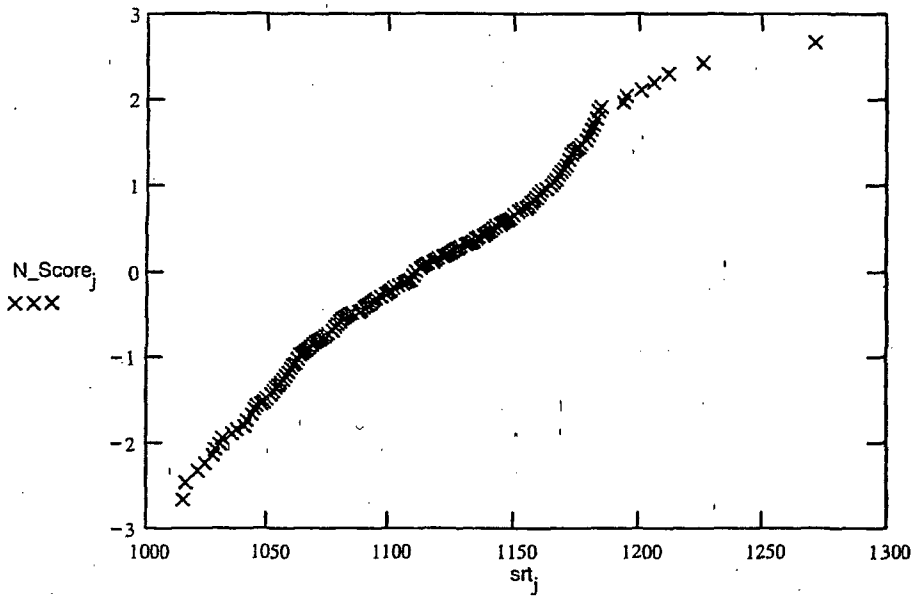
Kurtosis = −0.534

Lower $_{95\%Con}$ = $1.107 \cdot 10^3$ Upper $_{95\%Con}$ = $1.117 \cdot 10^3$

$\mu 86_{actual} = 1.112 \cdot 10^3$ $\sigma 86_{actual} = 45.002$ minpoint = $1.015 \cdot 10^3$

A Kurtosis value which is less than +/- 1.0 and approaches 0 is indicative of a normal distrubution

Normal Probability Plot



The Normal Probability Plot and the Kurtosis this data is normally distributed.

A Normal Probability Plot which approaches a straight line is indicative of a normal distrubution

OCT 2006 Data

The data shown below was collected in 2006 in the trench in Bay 5

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench5-1.txt")

$$Points_{49} := showcells(page, 7, 0)$$

$$Points_{49} = \begin{bmatrix} 1.067 & 1.072 & 1.041 & 1.035 & 1.03 & 1.015 & 1.047 \\ 1.093 & 1.05 & 1.099 & 1.039 & 1.033 & 0.992 & 1.033 \\ 1.142 & 1.094 & 1.099 & 1.086 & 1.086 & 1.039 & 1.048 \\ 1.151 & 1.122 & 1.112 & 1.074 & 1.115 & 1.073 & 1.049 \\ 1.132 & 1.115 & 1.103 & 1.106 & 1.083 & 1.052 & 1.047 \\ 1.137 & 1.13 & 1.139 & 1.119 & 1.106 & 1.084 & 1.087 \\ 1.113 & 1.131 & 1.097 & 1.122 & 1.131 & 1.104 & 1.063 \end{bmatrix}$$

$$XXXS := convert(Points_{49}, 7) \qquad No_{DataCells} := length(XXXS)$$

$$XXXS := deletezero_{cells}(XXXS, No_{DataCells})$$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench5-2.txt")

$$Points_{49} := showcells(page, 7, 0)$$

$$Points_{49} = \begin{bmatrix} 1.02 & 1.065 & 1.068 & 1.021 & 1.04 & 1.001 & 1.066 \\ 1.085 & 1.064 & 1.045 & 1.033 & 1.006 & 1.033 & 1.056 \\ 1.047 & 1.059 & 0.997 & 1.083 & 1.018 & 1.065 & 1.03 \\ 1.084 & 1.062 & 1.063 & 1.105 & 1.143 & 1.089 & 1.048 \\ 1.107 & 1.093 & 1.057 & 1.05 & 1.13 & 1.061 & 1.064 \\ 1.099 & 1.066 & 1.005 & 1.027 & 1.044 & 1.018 & 1.073 \\ 1.059 & 1.118 & 1.045 & 1.023 & 1.039 & 1.068 & 1.087 \end{bmatrix}$$

$$XXX := convert(Points_{49}, 7) \qquad No_{DataCells} := length(XXX)$$

$$XXX := deletezero_{cells}(XXX, No_{DataCells})$$

$$Cells_{06} := stack(XXX, XXXS) \qquad No_{DataCells} := length(Cells_{06})$$

$$No_{DataCells} = 98$$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench5-3.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.126 & 1.094 & 1.159 & 1.058 & 1.088 & 1.109 & 1.134 \\ 1.129 & 1.1 & 1.162 & 1.023 & 1.096 & 1.112 & 1.07 \\ 1.089 & 1.159 & 1.137 & 1.109 & 1.091 & 1.165 & 1.124 \\ 1.135 & 1.167 & 1.099 & 1.075 & 1.141 & 1.122 & 1.05 \\ 1.054 & 1.05 & 1.036 & 1.074 & 1.032 & 1.078 & 1.07 \\ 1.134 & 1.045 & 1.026 & 1.082 & 1.171 & 1.145 & 1.178 \\ 1.069 & 1.085 & 1.102 & 1.142 & 1.12 & 1.061 & 1.116 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\qquad$ $No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{06} := stack(Cells_{06}, XXX)$

$No_{DataCells} := length(Cells_{06})$

$No_{DataCells} = 147$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench5-4.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.127 & 1.042 & 1.119 & 1.126 & 1.079 & 1.102 & 1.075 \\ 1.109 & 1.176 & 1.169 & 1.112 & 1.054 & 1.131 & 1.113 \\ 1.106 & 1.09 & 1.096 & 1.079 & 1.073 & 1.083 & 1.03 \\ 1.094 & 1.115 & 1.073 & 1.068 & 1.065 & 1.073 & 1.091 \\ 1.045 & 1.117 & 1.049 & 1.114 & 1.082 & 1.09 & 1.095 \\ 1.111 & 1.123 & 1.117 & 1.086 & 1.138 & 1.09 & 1.091 \\ 1.151 & 1.131 & 1.145 & 1.091 & 1.075 & 1.116 & 1.114 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\qquad$ $No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{06} := stack(Cells_{06}, XXX)$

$No_{DataCells} := length(Cells_{06})$

$No_{DataCells} = 196$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench5-5.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.065 & 1.023 & 1.069 & 1.043 & 1.092 & 1.028 & 1.03 \\ 1.111 & 1.037 & 1.086 & 1.071 & 1.044 & 0.996 & 0.976 \\ 1.061 & 1.034 & 1.009 & 1.099 & 1.036 & 0.988 & 1.105 \\ 1.014 & 1.022 & 1.028 & 1.142 & 1.064 & 1.04 & 1.041 \\ 1.125 & 1.146 & 1.145 & 1.125 & 1.079 & 1.087 & 1.089 \\ 1.101 & 1.157 & 1.127 & 1.155 & 1.072 & 1.13 & 1.043 \\ 1.116 & 1.077 & 1.108 & 1.094 & 1.087 & 1.056 & 1.051 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\quad No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{06} := stack(Cells_{06}, XXX)$ $\quad No_{DataCells} := length(Cells_{06})$

$No_{DataCells} = 245$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench5-6.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.059 & 1.034 & 1.036 & 1.106 & 1.074 & 1.131 & 1.078 \\ 1.061 & 1.021 & 1.008 & 1.051 & 1.047 & 1.049 & 1.024 \\ 1.062 & 1.026 & 1.047 & 1.026 & 0.968 & 1.049 & 1.032 \\ 1.016 & 1.055 & 1.026 & 0.959 & 1.013 & 1.061 & 0.987 \\ 1.027 & 1.046 & 1.001 & 0.993 & 1.064 & 1.07 & 0.993 \\ 1.035 & 1.021 & 1.004 & 0.985 & 1.013 & 1.15 & 0.957 \\ 1.032 & 1.054 & 1.023 & 1.033 & 0.962 & 0.962 & 0.991 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\quad No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{06} := stack(Cells_{06}, XXX)$ $\quad No_{DataCells} := length(Cells_{06})$ $\quad No_{DataCells} = 294$

$minpoint := min(XXX)$ $\quad minpoint = 957$

The thinnest point at this location is shown below

$minpoint := min(Cells_{06})$ $\quad minpoint = 957$

Mean and Standard Deviation

$\mu 06_{actual} := mean(Cells_{06})$ $\mu 06_{actual} = 1.0743 \cdot 10^3$ $\sigma 06_{actual} := Stdev(Cells_{06})$ $\sigma 06_{actual} = 45.628$

Standard Error

$$Standard_{error} := \frac{\sigma 06_{actual}}{\sqrt{No_{DataCells}}}$$

$Standard_{error} = 2.661$

Skewness

$$Skewness := \frac{(No_{DataCells}) \cdot \overrightarrow{\Sigma(Cells_{06} - \mu 06_{actual})^3}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (\sigma 06_{actual})^3}$$

$Skewness = -0.071$

Kurtosis

$$Kurtosis := \frac{No_{DataCells} \cdot (No_{DataCells} + 1) \cdot \overrightarrow{\Sigma(Cells_{06} - \mu 06_{actual})^4}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (No_{DataCells} - 3) \cdot (\sigma 06_{actual})^4} \cdots + - \frac{3 \cdot (No_{DataCells} - 1)^2}{(No_{DataCells} - 2) \cdot (No_{DataCells} - 3)}$$

$Kurtosis = -0.432$

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.

$j := 0 .. \text{last}(\text{Cells}_{06})$

$\text{srt} := \text{sort}(\text{Cells}_{06})$

Then each data point is ranked. The array rank captures these ranks

$z_j := j + 1$

$$\text{rank}_j := \frac{\Sigma\left(\overrightarrow{\text{srt} = \text{srt}_j}\right) \cdot z}{\Sigma \overrightarrow{\text{srt} = \text{srt}_j}}$$

$$p_j := \frac{\text{rank}_j}{\text{rows}(\text{Cells}_{06}) + 1}$$

The normal scores are the corresponding pth percentile points from the standard normal distribution:

$x := 1 \qquad \text{N_Score}_j := \text{root}\left[\text{cnorm}(x) - (p_j), x\right]$

Upper and Lower Confidence Values

The Upper and Lower confidence values are calculated based on .05 degree of confidence "α"

$No_{DataCells} := length(Cells_{06})$

$\alpha := .05$ $\qquad T\alpha := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right]$ $\qquad T\alpha = 1.968$

$Lower_{95\%Con} := \mu06_{actual} - T\alpha \cdot \frac{\sigma06_{actual}}{\sqrt{No_{DataCells}}}$ $\qquad Lower_{95\%Con} = 1.069 \cdot 10^3$

$Upper_{95\%Con} := \mu06_{actual} + T\alpha \cdot \frac{\sigma06_{actual}}{\sqrt{No_{DataCells}}}$ $\qquad Upper_{95\%Con} = 1.08 \cdot 10^3$

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

$Bins := Make_{bins}(\mu06_{actual}, \sigma06_{actual})$

$Distribution := hist(Bins, Cells_{06})$

$Distribution =$

2
4
13
28
54
51
48
42
33
14
5
0

The mid points of the Bins are calculated

$k := 0 .. 11$ $\qquad Midpoints_k := \frac{(Bins_k + Bins_{k+1})}{2}$

The Mathcad function pnorm calculates a portion of normal distribution curve based on a given mean and standard deviation

$normal_{curve_0} := pnorm(Bins_1, \mu06_{actual}, \sigma06_{actual})$

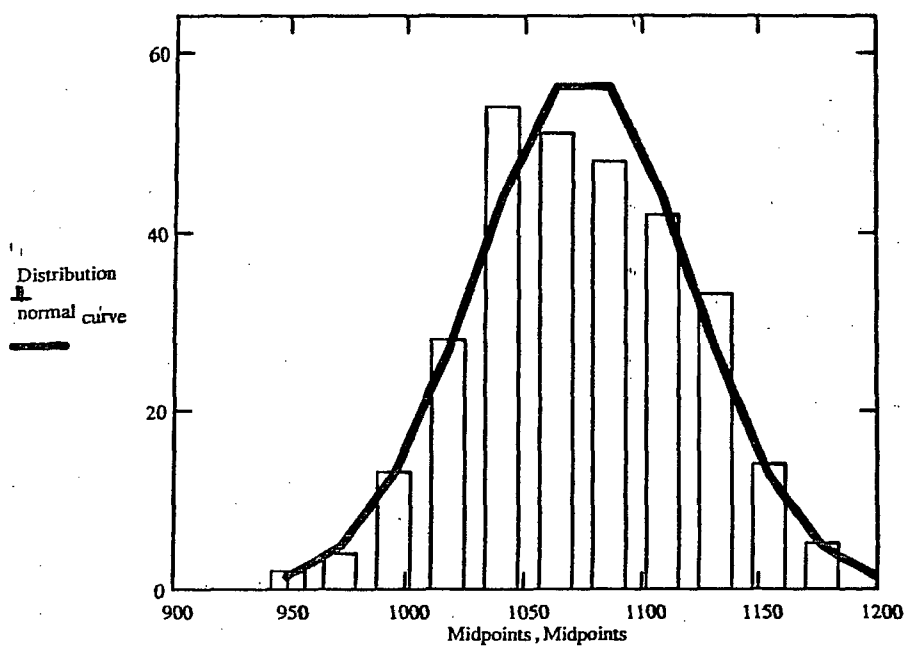
$normal_{curve_k} := pnorm(Bins_{k+1}, \mu06_{actual}, \sigma06_{actual}) - pnorm(Bins_k, \mu06_{actual}, \sigma06_{actual})$

$normal_{curve} := No_{DataCells} \cdot normal_{curve}$

Results For Elevation Sandbed elevation Locatiobn Oct. 2006

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



minpoint = 957

Standard $_{error}$ = 2.661

Skewness = −0.071

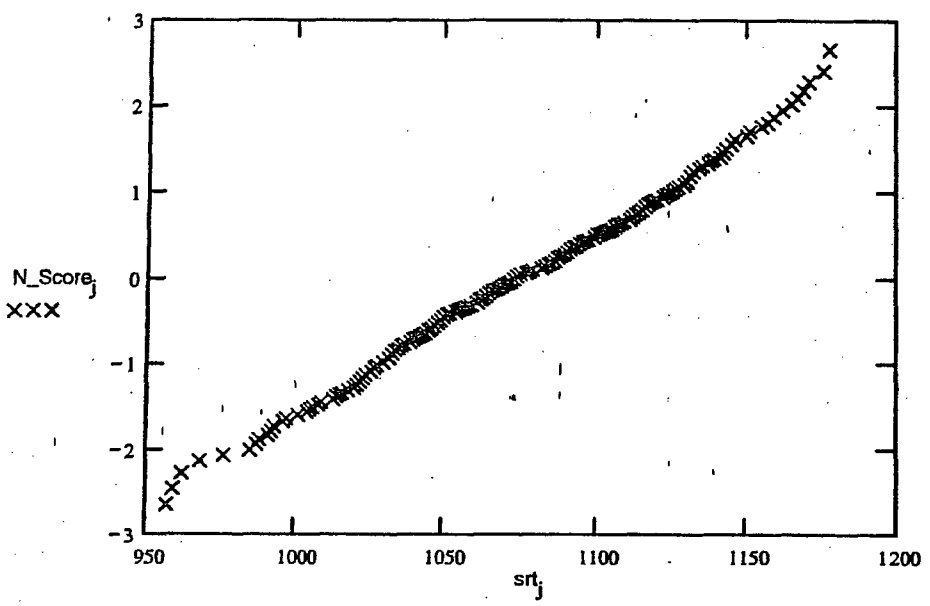
Kurtosis = −0.432

Lower $_{95\%Con}$ = $1.069 \cdot 10^3$ Upper $_{95\%Con}$ = $1.08 \cdot 10^3$

$\mu 06_{actual} = 1.074 \cdot 10^3$ $\sigma 06_{actual} = 45.628$ minpoint = 957

A Kurtosis value which is less than +/- 1.0 and approaches 0 is indicative of a normal distrubution

Normal Probability Plot



The Normal Probability Plot and the Kurtosis this data is normally distributed.

A Normal Probability Plot which approaches a straight line is indicative of a normal distrubution

Corrosion Rate assuming corrosion occured between 1986 and 2006

$$\frac{(\mu 86_{\text{actual}} - \mu 06_{\text{actual}})}{2006 - 1986} = 1.9$$

Corrosion Rate assuming corrosion occured between 1986 and 1992

$$\frac{(\mu 86_{\text{actual}} - \mu 06_{\text{actual}})}{1992 - 1986} = 6.334$$

Attachment 3 Bay 17 Trench

1986 Data

The data shown below was collected in 1986 in the trench in Bay 17

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench17-1.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 0.93 & 0.932 & 0.943 & 0.958 & 0.927 & 0.889 & 0.913 \\ 1.014 & 0.953 & 0.984 & 0.987 & 0.973 & 0.939 & 0.956 \\ 0.991 & 1.005 & 0.951 & 0.968 & 0.939 & 0.945 & 0.956 \\ 0.995 & 0.995 & 1.038 & 1.031 & 0.992 & 1.003 & 1.011 \\ 1.025 & 1.011 & 0.968 & 1.024 & 1.004 & 1.002 & 1.055 \\ 1.017 & 1.036 & 1.029 & 1.031 & 1.084 & 1.026 & 1.05 \\ 1.041 & 1.055 & 1.044 & 1.047 & 1.043 & 0 & 0 \end{bmatrix}$$

$XXXS := convert(Points_{49}, 7)$

$No_{DataCells} := length(XXXS)$

$XXXS := deletezero_{cells}(XXXS, No_{DataCells})$

$Grid_{Top1986} := XXXS$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench17-2.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.045 & 1.009 & 1.024 & 1.026 & 1.008 & 1.07 & 1.07 \\ 0.991 & 1.012 & 1.041 & 1.031 & 1.017 & 1.076 & 1.076 \\ 1.031 & 1.101 & 1.081 & 1.077 & 1.04 & 1.076 & 1.072 \\ 1.087 & 1.059 & 1.069 & 1.057 & 1.102 & 1.088 & 1.047 \\ 0.998 & 1.065 & 1.048 & 1.004 & 1.014 & 1.016 & 1.016 \\ 0.964 & 1.019 & 0.987 & 1.055 & 1.045 & 1.022 & 1.061 \\ 0.906 & 1.04 & 1.019 & 0.98 & 1.024 & 1.01 & 1.014 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$

$No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{86} := stack(XXX, XXXS)$

$No_{DataCells} := length(Cells_{86})$

$No_{DataCells} = 96$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench17-3.txt")

$$Points_{49} := showcells(page, 7, 0)$$

$$Points_{49} = \begin{bmatrix} 0.964 & 1.105 & 1.083 & 1.011 & 1.047 & 1.016 & 1.028 \\ 1.063 & 1.012 & 1.029 & 1.047 & 1.056 & 0.972 & 0.907 \\ 1.021 & 1.097 & 1.071 & 1.068 & 1.033 & 0.911 & 0.952 \\ 1.066 & 1.023 & 1.006 & 1.063 & 1.045 & 1.035 & 0.992 \\ 1.052 & 1.037 & 1.044 & 1.078 & 1.05 & 1.054 & 1.051 \\ 1.037 & 1.015 & 1.026 & 1.064 & 1.07 & 1.056 & 1.044 \\ 1.065 & 1.059 & 1.026 & 1.058 & 1.047 & 1.067 & 1.075 \end{bmatrix}$$

$$XXX := convert(Points_{49}, 7) \qquad No_{DataCells} := length(XXX)$$

$$XXX := deletezero_{cells}(XXX, No_{DataCells})$$

$$Cells_{86} := stack(Cells_{86}, XXX) \qquad No_{DataCells} := length(Cells_{86})$$

$$No_{DataCells} = 145$$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench17-4.txt")

$$Points_{49} := showcells(page, 7, 0)$$

$$Points_{49} = \begin{bmatrix} 1.088 & 1.046 & 1.019 & 1.103 & 0.993 & 1.086 & 1.041 \\ 1.056 & 1.045 & 0.995 & 1.044 & 1.042 & 1.026 & 1.116 \\ 1.102 & 1.001 & 1.044 & 1.082 & 1.028 & 1 & 1.08 \\ 1.106 & 1.05 & 1.002 & 1.017 & 1.042 & 1.034 & 1.037 \\ 1.069 & 0.965 & 0.988 & 1.122 & 1.034 & 1.032 & 1.07 \\ 1.097 & 1.028 & 1.051 & 0.951 & 1.059 & 1.015 & 1.005 \\ 1.135 & 1.022 & 1.076 & 1.058 & 0.952 & 0.981 & 1.023 \end{bmatrix}$$

$$XXX := convert(Points_{49}, 7) \qquad No_{DataCells} := length(XXX)$$

$$XXX := deletezero_{cells}(XXX, No_{DataCells})$$

$$Cells_{86} := stack(Cells_{86}, XXX) \qquad No_{DataCells} := length(Cells_{86})$$

$$No_{DataCells} = 194$$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench17-5.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.023 & 1.049 & 0.987 & 1.085 & 1.048 & 1.072 & 0.98 \\ 1.1 & 1.017 & 0.958 & 1.044 & 0.991 & 1.056 & 1.074 \\ 1.053 & 1.03 & 1.025 & 0.987 & 1.031 & 1.059 & 1.087 \\ 1.005 & 1.049 & 1.006 & 1.058 & 1.058 & 1.011 & 0.992 \\ 0.972 & 0.985 & 1.012 & 1.009 & 1.067 & 1.017 & 0.975 \\ 0.985 & 0.979 & 0.974 & 0.961 & 1.017 & 1.008 & 0.982 \\ 0.999 & 0.987 & 1.021 & 0.958 & 0.954 & 1.064 & 0.942 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\quad No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{86} := stack(Cells_{86}, XXX)$ $\quad No_{DataCells} := length(Cells_{86})$ $\quad No_{DataCells} = 243$

page := READPRN("H:\MSOFFICE\Drywell Program data\1986 trenches\Trench17-6.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 0.923 & 0.981 & 0.976 & 0.97 & 0.964 & 0.99 & 1.004 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\quad No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{86} := stack(Cells_{86}, XXX)$

$No_{DataCells} := length(Cells_{86})$

$No_{DataCells} = 250$

The thinnest point at this location is shown below

$minpoint := min(Cells_{86})$ $\quad minpoint = 889$

Mean and Standard Deviation

$\mu 86_{actual} := \text{mean}(\text{Cells}_{86})$ $\mu 86_{actual} = 1.0239 \cdot 10^3$ $\sigma 86_{actual} := \text{Stdev}(\text{Cells}_{86})$ $\sigma 86_{actual} = 45.019$

Standard Error

$$\text{Standard}_{error} := \frac{\sigma 86_{actual}}{\sqrt{\text{No}_{DataCells}}}$$

$\text{Standard}_{error} = 2.847$

Skewness

$$\text{Skewness} := \frac{(\text{No}_{DataCells}) \cdot \overrightarrow{\Sigma(\text{Cells}_{86} - \mu 86_{actual})^3}}{(\text{No}_{DataCells} - 1) \cdot (\text{No}_{DataCells} - 2) \cdot (\sigma 86_{actual})^3}$$

$\text{Skewness} = -0.387$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{DataCells} \cdot (\text{No}_{DataCells} + 1) \cdot \overrightarrow{\Sigma(\text{Cells}_{86} - \mu 86_{actual})^4}}{(\text{No}_{DataCells} - 1) \cdot (\text{No}_{DataCells} - 2) \cdot (\text{No}_{DataCells} - 3) \cdot (\sigma 86_{actual})^4} \cdots + - \frac{3 \cdot (\text{No}_{DataCells} - 1)^2}{(\text{No}_{DataCells} - 2) \cdot (\text{No}_{DataCells} - 3)}$$

$\text{Kurtosis} = -0.033$

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.

$$j := 0 .. \mathrm{last}(\mathrm{Cells}_{86}) \qquad srt := \mathrm{sort}(\mathrm{Cells}_{86})$$

Then each data point is ranked. The array rank captures these ranks

$$r_j := j + 1 \qquad rank_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt = srt_j}\right) \cdot r}}{\overrightarrow{\Sigma srt = srt_j}}$$

$$p_j := \frac{rank_j}{\mathrm{rows}(\mathrm{Cells}_{86}) + 1}$$

The normal scores are the corresponding pth percentile points from the standard normal distribution:

$$x := 1 \qquad N_Score_j := \mathrm{root}\left[\mathrm{cnorm}(x) - (p_j), x\right]$$

Upper and Lower Confidence Values

The Upper and Lower confidence values are calculated based on .05 degree of confidence "α"

$No_{DataCells} := length(Cells_{86})$

$\alpha := .05$ $\qquad Tα := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right]$ $\qquad Tα = 1.969$

$$Lower_{95\%Con} := \mu86_{actual} - Tα \cdot \frac{\sigma86_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 1.018 \cdot 10^3$$

$$Upper_{95\%Con} := \mu86_{actual} + Tα \cdot \frac{\sigma86_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 1.029 \cdot 10^3$$

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

$Bins := Make_{bins}(\mu86_{actual}, \sigma86_{actual})$

$Distribution := hist(Bins, Cells_{86})$

Distribution =

4
5
13
17
30
47
50
44
28
9
3
0

The mid points of the Bins are calculated

$k := 0..11$ $\qquad Midpoints_k := \frac{(Bins_k + Bins_{k+1})}{2}$

The Mathcad function pnorm calculates a portion of normal distribution curve based on a given mean and standard deviation

$normal_{curve_0} := pnorm(Bins_1, \mu86_{actual}, \sigma86_{actual})$

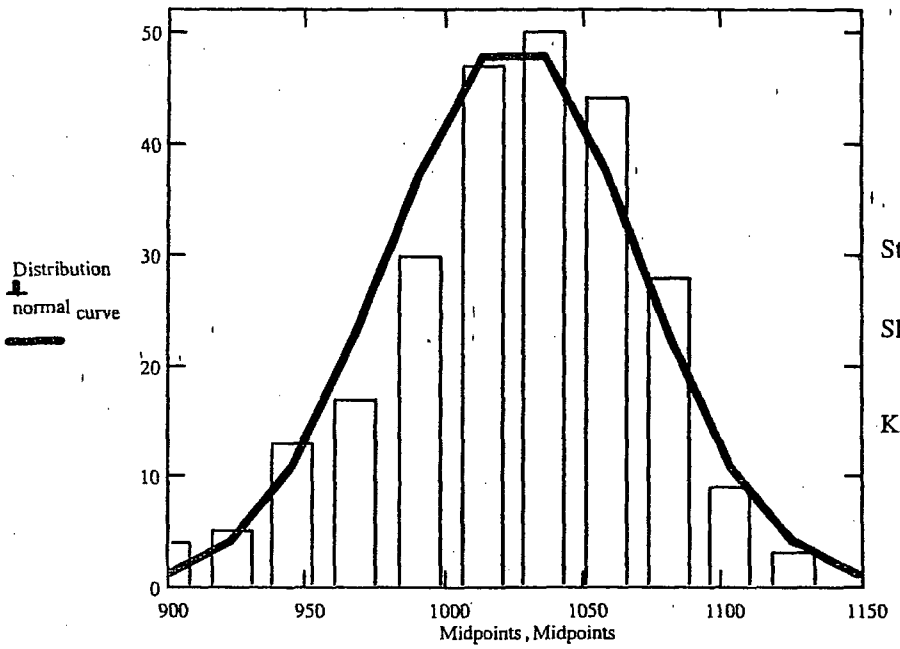
$normal_{curve_k} := pnorm(Bins_{k+1}, \mu86_{actual}, \sigma86_{actual}) - pnorm(Bins_k, \mu86_{actual}, \sigma86_{actual})$

$normal_{curve} := No_{DataCells} \cdot normal_{curve}$

Results For Trench 17 1986 Data

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



minpoint = 889

Standard $_{error}$ = 2.847

Skewness = −0.387

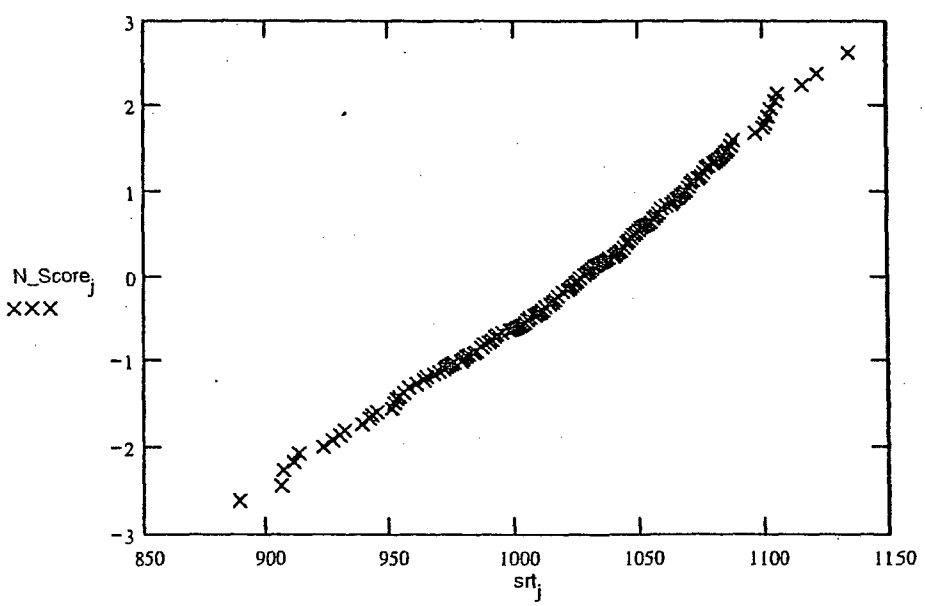
Kurtosis = −0.033

Lower $_{95\%Con}$ = $1.018 \cdot 10^3$ Upper $_{95\%Con}$ = $1.029 \cdot 10^3$

$\mu 86_{actual} = 1.024 \cdot 10^3$ $\sigma 86_{actual}$ = 45.019 minpoint = 889

A Kurtosis value which is less than +/- 1.0 and approaches 0 is indicative of a normal distrubution

Normal Probability Plot



The Normal Probability Plot and the Kurtosis this data is normally distributed.

A Normal Probability Plot which approaches a straight line is indicative of a normal distrubution. Therefore the 1986 Bay 17 trench data had a normal distribution.

2006 Data

The data shown below was collected in 2006 in the trench in Bay 17

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench17-1.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 0.963 & 0.972 & 0.877 & 0.835 & 0.891 & 0.831 & 0.894 \\ 0.897 & 0.937 & 0.903 & 0.893 & 0.838 & 0.781 & 0.841 \\ 0.855 & 0.884 & 0.853 & 0.85 & 0.84 & 0.814 & 0.788 \\ 0.802 & 0.891 & 0.838 & 0.79 & 1.082 & 0 & 0.809 \\ 0.746 & 0.795 & 0.776 & 0.822 & 0.757 & 1.042 & 0.794 \\ 0.702 & 0.779 & 0.811 & 0.835 & 0.723 & 0.738 & 0.837 \\ 0.726 & 0.825 & 0.878 & 0.868 & 0 & 0.864 & 0.954 \end{bmatrix}$$

$XXXS := convert(Points_{49}, 7)$

$No_{DataCells} := length(XXXS)$

$XXXS := deletezero_{cells}(XXXS, No_{DataCells})$

$Grid_{Top2006} := XXXS$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench17-2.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 0.997 & 1.023 & 1.06 & 1.015 & 0.964 & 0.995 & 0.997 \\ 1.061 & 0.958 & 1.022 & 1.044 & 0.991 & 0.99 & 1.001 \\ 1.008 & 1.021 & 1.01 & 1.01 & 1.003 & 0.959 & 0.963 \\ 0.988 & 0.991 & 0.961 & 0.94 & 1.029 & 0.979 & 0.929 \\ 1.005 & 1.014 & 1.003 & 0.896 & 0.944 & 1.013 & 0.885 \\ 0.99 & 0.976 & 0.962 & 0.909 & 0.905 & 0.863 & 0.923 \\ 0.954 & 0.954 & 0 & 0.885 & 0.887 & 0.877 & 0.93 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$

$No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{06} := stack(XXX, XXXS)$

$No_{DataCells} := length(Cells_{06})$

$Grid_2 := XXX$

$No_{DataCells} = 95$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench17-3.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 0.973 & 0.954 & 1.004 & 1.013 & 1.011 & 1.043 & 0.948 \\ 0.998 & 0.952 & 1.007 & 1 & 0.963 & 1.006 & 0.951 \\ 0 & 0.978 & 0.979 & 0.935 & 1.014 & 0.981 & 1.015 \\ 1.017 & 1.074 & 0.968 & 0.963 & 0.966 & 1.014 & 1.03 \\ 1.038 & 1.053 & 1.026 & 1.008 & 0.983 & 0.979 & 1.039 \\ 0.968 & 1.028 & 0.998 & 1.017 & 1.004 & 1.03 & 1.046 \\ 1.028 & 0.95 & 1.047 & 1 & 0.977 & 1.002 & 1.01 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$

$No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{06} := stack(Cells_{06}, XXX)$

$Grid_3 := XXX$

$No_{DataCells} := length(Cells_{06})$

$No_{DataCells} = 143$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench17-4.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 0.966 & 1.069 & 1.014 & 1.055 & 0.995 & 1.002 & 1.029 \\ 0.987 & 0.983 & 0.942 & 0.941 & 1.01 & 1.023 & 1.016 \\ 1.034 & 1.008 & 0.971 & 1.064 & 0.985 & 1.022 & 1.032 \\ 0.972 & 1.021 & 0.985 & 0.992 & 1.003 & 0.997 & 1.008 \\ 0.975 & 0.951 & 0.985 & 1.059 & 1.047 & 0.935 & 0.98 \\ 0.94 & 0.967 & 0.895 & 1.02 & 1.044 & 1.075 & 0.98 \\ 0.918 & 0.897 & 0.934 & 1.036 & 1.058 & 0.998 & 1.009 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$

$No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Cells_{06} := stack(Cells_{06}, XXX)$

$Grid_4 := XXX$

$No_{DataCells} := length(Cells_{06})$

$No_{DataCells} = 192$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench17-5.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 1.026 & 0.958 & 0.958 & 1.026 & 0.982 & 0.988 & 0.967 \\ 1.026 & 0.906 & 0.915 & 0.991 & 1.006 & 0.984 & 0.962 \\ 0.979 & 0.933 & 1.027 & 0.934 & 0.969 & 0.956 & 1.042 \\ 0.963 & 1.003 & 1.016 & 1.062 & 0.969 & 0.987 & 1.03 \\ 1.027 & 0.977 & 1.039 & 0.999 & 0.998 & 1.027 & 1.039 \\ 1.023 & 1.001 & 0.959 & 0.997 & 0.974 & 1.003 & 1.09 \\ 0.986 & 1.004 & 1.009 & 0.946 & 1.016 & 1.023 & 0.995 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\quad No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$

$Grid_5 := XXX$

$Cells_{06} := stack(Cells_{06}, XXX)$ $\quad No_{DataCells} := length(Cells_{06})$

$No_{DataCells} = 241$

page := READPRN("H:\MSOFFICE\Drywell Program data\2006 trenchs\Trench17-6.txt")

$Points_{49} := showcells(page, 7, 0)$

$$Points_{49} = \begin{bmatrix} 0.937 & 0.97 & 0.927 & 0.946 & 0.932 & 0.918 & 0.942 \\ 0.924 & 1.059 & 0.934 & 0.941 & 0.968 & 0.924 & 0.916 \\ 0.948 & 0.948 & 0.963 & 0.941 & 0.932 & 0.937 & 0.967 \\ 0.977 & 0.983 & 1.032 & 0.982 & 0.983 & 0.997 & 0.953 \\ 0.972 & 0.932 & 0.977 & 0.973 & 1.005 & 0.959 & 1.028 \\ 1.026 & 1.002 & 0.968 & 0.972 & 0.953 & 0.964 & 0.99 \\ 0.981 & 1.006 & 0.967 & 0.945 & 0.968 & 0.943 & 0.978 \end{bmatrix}$$

$XXX := convert(Points_{49}, 7)$ $\quad No_{DataCells} := length(XXX)$

$XXX := deletezero_{cells}(XXX, No_{DataCells})$ $\quad Grid_6 := XXX$

$Cells_{06} := stack(Cells_{06}, XXX)$

$No_{DataCells} := length(Cells_{06})$ $\quad No_{DataCells} = 290$

$minpoint := min(XXX)$ $\quad minpoint = 916$

The thinnest point at this location is shown below

$minpoint := min(Cells_{06})$ $\quad minpoint = 702$

Mean and Standard Deviation

$\mu 06_{actual} := mean(Cells_{06})$ $\mu 06_{actual} = 962.7897$ $\sigma 06_{actual} := Stdev(Cells_{06})$ $\sigma 06_{actual} = 71.259$

Standard Error

$$Standard_{error} := \frac{\sigma 06_{actual}}{\sqrt{No_{DataCells}}}$$

$Standard_{error} = 4.184$

Skewness

$$Skewness := \frac{(No_{DataCells}) \cdot \overrightarrow{\Sigma(Cells_{06} - \mu 06_{actual})^3}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (\sigma 06_{actual})^3}$$

$Skewness = -1.252$

Kurtosis

$$Kurtosis := \frac{No_{DataCells} \cdot (No_{DataCells} + 1) \cdot \overrightarrow{\Sigma(Cells_{06} - \mu 06_{actual})^4}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (No_{DataCells} - 3) \cdot (\sigma 06_{actual})^4} \cdots + -\frac{3 \cdot (No_{DataCells} - 1)^2}{(No_{DataCells} - 2) \cdot (No_{DataCells} - 3)}$$

$Kurtosis = 1.587$

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.

$$j := 0 .. \text{last}(\text{Cells}_{06}) \qquad srt := \text{sort}(\text{Cells}_{06})$$

Then each data point is ranked. The array rank captures these ranks

$$z_j := j + 1$$

$$\text{rank}_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt = srt_j}\right) \cdot z}}{\overrightarrow{\Sigma srt = srt_j}}$$

$$p_j := \frac{\text{rank}_j}{\text{rows}(\text{Cells}_{06}) + 1}$$

The normal scores are the corresponding pth percentile points from the standard normal distribution:

$$x := 1 \qquad N_Score_j := \text{root}\left[\text{cnorm}(x) - (p_j), x\right]$$

Upper and Lower Confidence Values

The Upper and Lower confidence values are calculated based on .05 degree of confidence "α"

$No_{DataCells} := length(Cells_{06})$

$\alpha := .05$ $\qquad Tα := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right]$ $\qquad Tα = 1.968$

$$Lower_{95\%Con} := \mu06_{actual} - Tα \cdot \frac{\sigma06_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 954.554$$

$$Upper_{95\%Con} := \mu06_{actual} + Tα \cdot \frac{\sigma06_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 971.025$$

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

$Bins := Make_{bins}(\mu06_{actual}, \sigma06_{actual})$

$Distribution := hist(Bins, Cells_{06})$

$Distribution =$

4
8
13
12
18
49
80
74
23
4
0
0

The mid points of the Bins are calculated

$k := 0..11$ $\qquad Midpoints_k := \frac{(Bins_k + Bins_{k+1})}{2}$

The Mathcad function pnorm calculates a portion of normal distribution curve based on a given mean and standard deviation

$normal_{curve_0} := pnorm(Bins_1, \mu06_{actual}, \sigma06_{actual})$

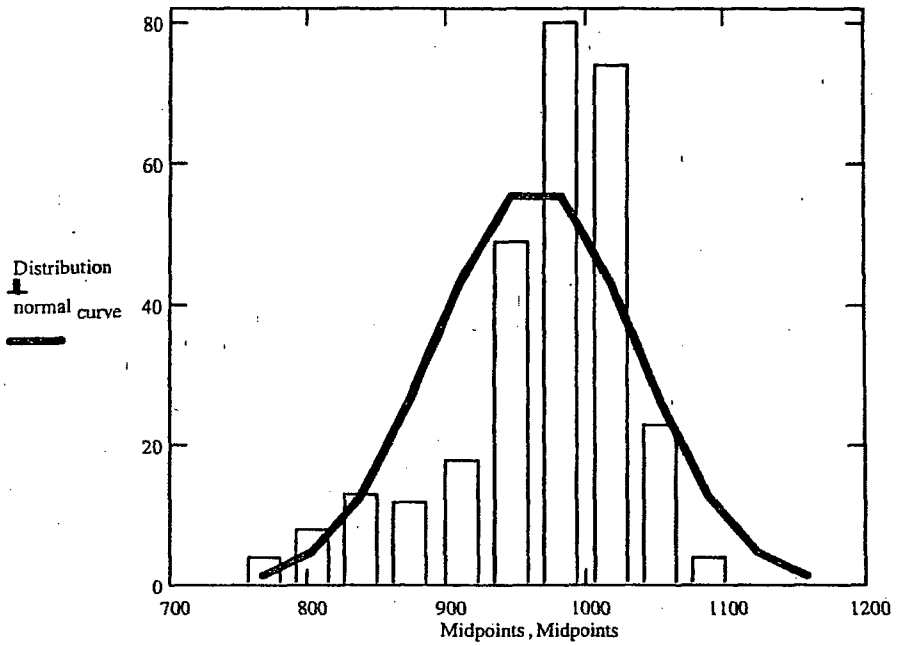
$normal_{curve_k} := pnorm(Bins_{k+1}, \mu06_{actual}, \sigma06_{actual}) - pnorm(Bins_k, \mu06_{actual}, \sigma06_{actual})$

$normal_{curve} := No_{DataCells} \cdot normal_{curve}$

Results For Trench 17 2006

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



minpoint = 702

Standard $_{error}$ = 4.184

Skewness = −1.252

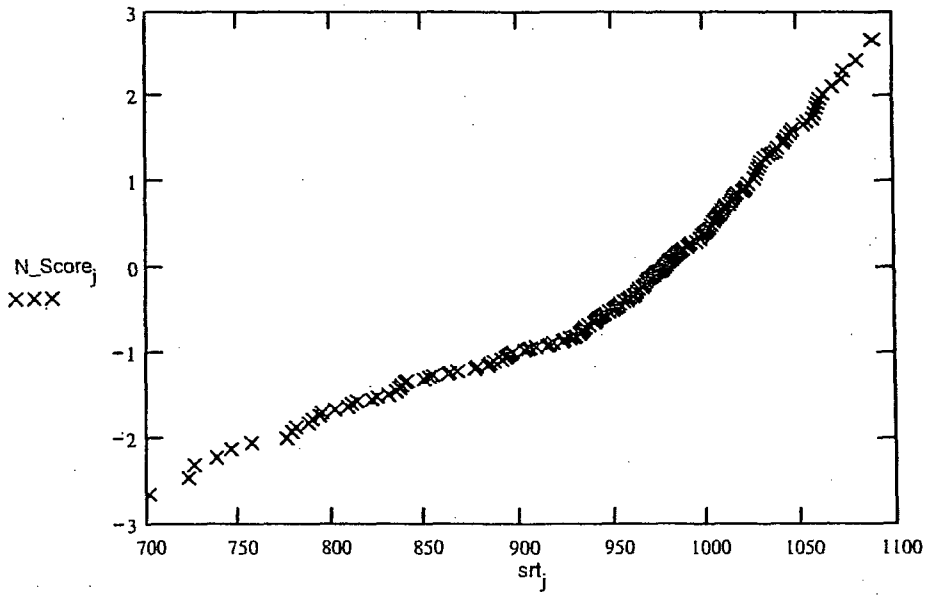
Kurtosis = 1.587

minpoint = 702

$\mu 06_{actual}$ = 962.79 Lower $_{95\%Con}$ = 954.554 $\sigma 06_{actual}$ = 71.259 Upper $_{95\%Con}$ = 971.025

A Kurtosis value which is less than +/- 1.0 and approaches 0 is indicative of a normal distrubution. Therefore this distribution may not be completely normal. The data is skewed towards the right.

Normal Probability Plot



A Normal Probability Plot indicates the distrubution of this data is not completely normal

Review of the 2006 data shows that the first 49 point grid located at the top of the trench is much thinner than the remaining five 49 point grids lower in the trenchs

The mean of the top grid is $\text{mean}(\text{Grid}_{\text{Top2006}}) = 845.128$

While the mean of the remaining five grids are:

$\mu 06_{\text{grid.actual}_0} := \text{mean}(\text{Grid}_2)$ $\quad \text{mean}(\text{Grid}_2) = 972.583$

$\mu 06_{\text{grid.actual}_1} := \text{mean}(\text{Grid}_3)$ $\quad \text{mean}(\text{Grid}_3) = 999.75$

$\mu 06_{\text{grid.actual}_2} := \text{mean}(\text{Grid}_4)$ $\quad \text{mean}(\text{Grid}_4) = 996.51$

$\mu 06_{\text{grid.actual}_3} := \text{mean}(\text{Grid}_5)$ $\quad \text{mean}(\text{Grid}_5) = 993.816$

$\mu 06_{\text{grid.actual}_4} := \text{mean}(\text{Grid}_6)$ $\quad \text{mean}(\text{Grid}_6) = 965.102$

$$\text{mean}(\mu 06_{\text{grid.actual}}) = 985.552$$

Therefore the distibuteion of each of these set of data were investigated. The follwoing creates an array of the lower 5 grids

$\text{five}_{\text{Cells}} := \text{stack}(\text{Grid}_3, \text{Grid}_2)$

$\text{five}_{\text{Cells}} := \text{stack}(\text{five}_{\text{Cells}}, \text{Grid}_4)$

$\text{five}_{\text{Cells}} := \text{stack}(\text{five}_{\text{Cells}}, \text{Grid}_5)$

$\text{five}_{\text{Cells}} := \text{stack}(\text{five}_{\text{Cells}}, \text{Grid}_6)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{five}_{\text{Cells}})$ $\quad \text{No}_{\text{DataCells}} = 243$

Mean and Standard Deviation

$\mu_{5grids.actual} := mean(five_{Cells})$ $\sigma_{5grids.actual} := Stdev(five_{Cells})$

$\mu_{5grids.actual} = 985.5473$ $\sigma_{5grids.actual} = 41.462$

Standard Error

$$Standard_{error} := \frac{\sigma_{5grids.actual}}{\sqrt{No_{DataCells}}}$$

$Standard_{error} = 2.66$

Skewness

$$Skewness := \frac{(No_{DataCells}) \cdot \overrightarrow{\Sigma(five_{Cells} - \mu_{5grids.actual})^3}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (\sigma_{5grids.actual})^3}$$

$Skewness = -0.242$

Kurtosis

$$Kurtosis := \frac{No_{DataCells} \cdot (No_{DataCells} + 1) \cdot \overrightarrow{\Sigma(five_{Cells} - \mu_{5grids.actual})^4}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (No_{DataCells} - 3) \cdot (\sigma_{5grids.actual})^4} + - \frac{3 \cdot (No_{DataCells} - 1)^2}{(No_{DataCells} - 2) \cdot (No_{DataCells} - 3)}$$

$Kurtosis = -0.082$

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.

$$j := 0 .. \text{last}(\text{five}_{\text{Cells}}) \qquad \text{srt} := \text{sort}(\text{five}_{\text{Cells}})$$

Then each data point is ranked. The array rank captures these ranks

$$zz_j := j + 1$$

$$\text{rank}_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{\text{srt}=\text{srt}_j}\right)\cdot zz}}{\overrightarrow{\Sigma\text{srt}=\text{srt}_j}}$$

$$p_j := \frac{\text{rank}_j}{\text{rows}(\text{five}_{\text{Cells}}) + 1}$$

The normal scores are the corresponding pth percentile points from the standard normal distribution:

$$x := 1 \qquad \text{N_Score}_j := \text{root}\left[\text{cnorm}(x) - (p_j), x\right]$$

Upper and Lower Confidence Values

The Upper and Lower confidence values are calculated based on .05 degree of confidence "α"

$No_{DataCells} := length(five_{Cells})$

$No_{DataCells} = 243$

$\alpha := .05$ $\quad Tα := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right]$ $\quad Tα = 1.97$

$Lower_{95\%Con} := \mu_{5grids.actual} - Tα \cdot \frac{\sigma_{5grids.actual}}{\sqrt{No_{DataCells}}}$ $\quad Lower_{95\%Con} = 980.308$

$Upper_{95\%Con} := \mu_{5grids.actual} + Tα \cdot \frac{\sigma 06_{actual}}{\sqrt{No_{DataCells}}}$ $\quad Upper_{95\%Con} = 994.552$

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 standa deviations

$Bins := Make_{bins}(\mu_{5grids.actual}, \sigma_{5grids.actual})$

$Distribution := hist(Bins, five_{Cells})$

Distribution =

2
6
8
25
32
47
45
42
23
9
3
1

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

$normal_{curve_0} := pnorm(Bins_1, \mu_{5grids.actual}, \sigma_{5grids.actual})$

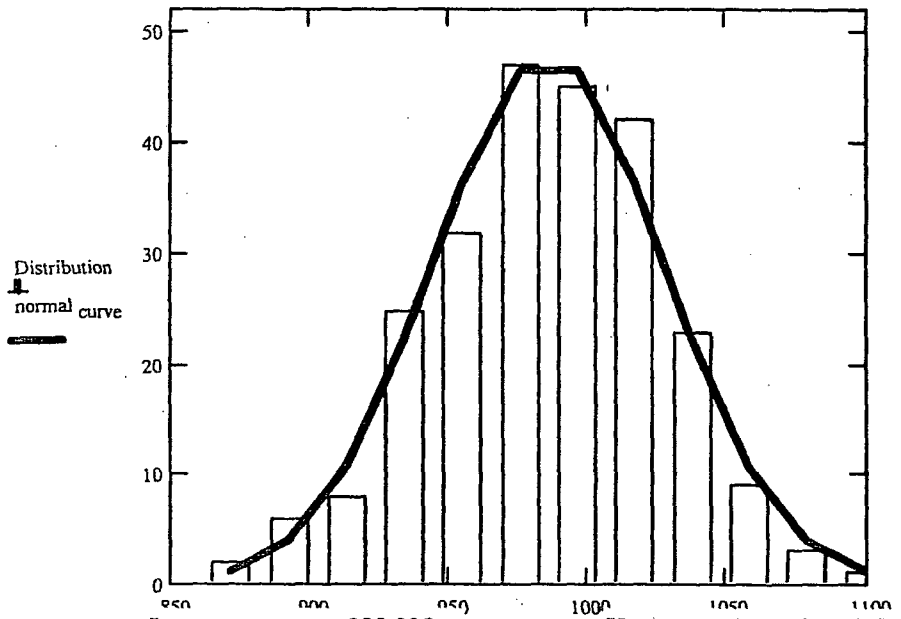
$normal_{curve_k} := pnorm(Bins_{k+1}, \mu_{5grids.actual}, \sigma_{5grids.actual}) - pnorm(Bins_k, \mu_{5grids.actual}, \sigma_{5grids.actual})$

$normal_{curve} := No_{DataCells} \cdot normal_{curve}$

Results For Trehcn 17 ower 5 grids Oct. 2006

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



minpoint = 702

Standard $_{error}$ = 2.66

Skewness = −0.242

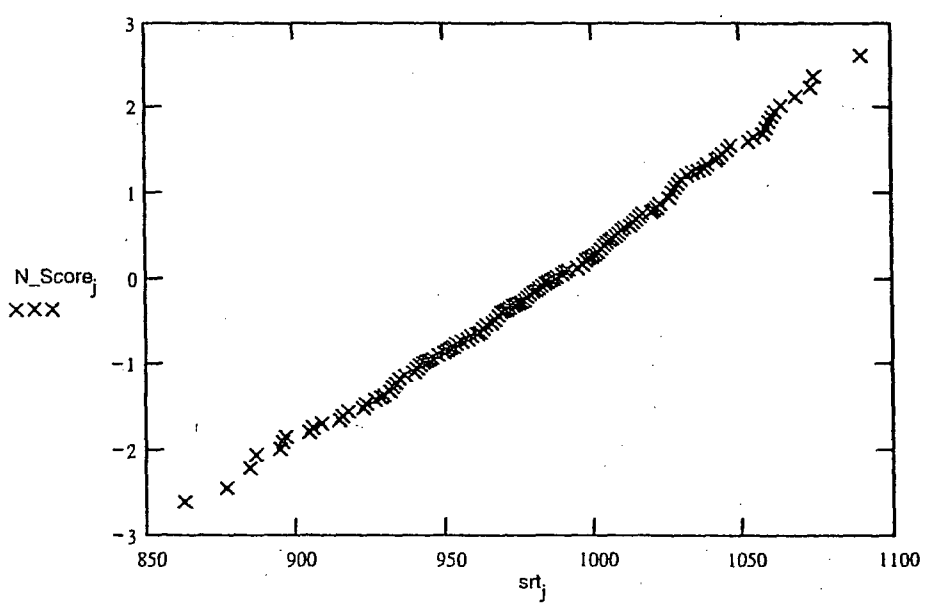
Kurtosis = −0.082

Lower $_{95\%Con}$ = 980.308 dpoints, Midpoir Upper $_{95\%Con}$ = 994.552

$\mu_{5grids.actual}$ = 985.547 $\sigma_{5grids.actual}$ = 41.462

A Kurtosis value which is less than +/- 1.0 and approaches 0 is indicative of a normal distrubution.

Normal Probability Plot



A Normal Probability Plot indicates the distrubution of this data is not completely normal

Therefore when considering the entire 2006 data (all 6 grids) set which is skewed, the corrosion rate from 1986 to 1992 was

$$\frac{\left(\mu 86_{\text{actual}} - \mu 06_{\text{actual}}\right)}{1992 - 1986} = 10.18$$

Therefore when considering the entire 2006 data (all 6 grids) set which is skewed, the apparent corrosion rate from 1986 to 2006 was

$$\frac{\left(\mu 86_{\text{actual}} - \mu 06_{\text{actual}}\right)}{2006 - 1986} = 3.054$$

When considering only the 5 lower grids of the 2006 data set which is normally distributed, the corrosion rate from 1986 to 1992 was

$$\frac{\left(\mu 86_{\text{actual}} - \mu_{5\text{grids.actual}}\right)}{1992 - 1986} = 6.387$$

This is very consistent with the Bay 5 trench results

When considering only the 5 lower grids of the 2006 data set which is normally distributed, the apparent corrosion rate from 1986 to 2006 was

$$\frac{\left(\mu 86_{\text{actual}} - \mu_{5\text{grids.actual}}\right)}{2006 - 1986} = 1.916$$

This is very consistent with the Bay 5 trench results

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Pg 1 of 2

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/22/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Leslie Richter		Level: II	Instrument Type:	Panametrics 37DL Plus	
Examiner: N/A		Level: N/A	Instrument No:	031124909	
Transducer Type: D795	Serial #: 104012	Size: 0.200"	Freq: 5 Mhz		Angle: 0°
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge		Block Number: CAL-STEP-080			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	11:59	13:00	13:30	14:30	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"		Inches to	1.500"	Inches
Delay Calib:	N/A	Thermometer: 246647		Comp. Temp: 82°		Block Temp: 79°
Range Calib:	N/A	W/O Number: R2086928				
Instrument Freq.	N/A	Total Crew Dose	C 2013477 Drywell Containment Vessel Thickness Examination.			
Gain:	74 db	7 mr	MMC 10-22-06 External UT Inspections.			
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 1

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E09 PT

BAY	Point Number	Vertical Location		Horizonal Location		

See Attached for Locations and Thickness Readings

COMMENTS: Coated surface is rough at all reading points. Unable to slide off of best measurement spot. Plot measurement numbers are more accurate if measuring tape is placed 13" to the right from the center of the weld on the nozzle, then follow down passing through point # 8.

MMC LIII 10-22-06

Reviewed by: Lee Stone Level II Date 10/22/2006

BAY 1

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D16	R27	0.720	0.710	
	2	D22	R17	0.716	0.690	
	3	D23	L3	0.705	0.665	
	4	D24	L33	0.760	0.738	Very Rough Surface
	5	D24	L45	0.710	0.680	
	6	D48	R19	0.760	0.731	
	7	D39	R7	0.700	0.669	
	8	D48	R0	0.805	0.783	
	9	D36	L38	0.805	0.754	
	10	D16	R23	0.839	0.824	
	11	D23	R12	0.714	0.711	
	12	D24	L5	0.724	0.722	
	13	D24	L40	0.792	0.719	
	14	D2	R35	1.147	1.157	
	15	D8	L51	1.156	1.160	
	16	D50	R40	0.796	0.795	
	17	D40	R16	0.860	0.846	
	18	D38	L2	0.917	0.899	
	19	D38	L24	0.890	0.865	
	20	D18	R13	0.965	0.912	
	21	D24	R15	0.726	0.712	
	22	D32	R13	0.852	0.854	
	23	D48	R15	0.850	0.828	

Data obtained from
NDE Data Sheets 92-072-12 page 1 of 1
NDE Data Sheets 92-072-18 page 1 of 1
NDE Data Sheets 92-072-19 page 1 of 1
All horizonal measurements taken 13" to the right of the centerline of the reinforcement ring (Boss).
All vertical measurements taken from bottom of vent nozzle at the 13" reference line.
Surface roughness prohibited characterization of all readings.

Note: Per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

PASSPORT#
00546049 07
AR# A2152754 E09
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General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/20/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Scott Erickson Scott R. Erickson	Level: II	Instrument Type:	Panametrics 37DL Plus		
Examiner: N/A	Level: N/A	Instrument No:	031120708		
Transducer Type: D7908	Serial #: 338302	Size: 0.200"	Freq: 7.5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe	Batch No: 19620		
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-136				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	2.0"	22:05	N/A	N/A	23:50	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"	Inches to	1.500"	Inches	
Delay Calib:	N/A	Thermometer: 246647	Comp. Temp:	78°	Block Temp:	75°
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose 1 mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	54 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 3

BAY	Point Number	Vertical Location		Horizonal Location		Thickness Reading
		See Attached for Locations and Thickness Readings				

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COMMENTS: N/A

M M'alh L III 10-22-06

Reviewed by: Lee Stone Level II Date 10/19/2006

BAY 3

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D16	R63	0.795	0.795	N/A
	2	D18	R48	1	0.999	
	3	D17	R33	0.857	0.850	
	4	D13	L5	0.898	0.903	
	5	D25	L8	0.823	0.819	
	6	D15	L56	0.968	0.972	
	7	D29	R4	0.826	0.816	
	8	D34	L4	0.78	0.764	

Data obtained from
NDE Data Sheets 92-072-14 page 1 of 1
Note: Per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

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Report # 1R21LR-019
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General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/20/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Leslie Richter	Level: II	Instrument Type:	Panametrics 37DL Plus		
Examiner: N/A	Level: N/A	Instrument No:	031124909		
Transducer Type: D795	Serial #: 104012	Size: 0.200"	Freq: 5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe	Batch No: 19620		
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-136				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	15:38	15:51	16:45	17:28	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches				
Delay Calib:	N/A	Thermometer: 246647	Comp. Temp: 82°	Block Temp: 76°		
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose 2 mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	72 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 5

BAY	Point Number	Vertical Location	Horizonal Location	Thickness Reading
		See Attached for Locations and Thickness Readings		

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COMMENTS: N/A

mm ach L CIII 10-22-06

Reviewed by: Scott Erickson Scott R Erickson Level II Date 10/19/2006

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BAY 5

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
*	1	D38	R12	0.97	0.948	up .97 dn .97
*	2	D38	R7	1.04	0.955	Rough surface - up .99 dn .99
*	3	D42	R10	1.02	0.989	up 1.0 dn 1.04
*	4	D41	L7	0.97	0.948	Rough surface, also dished
*	5	D42	L11	0.89	0.88	Rough surface
**	6	D47	R5	1.06	0.981	up 1.018 dn 1.014
**	7	D48	L18	0.99	0.974	Rough surface left .99 right N/A
**	8	D46	L31	1.01	1.007	Rough surface

Note: up, dn, left & right readings were taken 1/8" from recorded 2006 value reading.
Rough surface limited taking additional readings. Reference above.
* =Vertical and horizontal measurements taken from top of coating on long seam 62" to right
** =Vertical and horizontal measurements taken from bottom of nozzle at 6 o'clock position
Reference NDE Data Sheets 92-072-16 page 1 of 1

1 - Reference off the weld 62" to the right of the centerline of the bay.
2 The original data sheet is not clear as to whether this point is to the right or left of the weld.
Therefore NDE shall verify this dimension.

Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

10-20-06

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/19/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004 *

Examiner: Lee Stone		Level: II	Instrument Type:	Panametrics 37DL Plus	
Examiner: N/A		Level: N/A	Instrument No:	031124909	
Transducer Type: D795	Serial #: 1103007	Size: 0.200"	Freq: 5 Mhz		Angle: 0°
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge		Block Number: CAL-STEP-109			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	14:20	N/A	N/A	15:10	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"		Inches to	1.500"	Inches
Delay Calib:	N/A	Thermometer:	246737	Comp. Temp: 72°	Block Temp:	74°
Range Calib:	N/A	W/O Number:	C2013477			
Instrument Freq.	N/A	Total Crew Dose	**Drywell Containment Vessel Thickness Examination. External UT Inspections.**			
Gain:	67 db	12 mr				
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 7

BAY	Point Number	Vertical Location		Horizonal Location		Thickness Reading
		See Attached for Locations and Thickness Readings				

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COMMENTS: ~~N/A~~

* INSPECTION PERFORMED IAW ENGINEERING DIRECTION REF. REV 14 DRAFT. MAC 10-22-06

MAC 10-22-06

Reviewed by: Kimberly Wert Level II Date 10/19/2006

BAY 7

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D21	R39	0.92	N/A	Could not locate area
	2	D21	R32	1.016	N/A	Could not locate area
	3	D10	R20	0.984	0.964	up/dn ranged from 0.956 to 0.980
	4	D10	R10	1.04	1.04	N/A
	5	D21	L6	1.03	1.003	up/dn ranged from 1.000 to 1.049
	6	D10	L23	1.045	1.023	up/dn ranged from 1.020 to 1.052
	7	D21	L12	1	1.003	up/dn ranged from 1.002 to 1.026

Data obtained from
NDE Data Sheets 92-072-20 page 1 of 1
Note: up, dn readings were taken 1/8" from recorded 2006 value reading.

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Attach C III
10-26-06

1R21LR-006 Pg 1 of 2

General Electric	Ultrasonic Thickness Measurement Data Sheet	File Name:	N/A
Oyster Creek		Date:	10/19/2006
fueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Scott Erickson Scott R. Erickson	Level: II	Instrument Type:	Panametrics 37DL Plus		
Examiner: N/A	Level: N/A	Instrument No:	031120708		
Transducer Type: D7908	Serial #: 338302	Size: 0.200"	Freq: 7.5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe	Batch No:	19620	
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-080				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	2.0"	22:05	N/A	N/A	23:50	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"		Inches to	1.500"	Inches
Delay Calib:	N/A	Thermometer: 246737		Comp. Temp: 74°	Block Temp: 72°	
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	61 db	6 mr				
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 9

BAY	Point Number	Vertical Location		Horizonal Location		Thickness Reading
		See Attached for Locations and Thickness Readings				

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COMMENTS: N/A

[illegible] L III 10-22-06

Reviewed by: Lee Stone [illegible] Level II Date 10/19/2006

BAY 9

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D29	R32	0.96	0.968	N/A
	2	D18	R17	0.94	0.934	
	3	D20	R8	0.994	0.989	
	4	D27	R15	1.02	1.016	
	5	D35	L5	0.985	0.964	
	6	D13	L30	0.82	0.802	
	7	D16	L35	0.825	0.82	
	8	D21	L38	0.791	0.781	
	9	D20	L53	0.832	0.823	
	10	D30	L8	0.98	0.955	

Data obtained from
NDE Data Sheets 92-072-22 page 1 of 1

Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

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ATTACHMENT V
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IR21CR-006 Pg 2 of 2
24/42 III
10-22-06

1R21CR-008 Pg 1 of 2

General Electric	Ultrasonic Thickness Measurement Data Sheet	File Name:	N/A
Oyster Creek		Date:	10/20/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Graham McNabb	Level: II	Instrument Type:	Panametrics 37DL Plus		
Examiner: N/A	Level: N/A	Instrument No:	031124909		
Transducer Type: D795	Serial #: 104010	Size: 0.200"	Freq: 5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe	Batch No:	19620	
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-080				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	2:15	N/A	N/A	5:15	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"	Inches to	1.500"	Inches	
Delay Calib:	N/A	Thermometer: 246534	Comp. Temp: 74°	Block Temp: 72°		
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose 6 mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	58 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 11

BAY	Point Number	Vertical Location		Horizonal Location		Thickness Reading
		See Attached for Locations and Thickness Readings				

PASSPORT# 00546049 07
AR# A2152754 E09
ATTACHMENT
PAGE 1 OF 2

COMMENTS: N/A

MM'ach L III 10-22-06

Reviewed by: Scott Erickson Scott R. Erickson Level II Date 10/20/2006

BAY 11

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D20	R29	0.705	0.700	N/A
	2	D25	R32	0.77	0.760	
	3	D21	L4	0.832	0.830	
	4	D24	L6	0.755	0.751	
	5	D32	L14	0.831	0.823	
	6	D27	L22	0.8	0.756	
	7	D31	R20	0.831	0.817	
	8	D40	R13	0.85	0.825	

Data obtained from
NDE Data Sheets 92-072-10 page 1 of 1
Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

MMC L III 10-22-06

PASSPORT#
00546049 07
AR# A2152754 E09
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1R21LR-008 Pg 2 of 2

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/19/2006
fueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Scott Erickson Scott R. Erickson	Level: II	Instrument Type:	Panametrics 37DL Plus		
Examiner: N/A	Level: N/A	Instrument No:	031120708		
Transducer Type: D799	Serial #: 104044	Size: 0.312"	Freq: 5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe	Batch No:	04120B	
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-109				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	3:00	N/A	N/A	4:15	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"	Inches to	1.500"	Inches	
Delay Calib:	N/A	Thermometer: 246737	Comp. Temp:	72°	Block Temp:	70°
Range Calib:	N/A	W/O Number:	C2013477			
Instrument Freq.	N/A	Total Crew Dose	Drywell Containment Vessel Thickness Examination. External UT inspections.			
Gain:	51 db	0 mr				
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 13

BAY	Point Number	Vertical Location		Horizonal Location		Thickness Reading
		See Attached for Locations and Thickness Readings				

PASSPORT# 00546049 07
AR# A2152754 E09
ATTACHMENT 1/20
PAGE 13 OF

COMMENTS: N/A

[illegible] L III 10-22-06

Reviewed by: Lee Stone [illegible] Level II Date 10/19/2006

BAY 13

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	U1	R45	0.672	N/A	Could not locate area
	2	U1	R38	0.729	N/A	Could not locate area
	3	D21	R48	0.941	0.923	
	4	D12	R36	0.915	0.873	
	5	D21	R6	0.718	0.708	
	6	D24	L8	0.655	0.658	
	7	D17	L23	0.618	0.602	
	8	D24	L20	0.718	0.704	
	9	D28	R41	0.924	0.915	
	10	D28	R12	0.728	0.741	
	11	D28	L15	0.685	0.669	
	12	D28	L23	0.885	0.886	
	13	D18	D40	0.932	0.814	
	14	D18	R8	0.868	0.870	
	15	D20	L9	0.683	0.666	
	16	D20	L29	0.829	0.814	
	17	D9	R38	0.807	N/A	Could not locate area
	18	D22	R38	0.825	N/A	Could not locate area
	19	D37	R38	0.912	0.916	

5
8
8
19

Data obtained from
NDE Data Sheets 92-072-24 page 1 of 2
Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

PASSPORT#
00546049 07
AR# A2152754 E09
ATTACHMENT 4
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M. Hallal L III 10-22-06

IR21LR-06-PG 2 of 2

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/20/2006
fueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Matt Wilson		Level: II	Instrument Type:	Panametrics 37DL Plus	
Examiner: N/A		Level: N/A	Instrument No:	031124709	
Transducer Type: D795	Serial #: 1103008	Size: 0.200"	Freq: 5 Mhz		Angle: 0°
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge		Block Number: CAL-STEP-088			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	10:30	12:10	12:33	13:05	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches				
Delay Calib:	N/A	Thermometer: 246484		Comp. Temp: 82°		Block Temp: 76°
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose 2 mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	67 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 15

BAY	Point Number	Vertical Location		Horizonal Location		Thickness Reading

See Attached for Locations and Thickness Readings

PASSPORT# 00546049 07
AR# A2152754 E09
ATTACHMENT 4/30
PAGE 1 OF

COMMENTS: N/A

10-22-06

Reviewed by: Lee Stone Level II Date 10/20/2006

BAY 15

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D12	R26	0.786	0.779	0.711 to 0.779
	2	D22	R21	0.829	0.798	0.777 to 0.798
	3	D33	R17	0.932	0.935	
	4	D30	R7	0.795	0.791	
	5	D26	L3	0.85	0.855	0.817 to 0.855
	6	D6	L8	0.794	0.787	0.715 to 0.787
	7	D26	L18	0.808	0.805	
	8	D20	L36	0.77	0.760	
	9	D36	L44	0.722	0.749	0.720 to 0.749
	10	D24	L48	0.86	0.852	0.837 to 0.852
	11	D24	L65	0.825	0.843	0.798 to 0.843

Data obtained from
NDE Data Sheets 92-072-21 page 1 of 1
Note: scanned 0.25" area around recorded 2006 value number - see comments for ranges.

PASSPORT#
00546049 07
AR# A2152754 E09
ATTACHMENT Y
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IR21LK-010 19 0026

Report: 1R21LK-01 02
Pg. 1 OF 2

General Electric		Ultrasonic Thickness Measurement Data Sheet		File Name:	N/A
Oyster Creek				Date:	10/19/2006
Refueling Outage -	1R21			UT Procedure:	ER-AA-335-004
Page 1 of	2			Specification	IS-328227-004

Examiner: Matt Wilson		Level: II	Instrument Type:	Panametrics 37DL Plus	
Examiner: N/A		Level: N/A	Instrument No:	031124709	
Transducer Type: D795	Serial #: 104010	Size: 0.200"	Freq: 5 Mhz		Angle: 0°
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge		Block Number: CAL-STEP-088			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	15:36	N/A	N/A	17:18	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"		Inches to	1.500"	Inches
Delay Calib:	N/A	Thermometer: 246534		Comp. Temp: 82°		Block Temp: 78°
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose 2 mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	67 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 17

BAY	Point Number		Vertical Location			Horizonal Location			Thickness Reading
		See Attached for Locations and Thickness Readings							

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AR# A2152754 E09
ATTACHMENT 4
PAGE 1 OF 2

COMMENTS: N/A

10-22-06

Reviewed by: Scott Erickson Scott R Erickson Level II Date 10/19/2006

PASSPORT#
00546049 07
AR# A2152754 E09
ATTACHMENT 4
PAGE 14 OF 30

BAY 17

Note: measurement from vent pipe CL to floor 60"

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D12	R50	0.916	0.909	
	2	D9	R40	1.150	0.681	up .705 dn .663
	3	D16	R26	0.898	0.894	
	4	D34	R24	0.951	0.963	
	5	D6	R20	0.913	0.822	
	6	D17	R7	0.992	0.909	
	7	D18	L14	0.970	0.970	
	8	D34	L46	0.990	0.960	
	9	D21	L29	0.720	0.970	
	10	D3	L2	0.830	0.844	
	11	N/A	N/A	N/A	N/A	

Note: Down measurements taken from bottom of boss which is 18" below vent line.
Locations 8,9, & 3 look to be un-prepped flat areas of the original surface.
All left, right measurements taken from 8" left of liner long seam
Data obtained from
NDE Data Sheets 92-072-08 page 1 of 1

Note: Per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

Matthew E Watson 10-19-2006

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/22/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Matt Wilson	Level: II	Instrument Type:	Panametrics 37DL Plus		
Examiner: N/A	Level: N/A	Instrument No:	031124709		
Transducer Type: D795	Serial #: 104010	Size: 0.200"	Freq: 5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe	Batch No:	19620	
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-088				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	14:26	15:36	N/A	16:09	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"	Inches to	1.500"	Inches	
Delay Calib:	N/A	Thermometer: 246534	Comp. Temp: 82°	Block Temp: 82°		
Range Calib:	N/A	W/O Number: ~~R2088926~~ SW				
Instrument Freq.	N/A	Total Crew Dose 7 mr	C2013477 Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	67 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 19

BAY	Point Number		Vertical Location			Horizonal Location			Thickness Reading
		See Attached for Locations and Thickness Readings							

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AR# A2152754 E09
ATTACHMENT 4/2
PAGE 15 OF

COMMENTS: N/A

10-22-06

Reviewed by: Lee Stone Level II Date 10/22/2006

Pg. 2 of 2 10-22-06

BAY 19

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D30	R60	0.932	0.904	up .897 dn .867
	2	D52	R58	0.924	0.921	up .850 dn .907
	3	D33	R40	0.955	0.932	up .894 dn .905
	4	D32	R11	0.94	N/A	Could not locate area
	5	D31	R3	0.95	0.932	up .883 dn .897
	6	D52	L65	0.86	N/A	Could not locate area
	7	D54	L10	0.969	0.891	up .821 dn .912
	8	D16	R64	0.793/0.953 ***	0.745	up .721 dn .747
	9	D18	R12	0.776	0.780	up .728 dn .745
	10	D19	R0	0.79	0.791	up .736 dn .846
	11	20D	L18	N/A	0.738	up .738 dn .712

New Values.

Data obtained from
NDE Data Sheets 92-072-05 page 1 of 1
NDE Data Sheets 92-072-07 page 1 of 1
Note: Per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.
*** - This value is not clear form the original datasheet -NDE to verify this value.
Note: per discussion with Engineering, single ~~point~~ readings were taken in lieu of 6, based on surface curvature.

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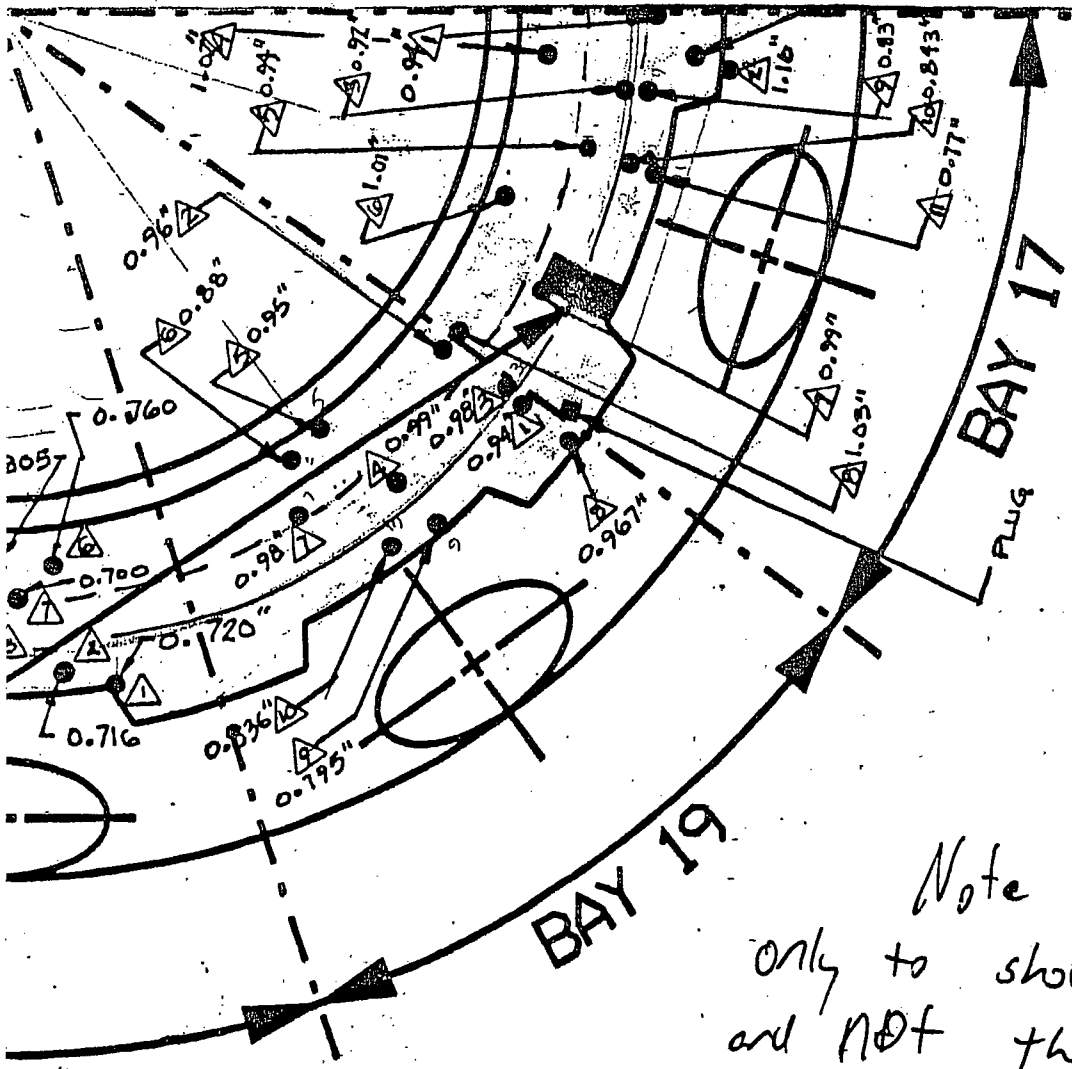
Matthew E Wilson 10/22/06



PASSPORT#
00546049 07
AR# A2152754 E09
ATTACHMENT 5
PAGE 1 OF 8

Note This sketch is provided only to show Location of points and NOT the actual Value. Refer to Attachment 4 for 1992 and 2006 thickness values.

BAY
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BAY
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BAY
PER
AREI

BAY
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AREI

BAY 1
PERI
12.
AREA

BAY 1
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12-16
AREA

PASSPORT#
00546049 07
AR# A2152754 E09
ATTACHMENT 5
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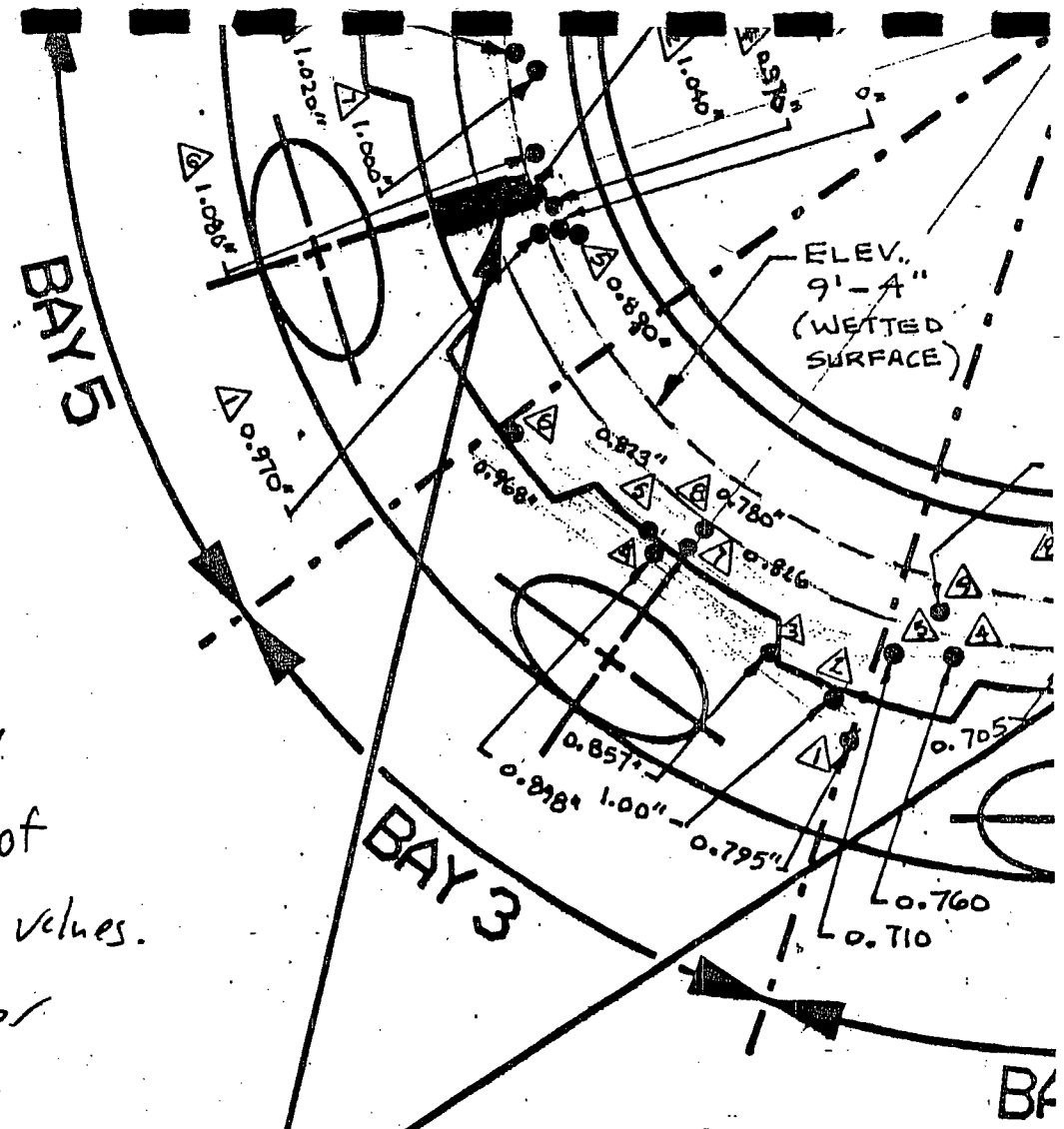

This sketch is provided only to show Location of points and not the actual values. Refer to Attachment 4 for 1992 and 2006 Thickness Readings

SEE DETAIL CROSS SECTION AREA OF TRENCH

Refer to Sheet 5 for Additional Points

KEY

KEY (SCAL

30°

11

BAY 13

BAY 15

FLOOR ELEV
10'-3"

ELEV. 12'-3"

△ - DATA POINT UT
WITH SHELL THICKNESS
FOR EACH INDIVIDUAL
BAY

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Refer to page
8 for additional
Points

BAY
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AREA

BAY
PERFO
AREA

BAY 5
PERFO
AREA

BAY 7
PERFO
AREA

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00546049 07
AR# A2152754 E09
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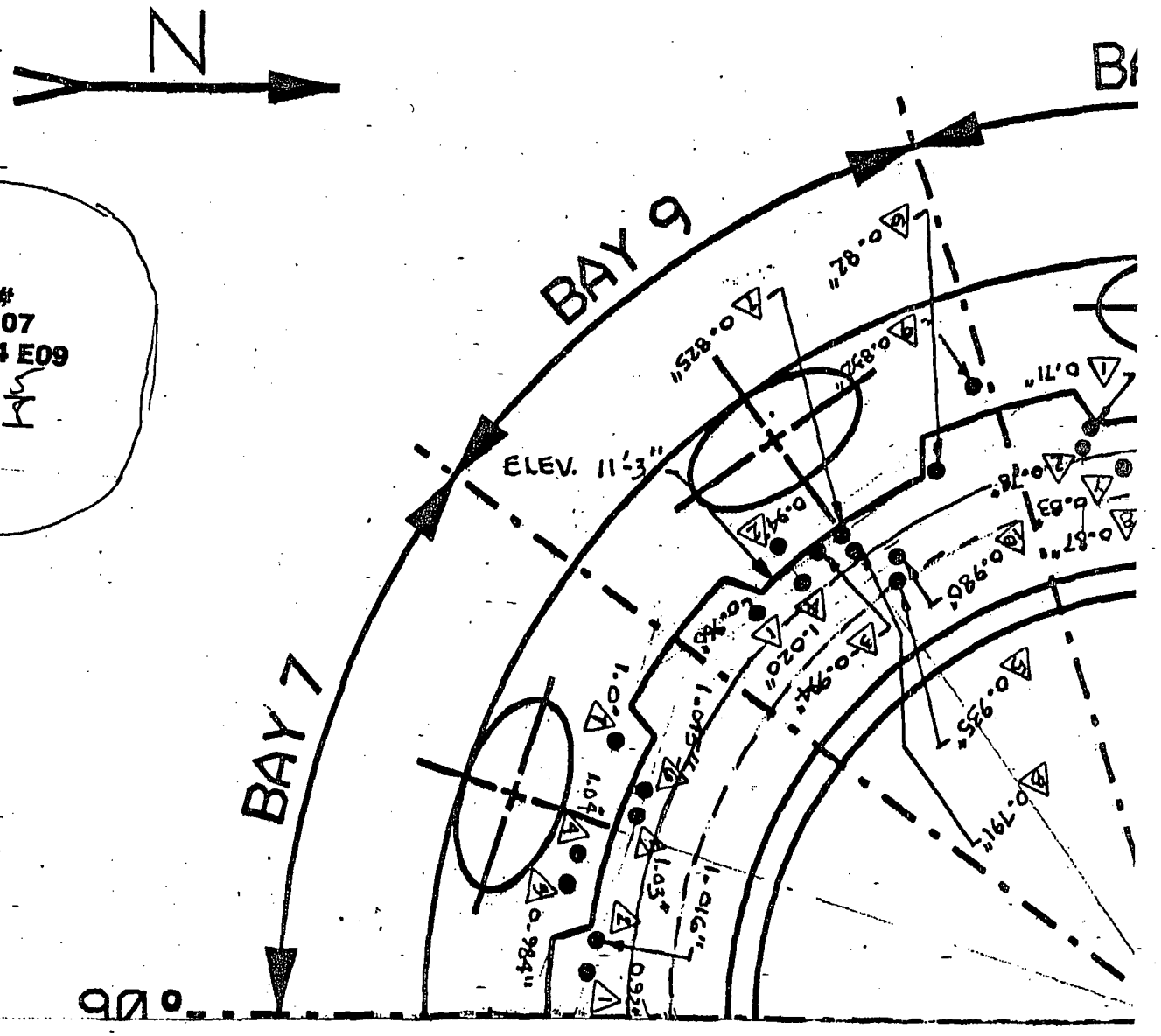

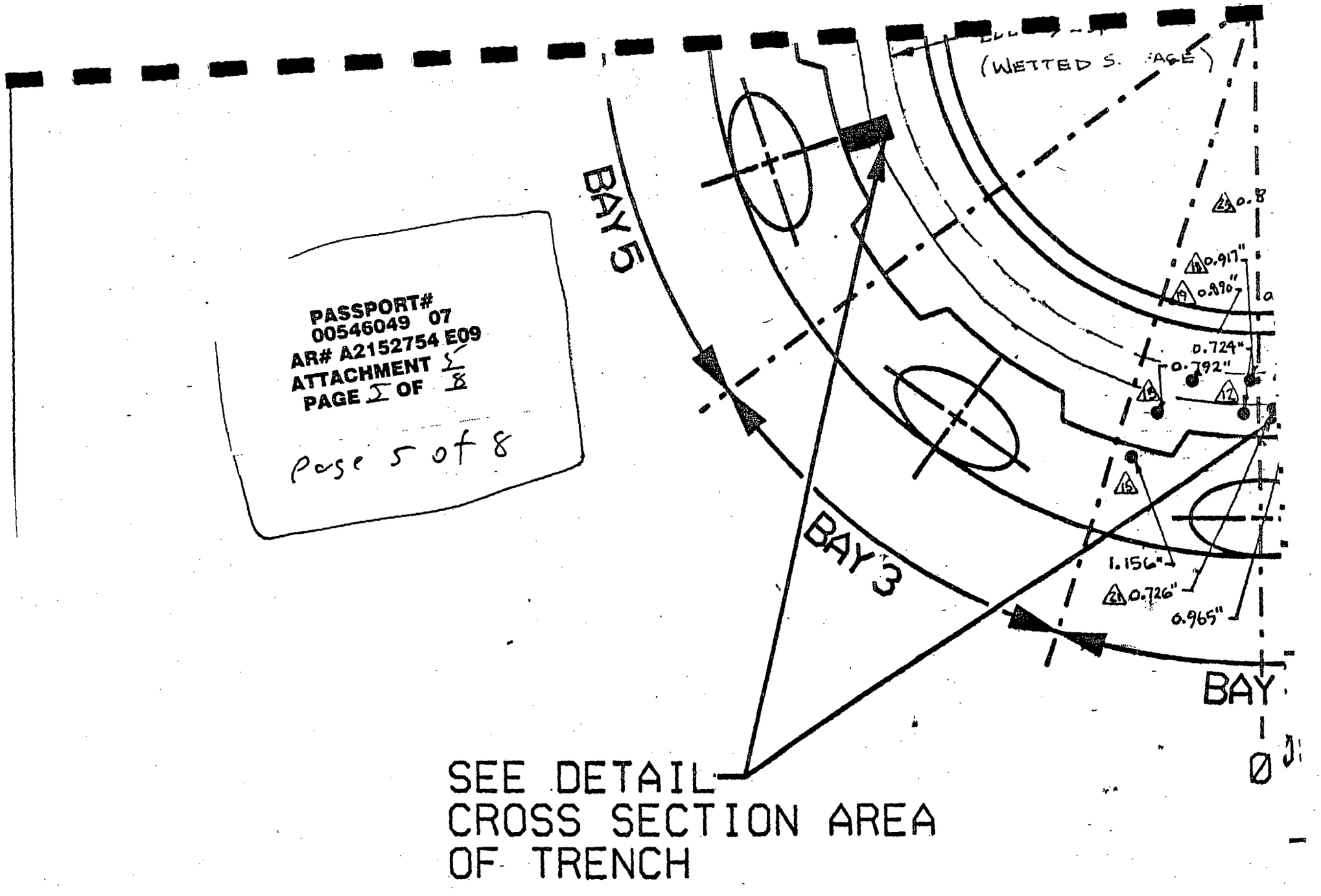

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00546049 07
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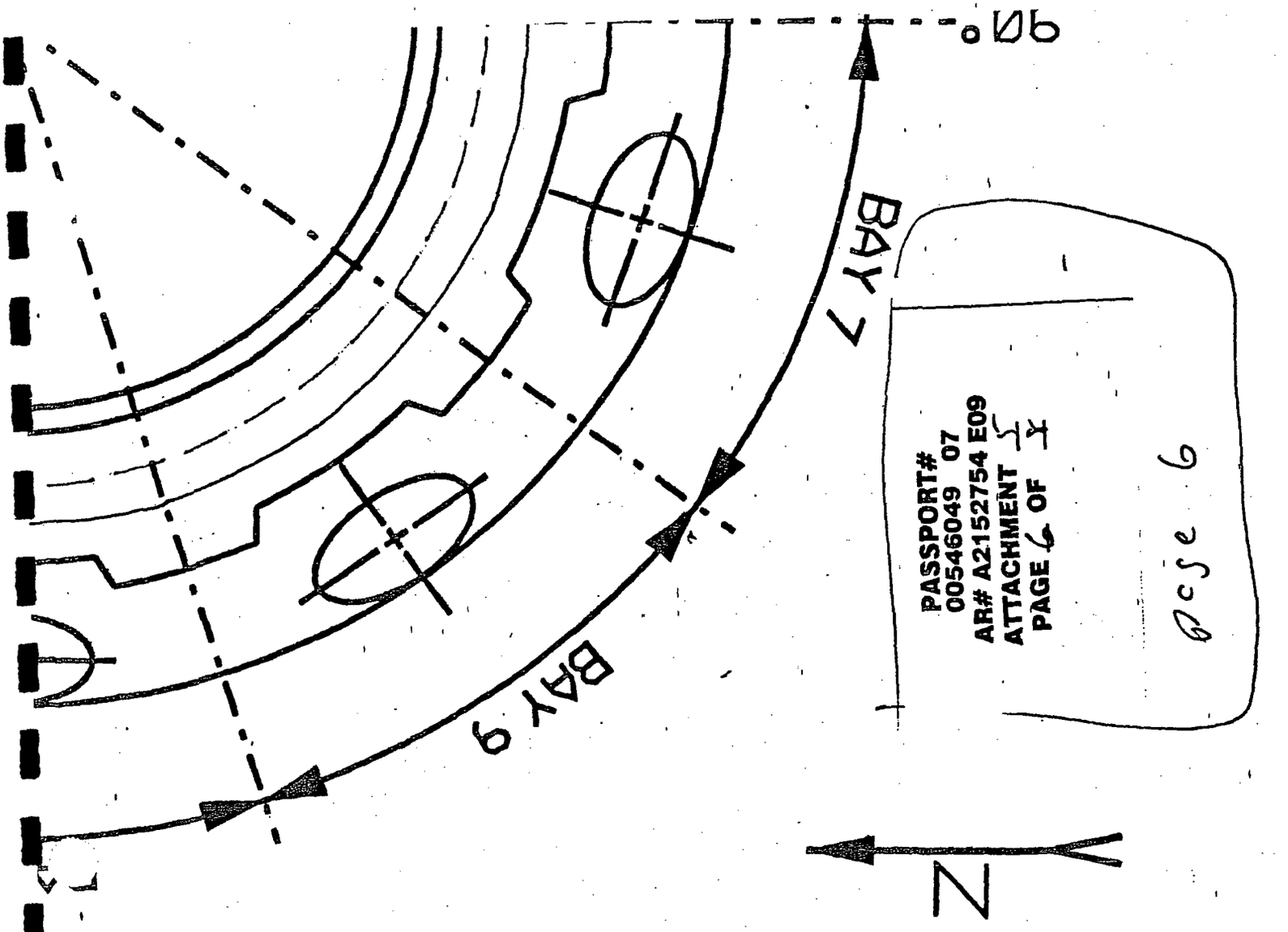

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00546049 07
AR# A2152754 E09
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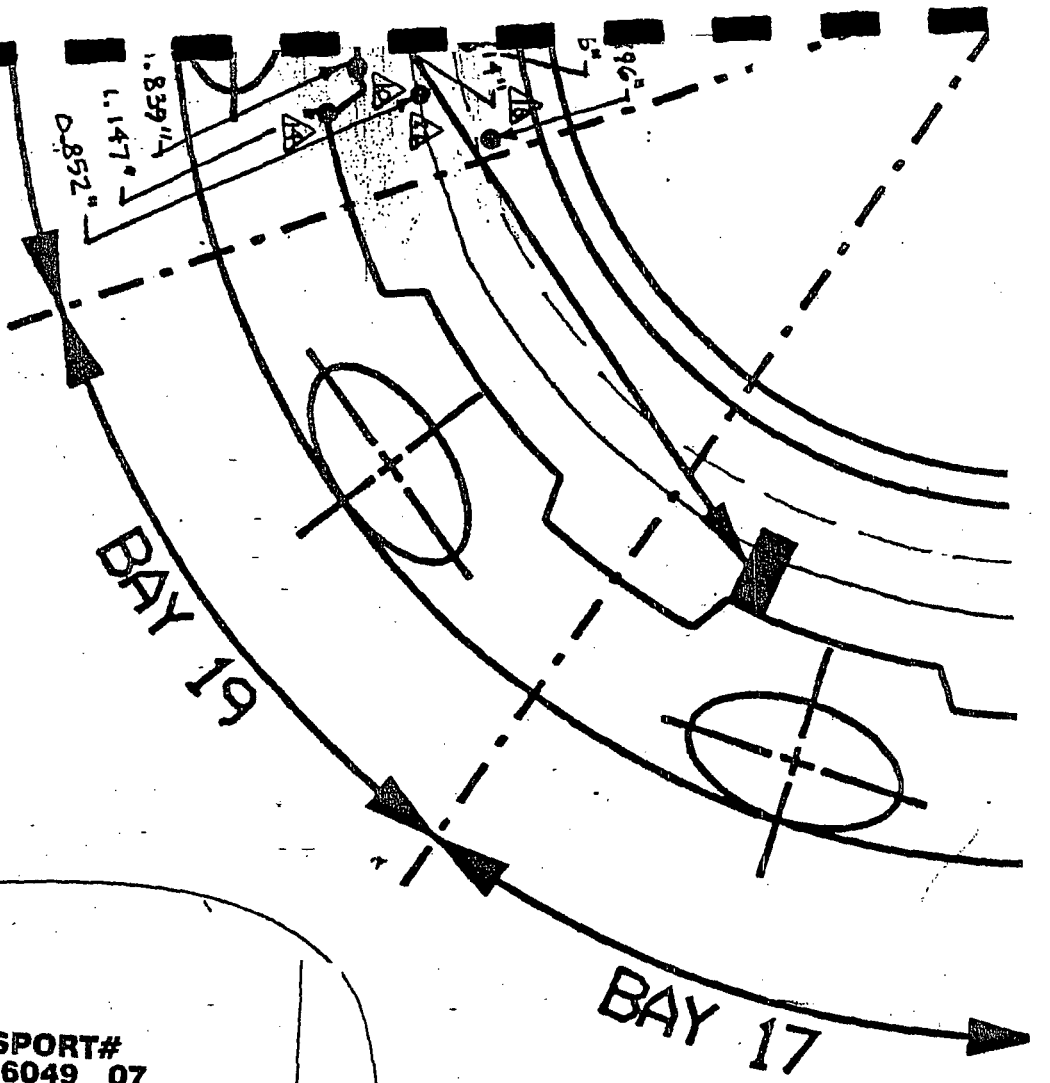
Case 6

PLAN PART II

(NONE)



PLAN PART II
(ZONE)

PASSPORT#
00546049 07
AR# A2152754 E09
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PASSPORT#
00546049 07
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ATTACHMENT 5
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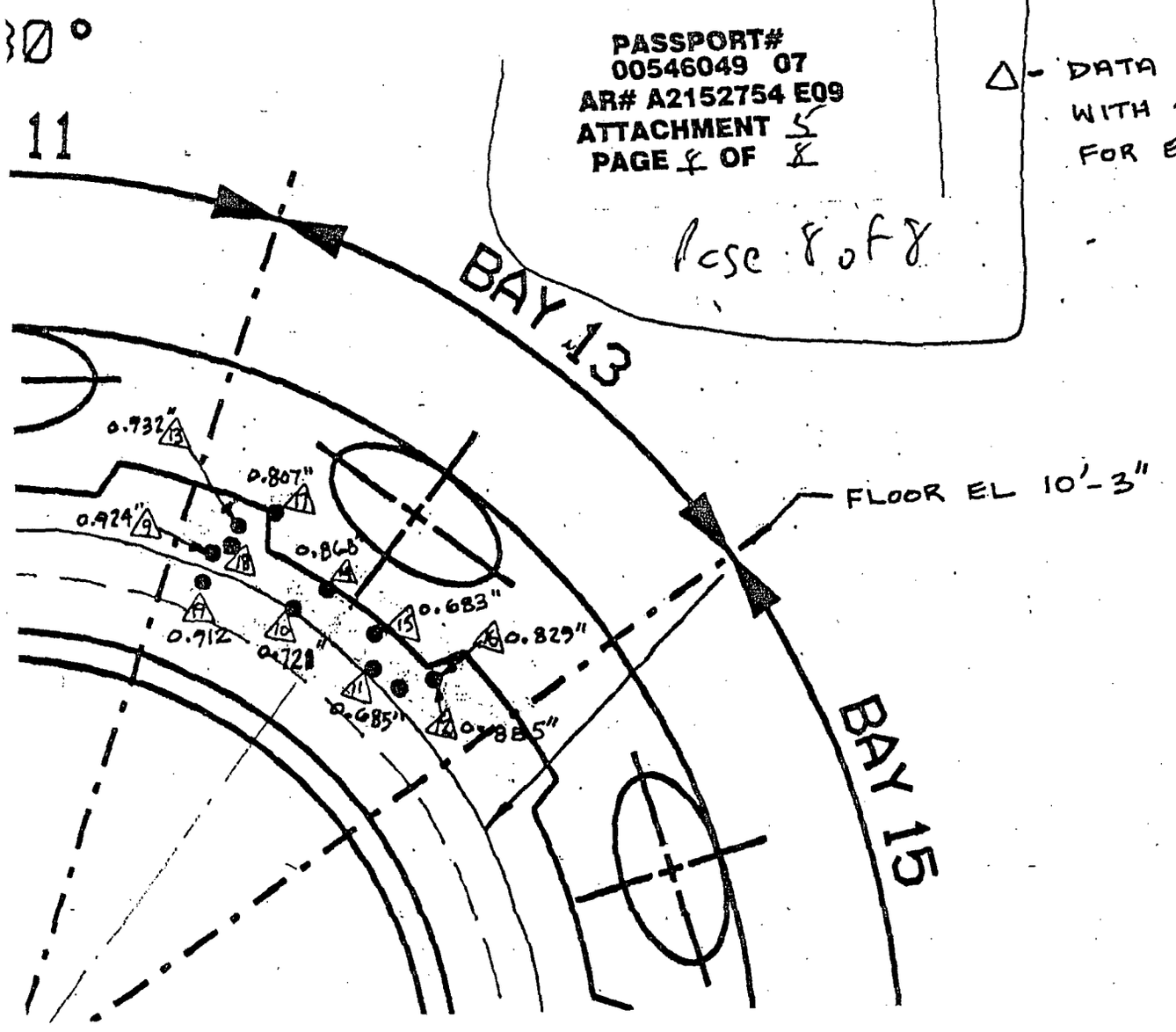
△ - DATA POINT UT
WITH SHELL THICKNESS
FOR EACH INDIVIDUAL BAY



BAY
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9 - 19
11A, (

Bay	Point	Vertical	Horizontal	Under Inside Floor	Under Wetted Concrete	1992 value	NDE Data Sheet	2006 Value	Corrosion Rate 1992 to 2006	Corrosion Rate Under floor above Wetted Area	Corrosion Rate in Wetted Area
1	6	D48	R16	Yes	Yes	0.76	1R21LR-022	0.731	2.071		2.071
1	7	D39	R5	Yes	Yes	0.7	1R21LR-022	0.669	2.214		2.214
1	8	D48	R0	Yes	Yes	0.805	1R21LR-022	0.783	1.571		1.571
1	9	D36	L38	Yes		0.805	1R21LR-022	0.754	3.643	3.643	
1	16	D50	R40	Yes	Yes	0.796	1R21LR-022	0.795	0.071		0.071
1	17	D48	R16	Yes	Yes	0.86	1R21LR-022	0.846	1.000		1.000
1	18	D38	L2	Yes		0.917	1R21LR-022	0.899	1.286	1.286	
1	19	D38	L24	Yes		0.89	1R21LR-022	0.865	1.786	1.786	
1	22	D32	R13	Yes		0.852	1R21LR-022	0.854	-0.143		
1	23	D48	R15	Yes	Yes	0.85	1R21LR-022	0.828	1.571		1.571
5	1	D40	R13 *1	Yes	Yes	0.97	1R21LR-019	0.948	1.571		1.571
5	2	D42	R3 *1	Yes	Yes	1.04	1R21LR-019	0.955	6.071		6.071
5	3	D44	R10 *1	Yes	Yes	1.02	1R21LR-019	0.989	2.214		2.214
5	4	D44	R/L7 *1 *2	Yes	Yes	0.97	1R21LR-019	0.948	1.571		1.571
5	5	D46	R/L11 *1 *2	Yes	Yes	0.89	1R21LR-019	0.88	0.714		0.714
5	6	D44	L4	Yes	Yes	1.06	1R21LR-019	0.981	5.643		5.643
13	7	D48	L24	Yes	Yes	0.99	1R21LR-019	0.974	1.143		1.143
5	8	D46	L28	Yes	Yes	1.01	1R21LR-019	1.007	0.214		0.214
9	5	D36	L4	Yes		0.985	92-072-22 Page 1 fo 5	0.964	1.500	1.500	
9	8	D22	L45*	Yes	Yes	0.791	92-072-22 Page 1 fo 8	0.781	0.714		0.714
11	5	D32	L14	Yes		0.831	92-072-10 page 1 of 4	0.823	0.571	0.571	
11	6	D27	L22	Yes		0.8	92-072-10 page 1 of 5	0.756	3.143	3.143	
11	7	D31	R20	Yes		0.831	92-072-10 page 1 of 6	0.817	1.000	1.000	
11	8	D40	R13	Yes	Yes	0.85	92-072-10 page 1 of 7	0.825	1.786		1.786
13	9	D28	R41	Yes		0.924	92-072-24 page 1 of 10	0.915	0.643	0.643	

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00546049 07
AR# A2152754 E09
ATTACHMENT 7 6 PT
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11/3/05

Bay	Point	Vertical	Horizontal	Under Inside Floor	Under Wetted Concrete	1992 value	NDE Data Sheet	2006 Value	Corrosion Rate 1992 to 2006	Corrosion Rate Under floor above Wetted Area	Corrosion Rate in Wetted Area
13	10	D28	R12	Yes		0.728	92-072-24 page 1 of 11	0.741	-0.929		
13	11	D28	L15	Yes		0.685	92-072-24 page 1 of 12	0.669	1.143	1.143	
15	3	D33	R17	Yes		0.932	1R21LR-015	0.935	-0.214		
15	5	D26	L3	Yes		0.85	1R21LR-015	0.855	-0.357		
15	9	D36	L40	Yes		0.722	1R21LR-015	0.749	-1.929		
17	3	D32	R28	Yes		0.898	1R21LR-021	0.894	0.286	0.286	
17	4	D52	R30	Yes	Yes	0.951	1R21LR-021	0.963	-0.857		
17	5	D36	R12	Yes		0.913	1R21LR-021	0.822	6.500	6.500	
17	6	D52	L6	Yes	Yes	0.992	1R21LR-021	0.909	5.929		5.929
17	7	D36	L26	Yes		0.97	1R21LR-021	0.97	0.000		
17	8	D52	L40	Yes	Yes	0.99	1R21LR-021	0.96	2.143		2.143
									0.000		
19	2	D52	R66	Yes	Yes	0.924	1R21LR-020	0.921	0.214		0.214
19	3	D33	R49	Yes		0.955	1R21LR-020	0.932	1.643	1.643	
19	4	D32	R11	Yes		0.94	1R21LR-020	Not Located			
19	5	D53	R2	Yes	Yes	0.95	1R21LR-020	0.932	1.286		1.286
19	6	D52	L65	Yes	Yes	0.86	1R21LR-020	Not Located			
19	7	D39	L12	Yes	Yes	0.969	1R21LR-020	0.891	5.571		5.571

Minimum Rate	0.286	0.071
Maximum Rate	6.500	6.071
Average Rate	2.280	2.334

Minimum Thickness Recorded in 2006 0.669

Assuming a maxiimum corrosion rate of 6.5 MPY and an uncertaintiy of 20 mils the 0.669 location will thin to the following in 2008 0.636

Assuming a Aveeage corrosion rate of 2.3 MPY and an uncertaintiy of 20 mils the 0.669 location will thin to the following in 2008 0.644

PASSPORT#
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11/13/08

1R21LR-032 Pg 20 of

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	Report Number:	1R21LR- 32
Oyster Creek		Date:	10/26/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification:	IS-328227-004

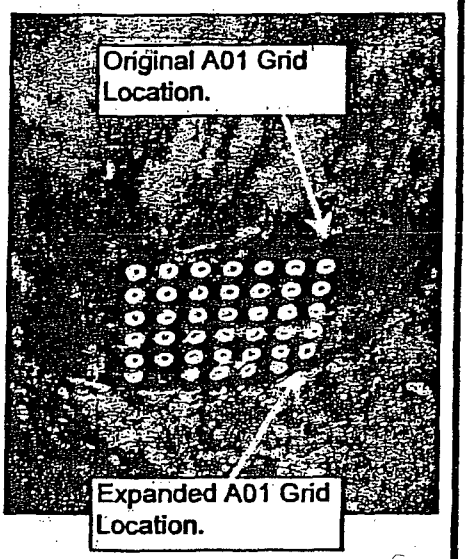
Examiner: Leslie Richter		Level: II	Instrument Type:	Panametrics 37DL Plus	
Examiner: N/A		Level: N/A	Instrument No:	031125409	
Transducer Type: DV 506	Serial #: 072561	Size: 0.438"	Freq: 5 Mhz		Angle: 0°
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge		Block Number: CAL-STEP-136			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	2.0"	9:20	9:35	9:38	10:00	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"		Inches to	1.500"	Inches
Delay Calib:	N/A	Thermometer: 246647		Comp. Temp: 68°		Block Temp: 65°
Range Calib:	N/A	W/O Number: ~~C2013479~~		C2013727-02		
Instrument Freq:	N/A	Total Crew Dose	Drywell Containment Vessel Thickness Examination. Internal UT Inspections.			
Gain:	55 db	45 mr				
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Trench 1 Bay 5 Extended Grid Data

The UT transducer was positioned in the same orientation at each grid point.



Area extended deeper into Trench

Location ID		Trench 1		Bay	5	Elev.	10' 3"	
6	1.182	1.145	1.088	1.085	1.088	1.083	1.060	6
5	1.142	1.106	1.070	1.105	1.094	1.077	1.084	5
4	1.147	1.070	1.083	1.085	1.125	1.087	1.059	4
3	1.161	1.133	1.131	1.127	1.094	1.060	1.052	3
2	1.165	1.152	1.148	1.138	1.130	1.113	1.096	2
1	1.151	1.142	1.142	1.125	1.144	1.138	1.148	1
	G	F	E	D	C	B	A	

Tscr.	AVG.
0.660	1.113
Min Reading	Max. Reading
1.052	1.182

COMMENTS:

The removal of concrete from trench exposed six more inches of liner. The template was placed below previous grid location with the centerline of the top row 1" +/- 1/16" from previous grid bottom row. The holes were painted on the liner using the 8"x 8" template, readings were then taken with template removed.

An area approximately 14"x 6" of extended trench area was scanned 100% with the minimum reading of 1.047" and a maximum reading of 1.150" recorded.

The 100% scan Inspection was performed using a D799 (Serial # 104141) transducer and the grid points inspection was preformed using a DV 506 transducer.

"V" was stamped above grid point 6D.

Reviewed by: Lee Stone

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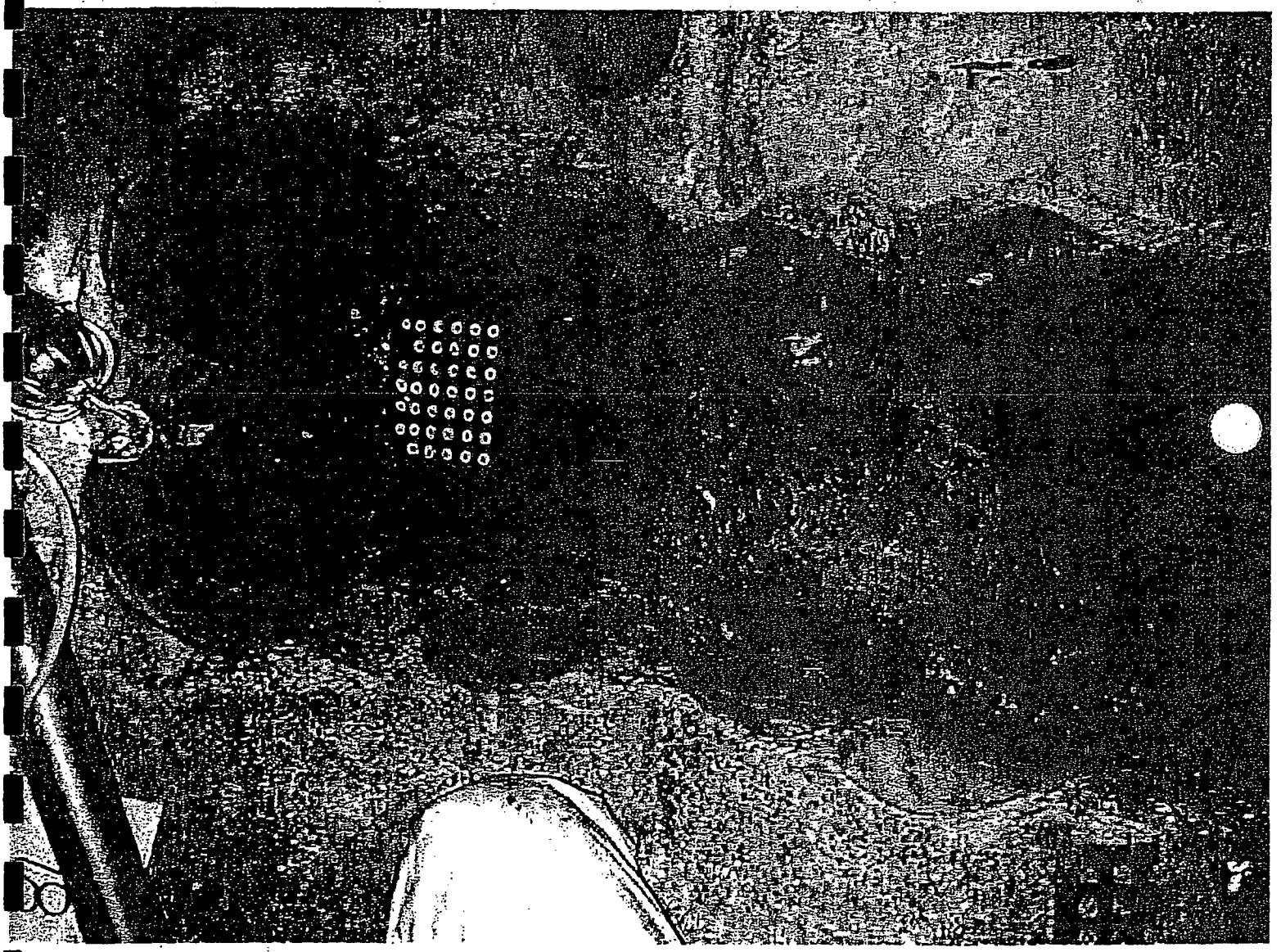
[illegible] c III 10-26-[illegible]



BAY 5 TRENCH 1

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ATTACHMENT 8
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Exelon Nuclear

Memorandum

Asset Management # AM-2006-011
Revision 3

Date: November 6, 2006

To: Howie Ray
Peter Tamburro

cc: Roman Gesior
Richard Hall

From: Steve Leshnoff

Subject: Final Report of the Third Party Independent Review of Oyster Creek Drywell Containment Corrosion Evaluation in Bay 5 and Bay 17 Trenches

The purpose of this memo is to document the independent third party review (ITPR) of the Oyster Creek (OC) Drywell Containment Corrosion Evaluation in Bay 5 and Bay 17 Trenches and to provide you with the results related to that review. The review was performed in accordance with Training & Reference Material (T&RM) HU-AA-1212, Revision 1, Technical Task Risk/Rigor Assessment, Pre-job Brief, Independent Third Party Review, and Post-Job Brief.

Purpose of the Review

Ultrasonic Testing (UT) measurements of the drywell thickness at and below the interior floor at the elevation of the sand bed were obtained during OC 1R21 Refueling Outage. The intent was to complete the assessment of the potential for on-going corrosion both above and below the drywell floor. The purpose of this review is to establish that the appropriate statistical methods were used to evaluate the data and that the correct conclusions were drawn from the statistical evaluation of the data.

Scope of Review

I performed a detailed review of the statistical methods that were used in the evaluation of the UT measurements. The evaluation included the following steps, each of which was reviewed:

- Establish that the UT data from a measurement template was normally distributed using the kurtosis tests
- Derive the standard deviation and standard error for each of the data distributions
- Derivation of the 95% confidence intervals for the data.

- Determination of the lower range of the calculated mean thickness for which there is 95% confidence.
- Calculation of the apparent corrosion rate on an average basis in the trench in Bay 5 and in the trench in Bay 17.

Limitations

There were no limitations to this review.

Conclusions

All of the statistical tests and steps were appropriate and necessary and were applied correctly. The apparent corrosion rate is minimal. Revision D to Technical Evaluation A2152754 E09 impacts only the narrative description of the UT data collection activities and includes added detailed discussion in the conclusion without modification.

Revision G to Technical Evaluation A2152754 E09 concerns the data collected in the trench in Bay 17. The revision aligns the lower 5 grids of 6 grids, in a single row, taken in 2006 with the 5 grids, in one row, taken in 1986. The alignment develops two comparable normal distributions such that a basis is established to determine an apparent average corrosion rate in the trench in Bay 17.

Comments

Refer to Attachment A for technical comments and resolution to those comments on Revision G of the technical evaluation. The comments did not warrant an Issues Report.

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ATTACHMENT A

AM-2006-011
Revision 3

REFERENCE DOCUMENT NO. /REV: OC Drywell Containment Corrosion Evaluation in Bay 5 and Bay 17 Trenches

COMMENTS		RESOLUTION	ACCEPTANCE OF RESOLUTION	
1	No comments on Revision G to Technical Evaluation A2152754 E09 c			
2				
3				
4				
5				
6				
7				
8				
9				
10				
END				

. Leshnoff	11/6/06	Peter Tamburro	11/06/06
SUBMITTED BY	DATE	RESOLVED BY	DATE

MPR ASSOCIATES INC.
ENGINEERS

Privileged and Confidential

November 3, 2006

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ATTACHMENT 5
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Mr. F. Howie Ray
Manager, Mech/Struct Design
Oyster Creek Generating Station
AmerGen Energy Company, LLC
U.S. Route #9
Forked River, NJ 08731-0388

Subject: Third Party Independent Review of Oyster Creek Drywell Water Evaluation

Dear Mr. Ray:

MPR has completed a HU-AA-1212 Independent Third Party Review of the Oyster Creek drywell evaluation concerning standing water found in drywell shell inspection trenches in the 10' 3" concrete floor in the drywell. This review included the following documents:

- Technical Evaluation A/R A2152754 E06, with attachments
- Technical Evaluation A/R A2152754 E09, with attachments
- ECR 06-00879

Based on this review, we generated two comments, one concerning reported local wall thinning in Bay 17 possibly exceeding limiting dimensions for being considered local, and one concerning the relatively low pH value (and possible corrosivity) of trench/drywell gap water during outages when the migration of CRD water through the concrete pad to the inspection trenches and drywell wall occurs. These were transmitted to you via email on November 2. Both comments have been resolved as follows:

- Local wall thinning in Bay 17: Technical Evaluation A/R A2152754 E09 has been revised to include another local thinning acceptance criterion documented in Oyster Creek calculation C-1302-187-5320-024. The UT measurements of concern meet this acceptance criterion and this issue is considered resolved.
- Characterization of the water in the drywell: Section 2.8 of Technical Evaluation A/R A2152754 E06 has been revised to clarify the following points:
  - Any subsequent water (such as reactor coolant) entering the concrete floor-to-drywell gap will increase in pH due to its migration through and contact with the concrete. This will reduce its corrosivity compared to neutral pH water.

- The corrosion of drywell steel surfaces in contact with gap water is expected to occur only during outages when oxygen is present. Corrosion during operation is expected to be almost nil since the drywell operates inerted and no oxygen is present to drive the corrosion reaction. During outages, shell corrosion losses in the gap are expected to be small since the exposure time is very limited and the water pH is expected to be relatively high.
- The expected low corrosion losses in the concrete-to-drywell gap area have been confirmed by examination of steel surfaces in the trenches which has revealed only superficial corrosion of the drywell shell.

With the resolution of these concerns, we consider that the Technical Evaluations and attachments successfully address:

- The structural integrity of the concrete and drywell shell,
- The adequacy of repairs, and the effect of the repairs on the assumptions or inputs used for safety and other analyses, and
- The impacts of past water migration and current repairs on design and the licensing bases.

We also reviewed the technical bases for the Technical Evaluation and conclude that all inputs are accurate or conservative, assumptions are conservative, chemical analysis results are used appropriately, and corrosion evaluations are correct and results used accurately.

Please let me know if you have any questions about this letter.

Sincerely,

J. E. Nestell, PhD

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