

Sandbed
Corrosion
Rate
Assessments

ATTACHMENT 1
Design Analysis Cover Sheet
Page 1 of 57

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		
Station(s): ⁷ Oyster Creek	Component(s): ¹⁴		
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			
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C-1302187-5300-030 Rev. 0	From		
SE-000243-002, Rev. 14	From		
ECR 02-01441, Rev. 0	From		
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Is this Design Analysis Safeguards Information? ¹⁸ Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> If yes, see SY-AA-101-106			
Does this Design Analysis contain Unverified Assumptions? ¹⁷ Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> If yes, AT/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	<i>PATL</i>	12/11/06	
<small>Print Name</small>	<small>Sign Name</small>	<small>Date</small>	
Method of Review: ²¹ Detailed Review <input checked="" type="checkbox"/> Alternate Calculations (attached) <input type="checkbox"/> Testing <input type="checkbox"/>			
Reviewer: ²² Stephen Leshnoff	<i>Stephen Leshnoff</i>	12/11/06	
<small>Print Name</small>	<small>Sign Name</small>	<small>Date</small>	
Review Notes: ²³ Independent review <input checked="" type="checkbox"/> Peer review <input type="checkbox"/>	CORP SIME	<i>APR 12/15/06</i>	
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	<i>Kevin Muggleston</i>	12/11/06	
<small>Print Name</small>	<small>Sign Name</small>	<small>Date</small>	
<small>(For External Analyses Only)</small>			
External Approver: ²⁴	<small>Print Name</small>	<small>Sign Name</small>	<small>Date</small>
Exelon Reviewer: ²⁵	<small>Print Name</small>	<small>Sign Name</small>	<small>Date</small>
Is a Supplemental Review Required? ²⁶ Yes <input checked="" type="checkbox"/> No <input checked="" type="checkbox"/> If yes, complete Attachment 3			
Exelon Approver: ²⁷ F. H. RAY	<i>F. H. RAY</i>	12/15/06	
<small>Print Name</small>	<small>Sign Name</small>	<small>Date</small>	

* See APPENDIX 23 FOR NU-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
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Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 2 of 55
---	---	----------------------	---------------------------	-------------------------

Table of Contents

Section	Pages
1.0 Purpose	3
2.0 Summary of Results	4
3.0 References	9
4.0 Assumptions	10
5.0 Design Inputs	11
6.0 Overall Approach and Methodology	12
7.0 Calculation	29
7.1 Sandbed Locations with 49 Readings	
7.2 Sandbed Locations with 7 Readings	
7.3 External Inspections	
7.4 Sensitivity of the Corrosion Test without the 1996 Data	
7.5 Sensitivity Study to Determine the Statistically Observable Corrosion Rate with Only Four Inspections	
8.0 Software	54
	No of pages
9.0 Appendices	
Appendix #1 - Bay 9 location 9D December 1992 through Oct 2006	16
Appendix #2 - Bay 11 location 11A December 1992 through Oct 2006	17
Appendix #3 - Bay 11 location 11C December 1992 through Oct 2006	25
Appendix #4 - Bay 13 location 13A December 1992 through Oct 2006	16
Appendix #5 - Bay 13 location 13D December 1992 through Oct 2006	31
Appendix #6 - Bay 15 location 15D December 1992 through Oct 2006	16
Appendix #7 - Bay 17 location 17A December 1992 through Oct 2006	26
Appendix #8 - Bay 17 location 17D December 1992 through Oct 2006	16
Appendix #9 - Bay 17 location 17-19 December 1992 through Oct 2006	26
Appendix #10 - Bay 19 location 19A December 1992 through Oct 2006	18
Appendix #11 - Bay 19 location 19B December 1992 through Oct 2006	16
Appendix #12 - Bay 19 location 19C December 1992 through Oct 2006	16
Appendix #13 - Bay 1 location 1D December 1992 through Oct 2006	16
Appendix #14 - Bay 3 location 3D December 1992 through Oct 2006	16
Appendix #15 - Bay 5 location 5D December 1992 through Oct 2006	16
Appendix #16 - Bay 7 location 7D December 1992 through Oct 2006	16
Appendix #17 - Bay 9 location 9A December 1992 through Oct 2006	16
Appendix 18 - Bay 13 location 13 C December 1992 through Oct 2006	16
Appendix 19 - Bay 15 location 15A December 1992 through Oct 2006	14
Appendix 20 - Review of the 2006 106 External UT inspections	21 12
Appendix 21 - Sensitivity of the Corrosion Test with out the 1996 Data	43
Appendix 22 - Sensitivity Studies to Determine Minimum Statistically Observable Corrosion Rates	4
Appendix 23 - Independent Third Party Review of Calculation	3
Attachment 1- 1992 UT Data	5
Attachment 2- 1994 UT Data	4
Attachment 3- 1996 UT Data	19
Attachment 4- 2006 UT Data 1R21LR-029, 030, 033 and 034.	5
Attachment 5- 1992 UT Data for First Inspections of Transition Elevations 23' 6" and 71' 6".	20

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 3 of 55
---	---	----------------------	---------------------------	-------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 4 of 55
---	---	----------------------	---------------------------	-------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 5 of 55
--	---	----------------------	---------------------------	-------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 6 of 55
---	---	----------------------	---------------------------	-------------------------

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	0.736	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		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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 7 of 55
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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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 8 of 55
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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)		
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)		
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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 9 of 55
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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"

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 10 of 55
--	---	----------------------	---------------------------	--------------------------

- 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 11 of 55
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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 than 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 12 of 55
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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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 13 of 55
--	---	----------------------	---------------------------	--------------------------

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 Drywell 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" by 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).

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 14 of 55
--	---	----------------------	---------------------------	--------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 15 of 55
--	---	----------------------	---------------------------	--------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 16 of 55
---	---	----------------------	---------------------------	--------------------------

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

$$\text{Standard error} := \frac{\sigma_{\text{actual}}}{\sqrt{\text{No DataCells}}} \qquad \text{Standard error} = 2.578$$

6.5.4 Skewness

Skewness is calculated using the following equation (reference 3.23).

For the matrix generated in section 6.5.1

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

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

$$\text{Kurtosis} := \frac{\text{No DataCells} \cdot \overrightarrow{\sum (\text{Cells} - \mu_{\text{actual}})^4}}{(\text{No DataCells} - 1) \cdot (\text{No DataCells} - 2) \cdot (\text{No DataCells} - 3) \cdot (\sigma_{\text{actual}})^4} + \frac{3 \cdot (\text{No DataCells} - 1)^2}{(\text{No DataCells} - 2) \cdot (\text{No DataCells} - 3)} \qquad \text{Kurtosis} = 0.262$$

A Kurtosis value close to zero is indicative of a normal distribution (reference 3.23)

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 17 of 55
---	---	----------------------	---------------------------	--------------------------

6.5.6 Normal Probability Plot

An alternative method to determine whether a sample distribution approaches a normal distribution is by a normal probability plot (reference 3.22 and 3.23). 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. The Mathcad function "sorts" sorts the "Cells" array

$$j := 0.. \text{last}(\text{Cells}) \quad \text{srt} := \text{sort}(\text{Cells})$$

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

$$r_j := j + 1 \quad \text{rank}_j := \frac{\sum_{\text{srt}=\text{srt}_j}^{\rightarrow} r}{\sum_{\text{srt}=\text{srt}_j}^{\rightarrow} 1}$$

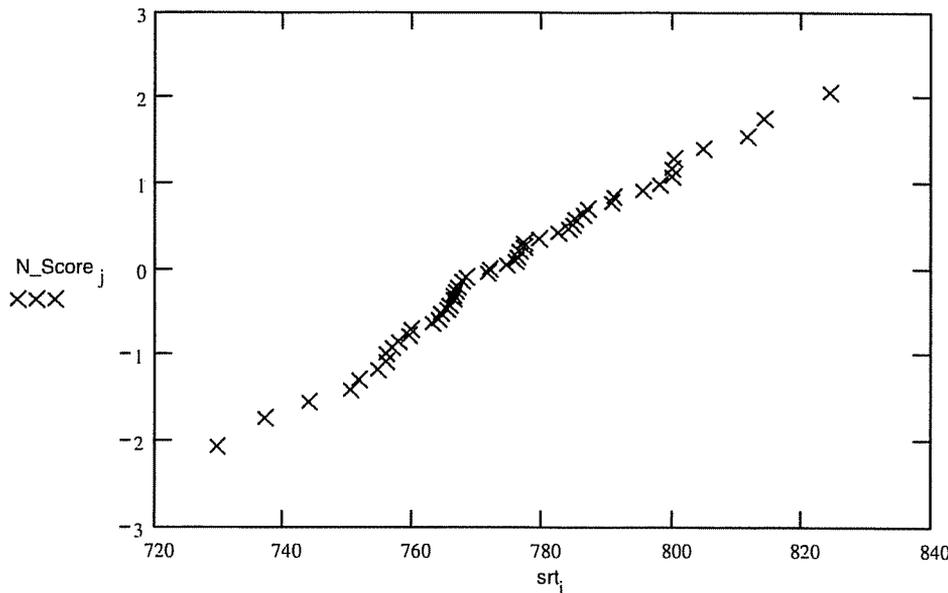
Each rank is proportioned into the "p" array. Then based on the proportion an estimate is calculated for the data point. The Van der Waerden's formula is used

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

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

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

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



Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 18 of 55
---	---	----------------------	---------------------------	--------------------------

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).

$$\alpha := .05 \quad T\alpha := qt\left[\left(1 - \frac{\alpha}{2}\right), 48\right] \quad T\alpha = 2.011$$

Therefore for the matrix generated in section 6.1

$$\text{Lower } 95\% \text{Con} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{N_{\text{DataCells}}}} \quad \text{Lower } 95\% \text{Con} = 767.726$$

$$\text{Upper } 95\% \text{Con} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{N_{\text{DataCells}}}} \quad \text{Upper } 95\% \text{Con} = 778.094$$

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.

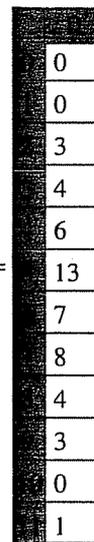
6.5.8 Graphical Representation

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.

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

$$\text{Distribution} := \text{hist}(\text{Bins}, \text{Cells})$$

Distribution =



The mid points of the Bins are calculated

$$k := 0..11 \quad \text{Midpoints}_k := \frac{(\text{Bins}_k + \text{Bins}_{k+1})}{2}$$

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 19 of 55
---	---	----------------------	---------------------------	--------------------------

$$\text{normal_curve}_0 := \text{pnorm}(\text{Bins}_1, \mu_{\text{actual}}, \sigma_{\text{actual}})$$

$$\text{normal_curve}_k := \text{pnorm}(\text{Bins}_{k+1}, \mu_{\text{actual}}, \sigma_{\text{actual}}) - \text{pnorm}(\text{Bins}_k, \mu_{\text{actual}}, \sigma_{\text{actual}})$$

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

$$\text{normal_curve} := \text{No_DataCells} \cdot \text{normal_curve}$$

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).

$\mu_{\text{actual}} = 772.91$

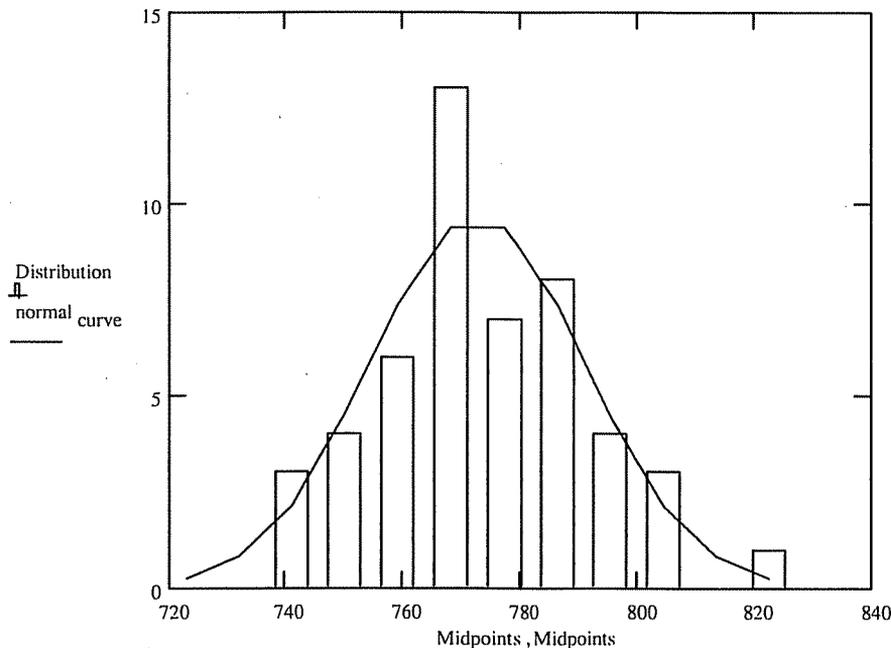
$\sigma_{\text{actual}} = 18.047$

Standard error = 2.578

Skewness = 0.354

Kurtosis = 0.262

No DataCells = 49



Lower 95%Con = 767.726

Upper 95%Con = 778.094

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 20 of 55
--	---	----------------------	---------------------------	--------------------------

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).

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 21 of 55
---	---	----------------------	---------------------------	--------------------------

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 :=

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

$$\mu_{\text{input}_d} := 775 - (\text{Rate}) \cdot (\text{Dates}_d - \text{Dates}_0)$$

$$\sigma_{\text{input}_d} := 20 \quad \text{Cells}_d := \text{rnorm}(\text{No DataCells}, \mu_{\text{input}_d}, \sigma_{\text{input}_d})$$

$$\mu_{\text{actual}_d} := \text{mean}(\text{Cells}_d) \quad \sigma_{\text{actual}_d} := \text{Stdev}(\text{Cells}_d)$$

The resulting simulated means are

$$\mu_{\text{actual}} = \begin{bmatrix} 770.163 \\ 769.826 \\ 773.738 \\ 767.08 \\ 752.938 \\ 754.346 \\ 750.331 \\ 744.589 \\ 742.622 \end{bmatrix}$$

$$\sigma_{\text{actual}} = \begin{bmatrix} 20.964 \\ 20.197 \\ 19.8 \\ 19.57 \\ 17.368 \\ 20.289 \\ 16.007 \\ 24.804 \\ 20.188 \end{bmatrix}$$

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^3 \\ 1.995 \cdot 10^3 \\ 1.997 \cdot 10^3 \\ 1.997 \cdot 10^3 \\ 1.999 \cdot 10^3 \\ 2.002 \cdot 10^3 \\ 2.004 \cdot 10^3 \\ 2.006 \cdot 10^3 \\ 2.008 \cdot 10^3 \end{bmatrix}$$

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 22 of 55
---	---	----------------------	---------------------------	--------------------------

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

$$\text{No_of_means} := \text{rows}(\mu_{\text{actual}}) \qquad \text{No_of_means} = 9$$

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

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

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.

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

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.

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

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

$$\text{DegreeFree}_{\text{ss}} := \text{No_of_means} - 2$$

Subject:Statistical Analysis of Drywell Vessel Sandbed
Thickness Data 1992, 1994, 1996, and 2006**Calculation No.**

C-1302-187-E310-041

Rev. No.

0

System Nos.

187

Sheet

23 of 55

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

$$\text{DegreeFree}_{\text{reg}} := 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \quad \text{MSE} = 7.519$$

$$\text{Standard error} := \sqrt{\text{MSE}} \quad \text{Standard error} = 2.742$$

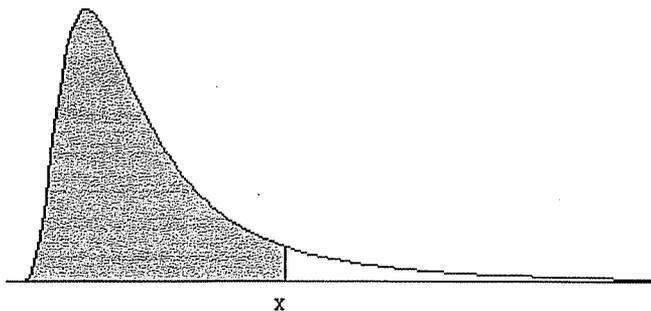
$$\text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \quad \text{MSR} = 741.797$$

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.

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

This ratio F_{actaul} is then compared to the "F" Distribution with the appropriate confidence factor. The Mathcad function pF computes cumulative probabilities for the "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%

$$\text{Confidence} := .95$$

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 24 of 55
--	---	----------------------	---------------------------	--------------------------

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

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

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

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 25 of 55
---	---	----------------------	---------------------------	--------------------------

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".

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

$$m_s = -2.159$$

$$y_b = 5.077 \cdot 10^3$$

The predicted curve is calculated over time where " year predict " is time (independent variable), and "Thick predict " is thickness (dependent variable).

$$\text{Remaining PI_life} := 23$$

$$f := 0.. \text{Remaining PI_life} - 1$$

$$\text{year predict}_f := 1993 + f \cdot 2$$

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

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

$$\alpha_t := 0.05$$

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

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

$$\text{upper}_f := \text{Thick predict}_f \dots$$

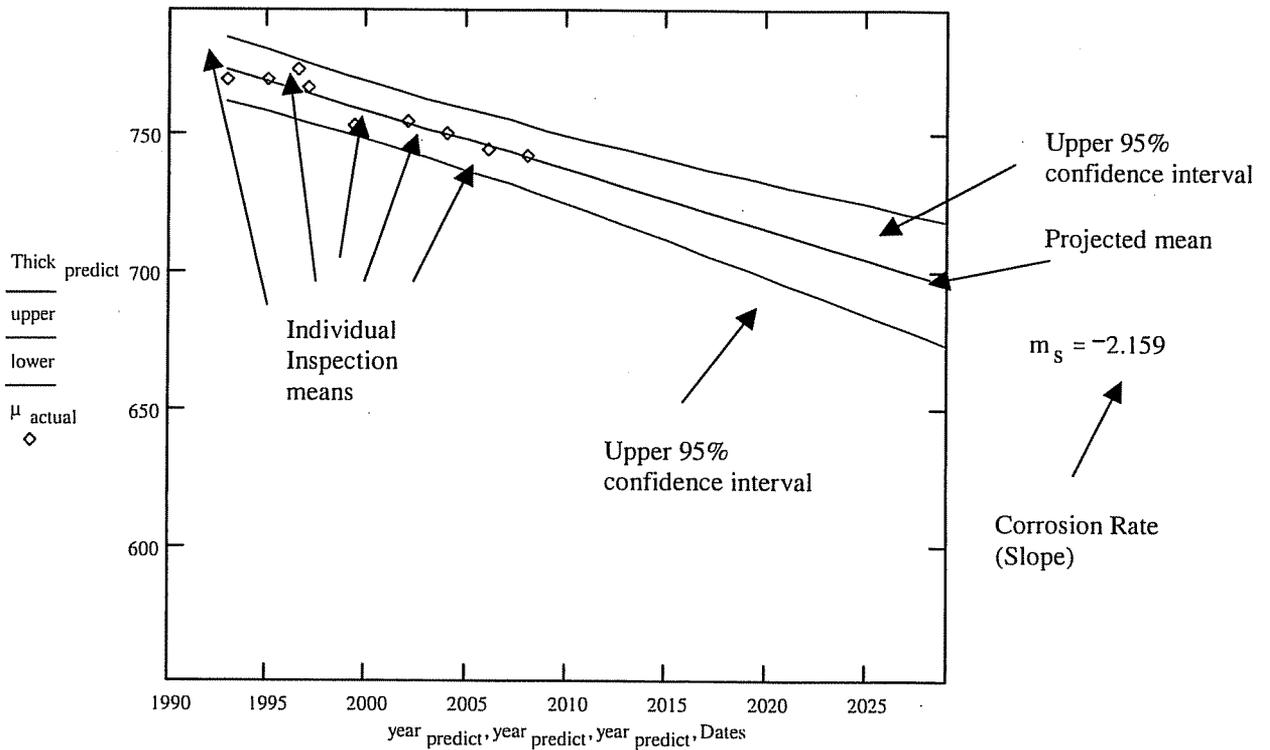
$$+ qt \left(1 - \frac{\alpha_t}{2}, \text{No_of means} - 2 \right) \cdot \text{Standard error} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year predict}_f - \text{Thick actualmean})^2}{\text{sum}}}$$

$$\text{lower}_f := \text{Thick predict}_f \dots$$

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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 26 of 55
---	---	----------------------	---------------------------	--------------------------

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.



Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 27 of 55
---	---	----------------------	---------------------------	--------------------------

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 corrosion rates of 5, 6, 7, 8, and 9 mils per year.

The simulation will generate 49 points arrays using the Mathcad function "norm". 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 28 of 55
--	---	----------------------	---------------------------	--------------------------

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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 29 of 55
--	---	----------------------	---------------------------	--------------------------

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 than 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 30 of 55
--	---	----------------------	---------------------------	--------------------------

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 than 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 result in a normal distribution,

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 31 of 55
--	---	----------------------	---------------------------	--------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 32 of 55
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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 than 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 than 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".

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 33 of 55
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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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 34 of 55
--	---	----------------------	---------------------------	--------------------------

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 than 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 35 of 55
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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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 36 of 55
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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 than 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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 37 of 55
--	---	----------------------	---------------------------	--------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 38 of 55
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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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 39 of 55
--	---	----------------------	---------------------------	--------------------------

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 than 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 40 of 55
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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 than 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 than 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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 41 of 55
--	---	----------------------	---------------------------	--------------------------

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 than 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 42 of 55
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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 than 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 than 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 than the minimum required thickness prior to 2029.

The calculated 1996 mean (1175 mils) in this calculation is different than 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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 43 of 55
--	---	----------------------	---------------------------	--------------------------

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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 44 of 55
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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 than the minimum required thickness prior to 2029.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 45 of 55
--	---	----------------------	---------------------------	--------------------------

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 than 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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 46 of 55
--	---	----------------------	---------------------------	--------------------------

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 than 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 47 of 55
--	---	----------------------	---------------------------	--------------------------

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 than 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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 48 of 55
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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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 49 of 55
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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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 50 of 55
--	---	----------------------	---------------------------	--------------------------

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 1.9×10^{-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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 51 of 55
---	---	----------------------	---------------------------	--------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 52 of 55
---	---	----------------------	---------------------------	--------------------------

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 corrossions 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

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 53 of 55
--	---	----------------------	---------------------------	--------------------------

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.

Subject: Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	Calculation No. C-1302-187-E310-041	Rev. No. 0	System Nos. 187	Sheet 54 of 55
--	---	----------------------	---------------------------	--------------------------

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.

Subject:	Calculation No.	Rev. No.	System Nos.	Sheet
Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996, and 2006	C-1302-187-E310-041	0	187	55 of 55

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".