UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

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

In the Matter of:	)	July 20, 2007
AmerGen Energy Company, LLC	)	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear Generating Station)	)	

AMERGEN'S PRE-FILED DIRECT TESTIMONY EXHIBITS

VOLUME 2 OF 2: EXHIBITS 20-24

Exelon Nuclear

APPLICANT'S EXH. 20

CC-AA-309-1001
Revision 2

ATTACHMENT 1
Design Analysis Cover Sheet
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Design Analysis (Major Revision)	**Last Page No.** Attachment 5 page 20 of 20

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

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

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

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

CONTROLLED DOCUMENT REFERENCES[15]

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

Is this Design Analysis Safeguards Information?[16] Yes ☐ No X If yes, see SY-AA-101-106

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

This Design Analysis SUPERCEDES:[18] in its entirety.

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

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

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

Reviewer:[22] Stephen Leshnoff Stephen Leshnoff 12/11/06
Print Name Corp SME Sign Name FHR 12/15/06 Date

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

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

Checker: Kevin Muggleston 12/11/06

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

Exelon Reviewer:[25]
Print Name Sign Name Date

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

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

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

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

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

REV	SUMMARY OF CHANGE	APPROVAL	DATE
0			

AmerGen **CALCULATION SHEET**

Preparer: Pete Tamburro
12/15/06

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	2 of 55

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1.0 Purpose

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

Specific objectives of this calculation are:

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

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

Background

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

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

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

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

2.0 Summary of Results

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

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

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

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

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

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

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

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

Table 1

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

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

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

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

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

2.1 Twelve Internal Locations with 49 Readings

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

Table 3 Compilation of the 49 Point Grid Means Over Time

Location ID		Mean Thickness based on 1992 Inspections	Mean Thickness based on 1994 Inspections	Mean Thickness based on 1996 Inspections	2006 Mean	Uniform Criteria	Conclusions
		(Inches)	(Inches)	(Inches)	(Inches)	(Inches)	
9D		1.004	0.992	1.008	0.993	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.

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.

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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)	(Inches)	
1D	1.121	1.101	1.151	1.122	0.736	No observable corrosion
3D	1.182	1.184	1.175	1.180		No observable corrosion
5D	1.182	1.168	1.173	1.185		No observable corrosion
7D	1.137	1.136	1.138	1.133		No observable corrosion
9A	1.157	1.157	1.155	1.154		No observable corrosion
13C	1.149	1.140	1.154	1.142		No observable corrosion
15A	1.133	1.114	1.127	1.121		No observable corrosion

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

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

3.1 References

3.1 GPUN Safety Evaluation SE-000243-002, Rev. 14 "Drywell Steel Shell Plate Thickness Reduction at the Base Sand Cushion Entrenchment Region."
3.2 GPUN TDR 854, Rev. 0 "Drywell Corrosion Assessment"
3.3 GPUN TDR 851, Rev. 0 "Assessment of Oyster Creek Drywell Shell"
3.4 GPUN Installation Specification, IS-328227-004, Rev 13, "Functional Requirements for Drywell Containment Vessel Thickness Examination"
3.5 Applied Regression Analysis, 2nd Edition, N. R. Draper & H. Smith, John Wiley and Sons 1981
3.6 Statistical Concepts and Methods, G.K. Bhattacharyya & R.A. Johnson, John Wiley and Sons 1977
3.7 GPUN calculation C-1302-187-5300-005, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru 12-31-88"
3.8 GPUN TDR 948, Rev. 1 "Statistical Analysis of Drywell Thickness Data"
3.9 Experimental Statistics, Mary Gobbons Natrella, John Wiley & Sons, 1966 Reprint (National Bureau of Standards Handbook 91)
3.10 Fundamental Concepts in the Design of Experiments, Charles C Hicks, Saunders College Publishing, Fort Worth, 1982
3.11 GPUN Calculation C-1302-187-5300-008, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru 2-8-90"
3.12 GPUN Calculation C-1302-187-5300-011, Rev.1, "Statistical Analysis of Drywell Thickness Data Thru 4-24-90"
3.13 GPUN Calculation C-1302-187-5300-015, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru March 1991"
3.14 GPUN Calculation C-1302-187-5300-017, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru May 1991"
3.15 GPUN Calculation C-1302-187-5300-019, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru November 1991"
3.16 GPUN Calculation C-1302-187-5300-020, Rev.0, "OCDW Projected Thickness Data Thru 11/02/91"
3.17 GPUN Calculation C-1302-187-5300-021, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru May 1992"
3.18 GPUN Calculation C-1302-187-5300-022, Rev.0, "OCDW Projected Thickness Data Thru 5/31/92"
3.19 GPUN Calculation C-1302-187-5300-025, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru December 1992"
3.20 GPUN Calculation C-1302-187-5300-024, Rev.0, "OCDW Projected Thickness Data Thru 12/8/92"
3.21 GPUN Calculation C-1302-187-5300-028, Rev.0, "OCDW Statistical Analysis of Drywell Thickness Data Thru September 1994"
3.22 GPUN Calculation C-1302-187-5300-030, Rev.0, "Statistical Analysis of Drywell Thickness Data Thru September 1996"

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

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

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

4.0 Assumptions

The statistical evaluation of the UT data to determine the corrosion rate at each location is based on the following assumptions:

4.1 Characterization of the scattering of the data over each grid is such that the thickness measurements are normally distributed. If the data is not normally distributed the grid is subdivided into normally distributed subdivisions.

4.2 Once the distribution of data is found to be close to normal, the mean value of the data points is the appropriate representation of the average condition.

4.3 A decrease in the mean value of the thickness over time is representative of the corrosion.

4.4 If corrosion does not exist, the mean value of the thickness will not vary with time except for random variations in the UT measurements

4.5 If corrosion is continuing at a constant rate, the mean thickness will decrease linearly with time. In this case, linear regression analysis can be used to fit the mean thickness values for a given zone to a straight line as a function of time. The corrosion rate is equal to the slope of the line.

5.0 Design Inputs:

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

1) General Uniform Thickness - 0.736 inches or greater.

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

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

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

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

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

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

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

6.0 OVERALL APPROACH AND METHODOLOGY:

6.1 Definitions

6.1.1 A Normal Distribution has the following properties
- Characterized by a bell shaped curve centered on the mean.
- A value of that quantity is just as likely to lie above the mean as below it
- A value of that quantity is less likely to occur the farther it is from the mean
- Values to one side of the mean are of the same probability as values at the same distance on the other side of the mean

6.1.2 Mean thickness is the mean of valid points, which are normally distributed from the most recent UT measurements at a location.

6.1.3 Variance is the mean of the square of the difference between each data point value and the mean of the population.

6.1.4 Standard Deviation is the square root of the variance.

6.1.5 Standard Error is the standard deviation divided by the square root of the number of data points. Used to measure the dispersion in the distribution.

6.1.6 Skewness measures the relative positions of the mean, medium and mode of a distribution. In general when the skewness is close to zero, the mean, medium and mode are centered on the distribution. The closer skewness is to zero the more symmetrical the distribution. Normal distributions have skewness, which approach zero. Values with +/- 1.0 are indicative that the distribution is normally skewed.

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

6.1.8 Linear Regression is a linear relationship between two variables. A line with a slope and an intercept with the vertical axis can characterize the linear relationship. In this case the linear relationship is between time (which is the independent variable) and corrosion (which is the dependent variable).

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

An F-Ratio of greater than 1.0 occurs when the amount of corrosion that has occurred since the initial measurement is significant compared to the random variations, and four or more measurements have been taken. In these cases the computed corrosion rate more accurately reflects the actual corrosion rate, and there is a very high probability that the actual corrosion rate is the computed corrosion rate. The greater the F-Ratio then the lower the uncertainty in the corrosion rate (reference 3.22).

Where the F-Ratio of 1.0 or greater provides confidence in the historical corrosion rate, the F-Ratio should be 4 to 5 if the corrosion rate is to be used to predict the thickness in the future. To have a high degree of confidence in the predicted thickness, the ratio should be at least 8 or 9 (reference 3.22).

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

6.1.10 Grand mean - when the F-Ratio test is less than 1.0 and/or the slope is positive this is the grand mean of all data.

6.1.11 Corrosion Rate – With three or more data sets and the F-Ratio test greater than 1.0 this is the slope of the regression line.

6.1.12 Upper and Lower 95% Confidence Interval – The upper and lower corrosion rate range for which there is 95% confidence that the actual rate lies within this range.

6.2 Methodology Background

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

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

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

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

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

6.3 The UT measurements within scope of this monitoring program are performed in accordance with ref. 3.4. This specification involves taking UT measurements using a template with 49 holes laid out on a 6" by 6" grid with 1" between centers on both axes or in 7 locations, 7 holes in one row laid on 1" centers. All measurements are made in the same location within 1/8" (reference 3.4).

6.3 Each 49 point data set is evaluated for missing data. Invalid points are those that are declared invalid by the UT operator or are at plug locations.

6.3 The thinnest single location in each of the grids will be trended and compared to acceptance criteria.

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

6.5 Methodology

6.5.1 Test Matrix

To demonstrate the methodology a 49 member array will be generated using the Mathcad "rnorm" function. This function returns an array with a probability density which is normally distributed, where the size of the array ($No_{DataCells}$), the target mean (μ_{input}), and the target standard deviation (σ_{input}) are input.

The following will build a matrix of 49 points

$No_{DataCells} := 49 \qquad i := 0 .. No_{DataCells} - 1 \qquad count := 7$

The array "Cells" is generated by Mathcad with the target mean (μ_{input}) and standard deviation (σ_{input})

$\mu_{input} := 775 \qquad \sigma_{input} := 20 \qquad Cells := rnorm\left(No_{DataCells}, \mu_{input}, \sigma_{input}\right)$

"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

$\mu_{actual} := mean(Cells) \qquad \sigma_{actual} := Stdev(Cells)$

$\mu_{actual} = 774.104 \qquad \sigma_{actual} = 18.258$

Inspection shows that the actual mean and standard deviations are not the same as the target mean and target standard deviation which were input. This is expected since the "rnorm" function returns an array with a probability density which is normally distributed.

6.5.3 Standard Error

The Standard Error is calculated using the following equation (reference 3.23).
For the matrix generated in section 6.5.1

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

6.5.4 Skewness

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

For the matrix generated in section 6.5.1

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

A skewness value close to zero is indicative of a normal distribution (reference 3.22 and 3.23)

6.5 Kurtosis

Kurtosis is calculated using the following equation (reference 3.23).
For the matrix generated in section 6.5.1

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

$$\text{Kurtosis} = 0.262$$

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

6.5.6 Normal Probability Plot

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

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

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

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

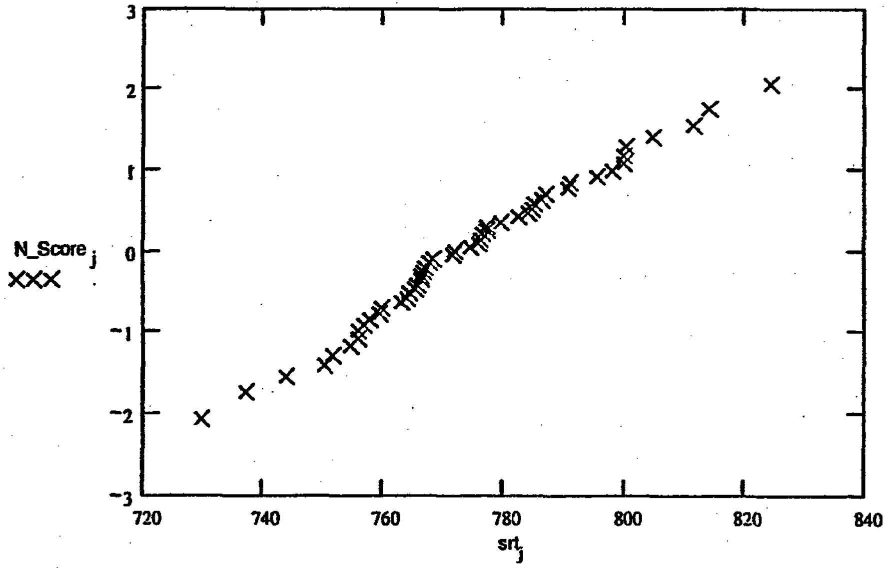
Each rank is proportioned into the "p" array. Then based on the proportion an estimate is is calculated for the data point. TheVan der Waerden's formula is used

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

The normal scores are the correspondingpth percentile points from the standard normal distribution:

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

If a sample is normally distributed, the points of the "Normal Plot" will seem to form a nearly straight line. The plot below shows the "Normal Plot" for the matrix generated in section 6.5.1



6.5.7 Upper and Lower Confidence Values

The Upper and Lower confidence values are calculated based on .05 degree of confidence α.* (reference 3.23).

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

Therefore for the matrix generated in section 6.1

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 767.726$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 778.094$$

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.

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

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

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

The mid points of the Bins are calculated

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

The Mathcad function pnorm calculates the normal distribution curve based on a given mean and standard deviation. The actual mean and standard deviation generated in section 6.5.2 are input. The resulting plot will provide a representation of the normally distribution corresponding the the actual mean and standard deviation.

$$\mathrm{normal}_{\mathrm{curve}_0} := \mathrm{pnorm}\left(\mathrm{Bins}_1, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right)$$

$$\mathrm{normal}_{\mathrm{curve}_k} := \mathrm{pnorm}\left(\mathrm{Bins}_{k+1}, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right) - \mathrm{pnorm}\left(\mathrm{Bins}_k, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right)$$

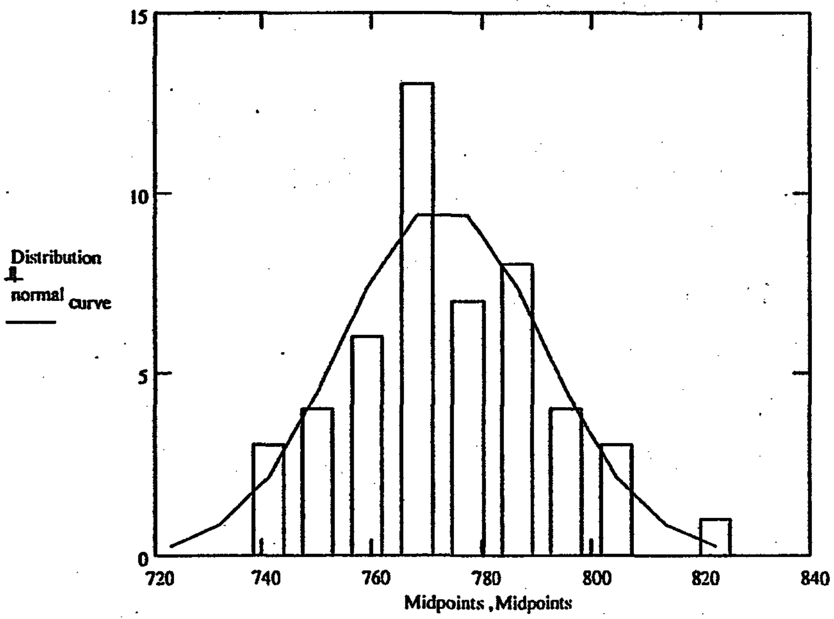
The normal curve is simply a proportion, which is multiplied by the number of "Cells" (49)

$$\mathrm{normal}_{\mathrm{curve}} := \mathrm{No}_{\mathrm{DataCells}} \cdot \mathrm{normal}_{\mathrm{curve}}$$

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 ($\mathrm{No}_{\mathrm{DataCells}}$), and the the lower and upper 95% confidence values $\mathrm{Lower}_{95\%\mathrm{Con}}, \mathrm{Upper}_{95\%\mathrm{Con}}$).

$\mu_{\mathrm{actual}} = 772.91$ $\sigma_{\mathrm{actual}} = 18.047$ $\mathrm{Standard}_{\mathrm{error}} = 2.578$

$\mathrm{Skewness} = 0.354$ $\mathrm{Kurtosis} = 0.262$ $\mathrm{No}_{\mathrm{DataCells}} = 49$



$\mathrm{Lower}_{95\%\mathrm{Con}} = 767.726$ $\mathrm{Upper}_{95\%\mathrm{Con}} = 778.094$

6.5.9 General Summary of Corrosion Rate Assessment Methodology

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

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

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

6.5.9.1 Appropriateness of the Regression Model for Corrosion

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

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

6.5.9.2 "F" Test Results for Corrosion

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

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

$$\mathrm{Dates}_i := \begin{array}{|c|}\hline 1993 \\ \hline 1995 \\ \hline 1996.5 \\ \hline 1997 \\ \hline 1999.4 \\ \hline 2002 \\ \hline 2004 \\ \hline 2006 \\ \hline 2008 \\ \hline \end{array}$$

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

$\mathrm{Rate} := 2.0$

$$\mu\ \mathrm{input}_d := 775 - (\mathrm{Rate})\cdot\left(\mathrm{Dates}_d - \mathrm{Dates}_0\right)$$

$$\sigma\ \mathrm{input}_d := 20 \qquad \mathrm{Cells}_d := \mathrm{rnorm}\left(\mathrm{No}\ \mathrm{DataCells}, \mu\ \mathrm{input}_d, \sigma\ \mathrm{input}_d\right)$$

$$\mu\ \mathrm{actual}_d := \mathrm{mean}\left(\mathrm{Cells}_d\right) \qquad \sigma\ \mathrm{actual}_d := \mathrm{Stdev}\left(\mathrm{Cells}_d\right)$$

The resulting simulated means are

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

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

$No\_of_{means} := rows(\mu_{actual})$ $\qquad$ $No\_of_{means} = 9$

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

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

The curve fit equation in which the date ($Dates$) is the independent variable and the measured mean thickness of the location (μ_{actual}) is the dependent variable, is then defined as the function "yhat". This function makes use of Mathcad function " intercept " which returns the intercept value of the "Best Fit" curve fit and the Mathcad function " slope " which returns the slope value of the "Best Fit" curve fit.

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

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

$$SSE = 125.623$$

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

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

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

$$DegreeFree_{ss} := No\_of_{means} - 2$$

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

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

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

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

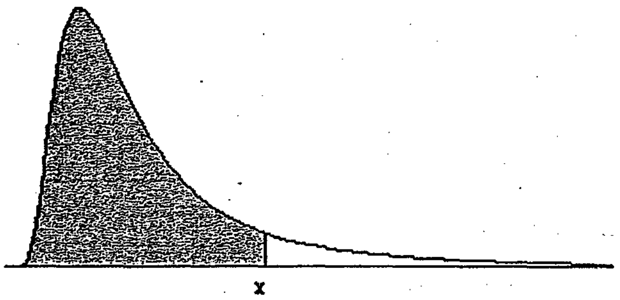
$$\text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MSR} = 741.797$$

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.

$$\text{F}_{\text{actaul}} := \frac{\text{MSR}}{\text{MSE}}$$

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

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



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

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

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

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

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.

6.9.3 Linear Regression with 95% Confidence Intervals

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

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

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

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

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

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

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

$$\alpha_t := 0.05$$

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

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

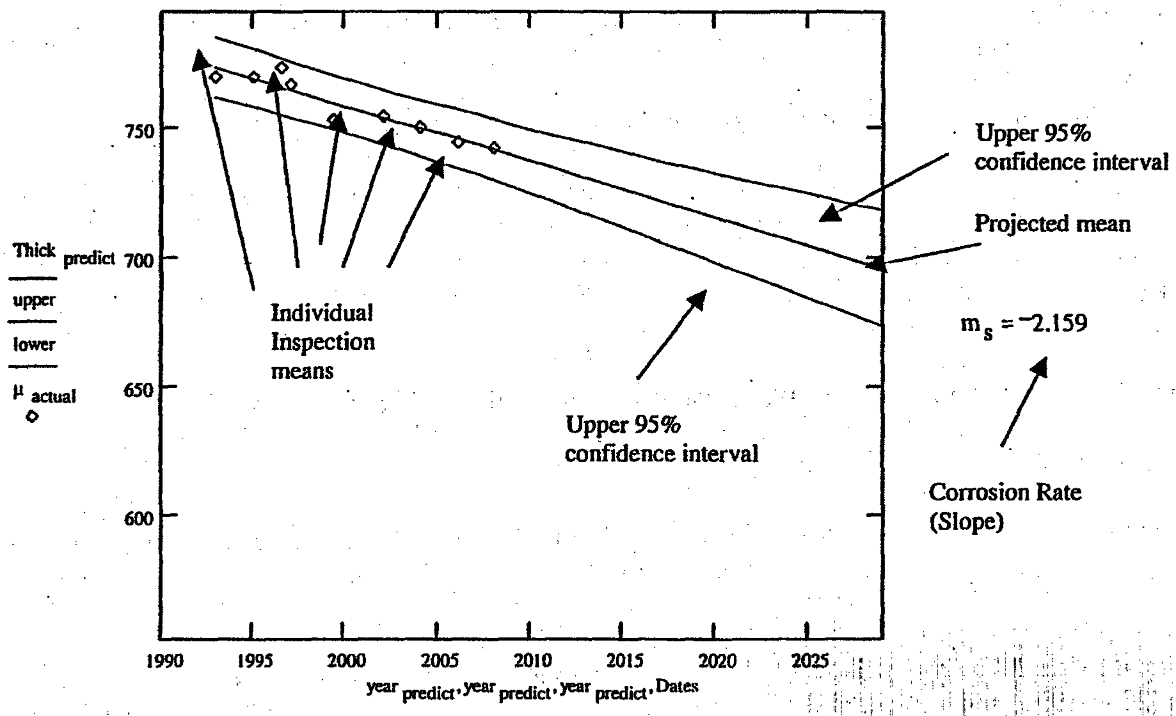
$$\text{upper}_f := \text{Thick}_{\text{predict}_f} \cdots$$

$$+\, \text{qt}\left(1 - \frac{\alpha_t}{2}, \text{No\_of}_{\text{means}} - 2\right) \cdot \text{Standard}_{\text{error}} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{\text{predict}_f} - \text{Thick}_{\text{actualmean}}\right)^2}{\text{sum}}}$$

$$\text{lower}_f := \text{Thick}_{\text{predict}_f} \cdots$$

$$+ - \left[\text{qt}\left(1 - \frac{\alpha_t}{2}, \text{No\_of}_{\text{means}} - 2\right) \cdot \text{Standard}_{\text{error}} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{\text{predict}_f} - \text{Thick}_{\text{actualmean}}\right)^2}{\text{sum}}}\right]$$

Therefore the following is a plot of the curve fit of the data generated in section 6.9.2 and the Upper and Lower 95% confidence Intervals. The Upper and Lower 95% Confidence Intervals are the two curves shown below which bound the data points and the curve fit.



6.9.4 Sensitivity Studies to Determine Observable Corrosion Rates

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

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

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

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

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

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

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

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

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

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

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

Appendix 10 shows the following data for location 19A

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

7.0 Calculation

7.1 Sandbed Locations with 49 Readings

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

Refer to Appendix #1 for the complete calculation.

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

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

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

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

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

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

7.1.2 Bay 11 location 11A December 1992 through Oct 2006

Refer to Appendix #2 for the complete calculation.

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

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

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

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

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

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

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

7.1.3 Bay 11 location 11C December 1992 through Oct 2006

Refer to Appendix #3 for the complete calculation.

Four inspections have been performed at this location after the sand was removed and coating applied in 1992. The data collected in October 2006 is not normally distributed Removal of point number 5, which is much thinner, will results in a normal distribution, although slightly skewed. However past calculations (ref. 3.20, 3.21, and 3.22) have split this data and analyzed the top 3 rows and the bottom 4 row separately. This summary will only describe the evaluation of the entire 7 rows. Appendix 3 provides the results of the top 3 rows and the bottom 4 rows, which are consistent to the following conclusions. Point 1 was not collected due to an obstruction with the vent attachment weld.

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

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

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

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

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

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

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

7.1.4 Bay 13 location 13A December 1992 through Oct 2006

Refer to Appendix #4 for the complete calculation.

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

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

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

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

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

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

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

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

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

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

7.1.5 Bay 13 location 13D December 1992 through Oct 2006

Refer to Appendix #5 for the complete calculation.

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

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

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

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

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

The "F" Test result for No Corrosion on point 49 shows a ratio of 1.64. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

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

7.1.6 Bay 15 location 15D December 1992 through Oct 2006

Refer to Appendix #6 for the complete calculation.

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

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

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

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

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

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

7.6.9 Bay 17 location 17A December 1992 through Oct 2006

Refer to Appendix #7 for the complete calculation.

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

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

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

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

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

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

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

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

7.1.8 Bay 17 location 17D December 1992 through Oct 2006

Refer to Appendix #8 for the complete calculation.

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

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

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

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

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

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

The "F" Test result for No Corrosion on point 14 shows a ratio of 3.3. The "F" Test result for Corrosion on point 14 shows a ratio of 0.001. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this individual point would not reach the minimum required thickness prior to the 2016. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

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

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

Refer to Appendix #9 for the complete calculation.

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

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

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

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

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

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

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

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

7.1.10 Bay 19 location 19A December 1992 through Oct 2006

Refer to Appendix #10 for the complete calculation.

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

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

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

The "F" Test result for Corrosion on the means shows a ratio of 0.004. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2016. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

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

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

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

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

7.1.11 Bay 19 location 19B December 1992 through Oct 2006

Refer to Appendix #11 for the complete calculation.

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

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

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

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

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

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

7.1.12 Bay 19 location 19C December 1992 through Oct 2006

Refer to Appendix #11 for the complete calculation.

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

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

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

The "F" Test result for Corrosion on the means shows a ratio of 0.000007. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2018. Additional inspection will be required at this location prior to this year. It is expected that each added inspection will continue to reduce the uncertainties, which will eventually demonstrate that this location has sufficient margin to reach the full period of operation in 2029.

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

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

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

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

7.2 Sandbed Locations with 7 Readings

7.2.1 Bay 1 location 1D December 1992 through Oct 2006

Refer to Appendix #13 for the complete calculation.

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

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

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

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

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

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

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

7.2.2 Bay 3 location 3D December 1992 through Oct 2006

Refer to Appendix #14 for the complete calculation.

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

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

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

The calculated 1996 mean (1175 mils) in this calculation is different that the same mean calculated in 1996 (1181 mils). This is because the 1996 mean calculation eliminated point 5 from in the 1996 data (reference 3.22). However the 1992 and 1996 calculation did not eliminate this point. Review of the 2006 data shows that the point 5 value is within 2 sigma of the grandmean. Therefore the 1996 mean was recalculated in this calculation with the point 5 included.

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

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

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

7.2.3 Bay 5 location 5D December 1992 through Oct 2006

Refer to Appendix #15 for the complete calculation.

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

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

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

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

The "F" Test for No Corrosion for point 1 shows a ratio of 0.037. The "F" test results of the 1992, 1994, 1996 and 2006 point 1 value show an "F" ratio of 0.925, which is an indication that a slope might exist for this point. Review of the individual readings for each year shows the following values in each year.

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

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

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

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

7.2.4 Bay 7 location 7D December 1992 through Oct 2006

Refer to Appendix #16 for the complete calculation.

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

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

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

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

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

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

7.2.5 Bay 9 location 9A December 1992 through Oct 2006

Refer to Appendix #17 for the complete calculation.

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

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

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

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

The "F" Test result for No Corrosion on point 7 shows a ratio of 0.26. The "F" Test result for Corrosion on point 7 shows a ratio of 0.02. Sensitivity studies show that given only four inspections, a rate of 6.9 mils per year would be observed 95 times or more out of 100 iterations (see appendix 22). Therefore the conclusion is made that the mean rate for this location is less than the statistically observable rate of 6.9 mils per year. Projection based on this assumed rate shows that this location would not reach the minimum required thickness prior to the 2029.

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

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

Refer to Appendix 18 for the complete calculation.

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

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

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

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

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

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

7.2.7 Bay 15 location 15A December 1992 through Oct 2006

Refer to Appendix 19 for the complete calculation.

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

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

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

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

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

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

7.3 External Inspections

7.3.1 Background

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

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

7.3.2 Results

(Refer to Appendix 20)

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

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

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

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

7.3.3 Worst Case
(Refer to Appendix 20)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7.4 Sensitivity of the Corrosion Test without the 1996 Data

(Refer to appendix 21).

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

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

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

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

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

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

7.5 Sensitivity Study to Determine the Statistically Observable Corrosion Rate with Only Four Inspections

(Refer to appendix 22).

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

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

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

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

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

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

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

The mean value input into the random number generator for to the 1992 array was the 1992 actual mean for location 19A (800 mils- reference appendix 10 page 10). The standard deviation input into the random number generator for all arrays was 65 mils (which is an average of the calculated standard deviations from the 1992, 1994, 1996 and 2006 data (see appendix 10 page 10). The random number generator then generated 49 point arrays based on a mean of 800 mils and a standard deviation of 65 mils.

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

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

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

8.0 Software

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

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

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

9.0 Appendices

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

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

Appendix 1 - Sandbed 9D
October 2006 Data

The data shown below was collected on 10/18/06

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB9D.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$$\text{Points}_{49} = \begin{bmatrix} 1.005 & 1.056 & 0.985 & 1.133 & 1.132 & 1.136 & 1.101 \\ 0.896 & 0.927 & 1.067 & 1.037 & 0.974 & 1.077 & 1.069 \\ 0.751 & 0.883 & 0.975 & 1.071 & 1.033 & 1.105 & 1.123 \\ 0.885 & 0.993 & 0.949 & 0.984 & 0.995 & 1.022 & 1.041 \\ 0.98 & 0.968 & 0.936 & 0.942 & 0.88 & 0.927 & 0.998 \\ 0.96 & 0.869 & 0.976 & 0.987 & 0.967 & 0.965 & 0.949 \\ 0.968 & 0.967 & 0.963 & 1.004 & 0.947 & 0.892 & 0.943 \end{bmatrix}$$

$\text{Cells} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

The thinnest point is point 15 which is shown below

$\text{minpoint} := \min\left(\text{Points}_{49}\right)$ $\text{minpoint} = 0.751$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 987.612$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 78.292$

Standard Error

$$\text{Standard}_{error} := \frac{\sigma_{actual}}{\sqrt{\text{No}_{DataCells}}} \qquad \text{Standard}_{error} = 11.185$$

Skewness

$$\text{Skewness} := \frac{(\text{No}_{DataCells})\cdot\overrightarrow{\Sigma(\text{Cells} - \mu_{actual})^{3}}}{(\text{No}_{DataCells} - 1)\cdot(\text{No}_{DataCells} - 2)\cdot(\sigma_{actual})^{3}} \qquad \text{Skewness} = -0.14$$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{DataCells}\cdot(\text{No}_{DataCells} + 1)\cdot\overrightarrow{\Sigma(\text{Cells} - \mu_{actual})^{4}}}{(\text{No}_{DataCells} - 1)\cdot(\text{No}_{DataCells} - 2)\cdot(\text{No}_{DataCells} - 3)\cdot(\sigma_{actual})^{4}} + -\frac{3\cdot(\text{No}_{DataCells} - 1)^{2}}{(\text{No}_{DataCells} - 2)\cdot(\text{No}_{DataCells} - 3)} \qquad \text{Kurtosis} = 0.697$$

Normal Probability Plot

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

$$r_j := j + 1 \qquad \text{rank}_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{\text{srt} = \text{srt}_j}\right)\cdot r}}{\Sigma\overrightarrow{\text{srt} = \text{srt}_j}}$$

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

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

Upper and Lower Confidence Values

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

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

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 965.124$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 1.01 \cdot 10^{3}$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$\text{Distribution} = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 5 \\ 6 \\ 16 \\ 6 \\ 4 \\ 6 \\ 4 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

$$\text{normal}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_1, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

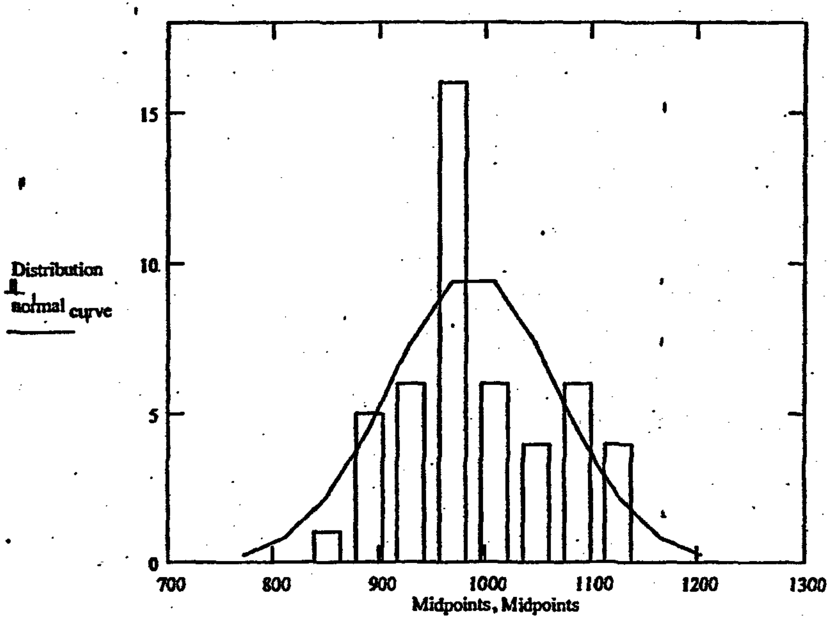
$$\text{normal}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{k+1}, \mu_{\text{actual}}, \sigma_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_k, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

$$\text{normal}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$$

Results For 9D

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values.

Data Distribution



$\mu_{actual} = 987.612$

$\sigma_{actual} = 78.292$

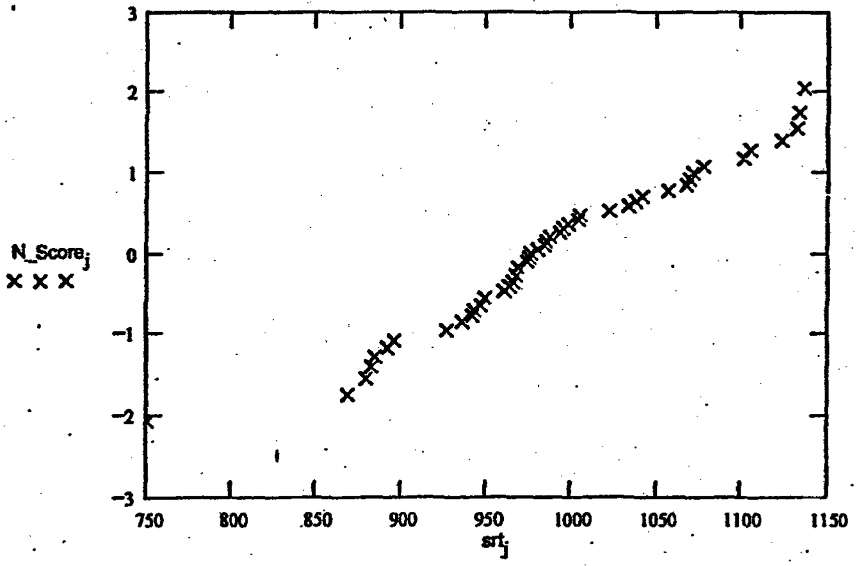
$Standard_{error} = 11.185$

$Skewness = -0.14$

$Kurtosis = 0.697$

$Lower_{95\%Con} = 965.124$ $Upper_{95\%Con} = 1.01 \cdot 10^3$

Normal Probability Plot



The distribution is normal

Data from . 1992 to 2006 is retrieved. $d := 0$

For Dec 31 1992

$\text{page} := \text{READPRN}(\text{"U:\\MSOFFICE\\Drywell Program data\\Dec. 1992 Data\\sandbed\\DATA ONLY\\SB9D.txt"})$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.01 & 1.052 & 0.998 & 1.165 & 1.163 & 1.141 & 1.106 \\ 0.966 & 0.96 & 0.992 & 1.024 & 0.979 & 1.063 & 1.075 \\ 0.763 & 0.883 & 0.978 & 1.053 & 1.033 & 1.112 & 1.125 \\ 0.914 & 1.003 & 0.992 & 0.985 & 1 & 1.023 & 1.042 \\ 1.034 & 0.969 & 0.921 & 0.94 & 0.897 & 0.927 & 1.01 \\ 0.955 & 0.872 & 0.98 & 1.017 & 0.972 & 0.966 & 0.948 \\ 1.103 & 1.011 & 0.978 & 0.991 & 0.975 & 0.897 & 0.975 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Pit}_{15_d} := \text{nnn}_{14}$ $\text{Pit}_{15} = .763$

$\text{Cells} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 15)$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{Cells}, \text{No}_{\text{DataCells}})$

$\text{No}_{\text{Cells}} := \text{length}(\text{Cells})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\DATA ONLY\SB9D.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.005 & 1.053 & 0.995 & 1.132 & 1.095 & 1.141 & 1.112 \\ 0.921 & 0.956 & 0.999 & 1.027 & 0.983 & 1.06 & 1.077 \\ 0.77 & 0.884 & 0.986 & 1.086 & 1.049 & 1.119 & 1.112 \\ 0.802 & 0.965 & 0.978 & 0.986 & 1.007 & 1.026 & 1.048 \\ 0.969 & 0.967 & 0.98 & 0.94 & 0.894 & 0.929 & 0.977 \\ 0.959 & 0.855 & 0.971 & 1.018 & 0.982 & 0.971 & 0.943 \\ 0.943 & 0.968 & 0.945 & 0.991 & 0.977 & 0.899 & 0.932 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Pit}_{15_d} := \text{nnn}_{14}$

$\text{Cells} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 15\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.004 \cdot 10^3 \\ 991.958 \end{bmatrix}$$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\DATA ONLY\SB9D.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.965 & 1.022 & 0.985 & 1.133 & 1.149 & 1.136 & 1.141 \\ 0.878 & 0.978 & 1.073 & 1.021 & 0.992 & 1.095 & 1.116 \\ 0.776 & 0.836 & 1.078 & 1.086 & 1.044 & 1.125 & 1.113 \\ 0.944 & 0.967 & 1.011 & 0.998 & 1.004 & 1.02 & 1.083 \\ 0.941 & 0.939 & 0.937 & 0.939 & 0.942 & 0.931 & 1.018 \\ 1.018 & 1.018 & 1.018 & 1.058 & 1.029 & 0.966 & 0.952 \\ 0.953 & 0.953 & 0.953 & 0.953 & 0.978 & 0.922 & 0.969 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{Pit}_{15_d} := \text{nnn}_{14}$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 15\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 2006 $d := d + 1$

$page := READPRN(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash OCT 2006 Data\textbackslash Sandbed\textbackslash SB9D.txt"})$

$Points_{49} := showcells(page, 7, 0)$ $Dates_d := Day_{year}(9, 23, 2006)$

Data

$$Points_{49} = \begin{bmatrix} 1.005 & 1.056 & 0.985 & 1.133 & 1.132 & 1.136 & 1.101 \\ 0.896 & 0.927 & 1.067 & 1.037 & 0.974 & 1.077 & 1.069 \\ 0.751 & 0.883 & 0.975 & 1.071 & 1.033 & 1.105 & 1.123 \\ 0.885 & 0.993 & 0.949 & 0.984 & 0.995 & 1.022 & 1.041 \\ 0.98 & 0.968 & 0.936 & 0.942 & 0.88 & 0.927 & 0.998 \\ 0.96 & 0.869 & 0.976 & 0.987 & 0.967 & 0.965 & 0.949 \\ 0.968 & 0.967 & 0.963 & 1.004 & 0.947 & 0.892 & 0.943 \end{bmatrix}$$

$nnn := convert\left(Points_{49}, 7\right)$

$Pit_{15_d} := nnn_{14}$ $No_{DataCells} := length(nnn)$

$Cells := Zero_{one}\left(nnn, No_{DataCells}, 15\right)$

$Cells := deletezero_{cells}\left(Cells, No_{DataCells}\right)$

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

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$

Below are the results

$$\mu_{measured} = \begin{bmatrix} 1.004\cdot10^{3} \\ 991.958 \\ 1.008\cdot10^{3} \\ 992.542 \end{bmatrix} \quad Dates = \begin{bmatrix} 1.993\cdot10^{3} \\ 1.995\cdot10^{3} \\ 1.997\cdot10^{3} \\ 2.007\cdot10^{3} \end{bmatrix} \quad Standard_{error} = \begin{bmatrix} 10.029 \\ 10.432 \\ 10.56 \end{bmatrix}$$

$$Pit_{15} = \begin{bmatrix} 763 \\ 770 \\ 776 \\ 751 \end{bmatrix} \quad \sigma_{measured} = \begin{bmatrix} 70.202 \\ 72.276 \\ 73.163 \\ 71.022 \end{bmatrix} \quad Pit_{15} = \begin{bmatrix} 763 \\ 770 \\ 776 \\ 751 \end{bmatrix}$$

$$Total_{means} := rows\left(\mu_{measured}\right) \qquad Total_{means} = 4$$

$$SST := \sum_{i=0}^{last(Dates)} \left(\mu_{measured_i} - mean\left(\mu_{measured}\right)\right)^2 \qquad SST = 192.385$$

$$SSE := \sum_{i=0}^{last(Dates)} \left(\mu_{measured_i} - yhat\left(Dates, \mu_{measured}\right)_i\right)^2$$

$$SSR := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, \mu_{measured}\right)_i - mean\left(\mu_{measured}\right)\right)^2$$

$$DegreeFree_{ss} := Total_{means} - 2 \qquad DegreeFree_{reg} := 1 \qquad DegreeFree_{st} := Total_{means} - 1$$

$$MSE := \frac{SSE}{DegreeFree_{ss}} \qquad MSR := \frac{SSR}{DegreeFree_{reg}} \qquad MST := \frac{SST}{DegreeFree_{st}}$$

$$MSE = 75.83 \qquad MSR = 40.724 \qquad MST = 64.128$$

$$StGrand_{err} := \sqrt{MSE}$$

F Test for Corrosion

$$\alpha := 0.05 \qquad F_{actaul\_Reg} := \frac{MSR}{MSE} \qquad F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.029$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

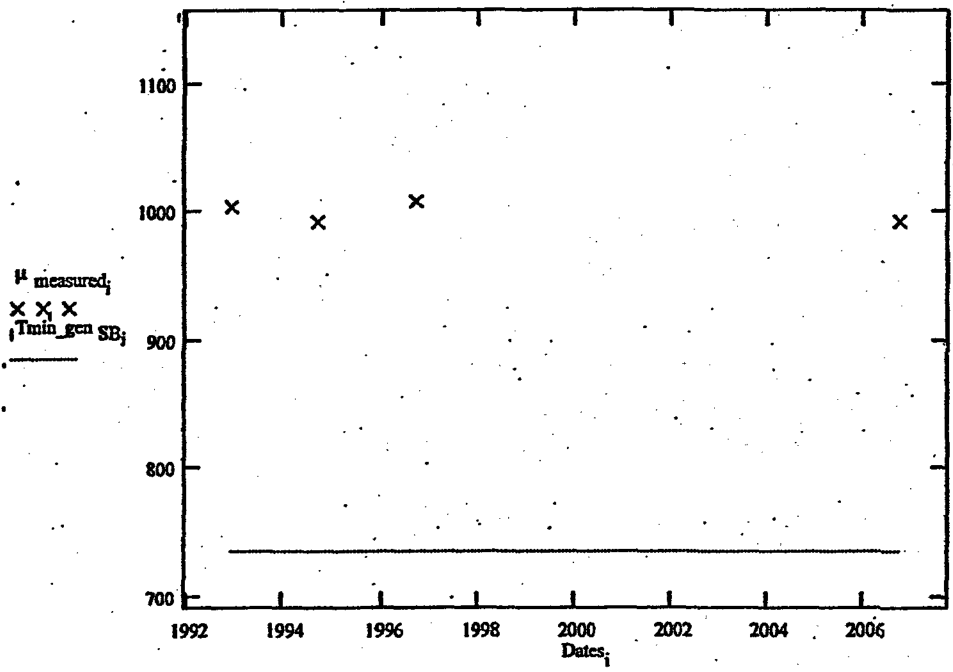
The following will plot the results for the overall mean, the mean of thinner points, and the mean of thicker points

$i := 0 .. Total_{means} - 1$

$\mu grand_{measured_i} := mean(\mu_{measured})$ $\sigma grand_{measured} := Stdev(\mu_{measured})$

$$GrandStandard_{error} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)



$\mu grand_{measured_0} = 999.016$ $GrandStandard_{error} = 4.004$

The F Test indicates that the regression model does not hold for the data sets. However, the slopes and 95% Confidence curve is generated for this case.

$m_s := \mathrm{slope}(\mathrm{Dates}, \mu_{measured})$ $\qquad y_b := \mathrm{intercept}(\mathrm{Dates}, \mu_{measured})$

$\alpha_t := 0.05 \qquad k := 23 \qquad f := 0..k-1 \qquad \mathrm{year}_{predict_f} := 1985 + f \cdot 2$

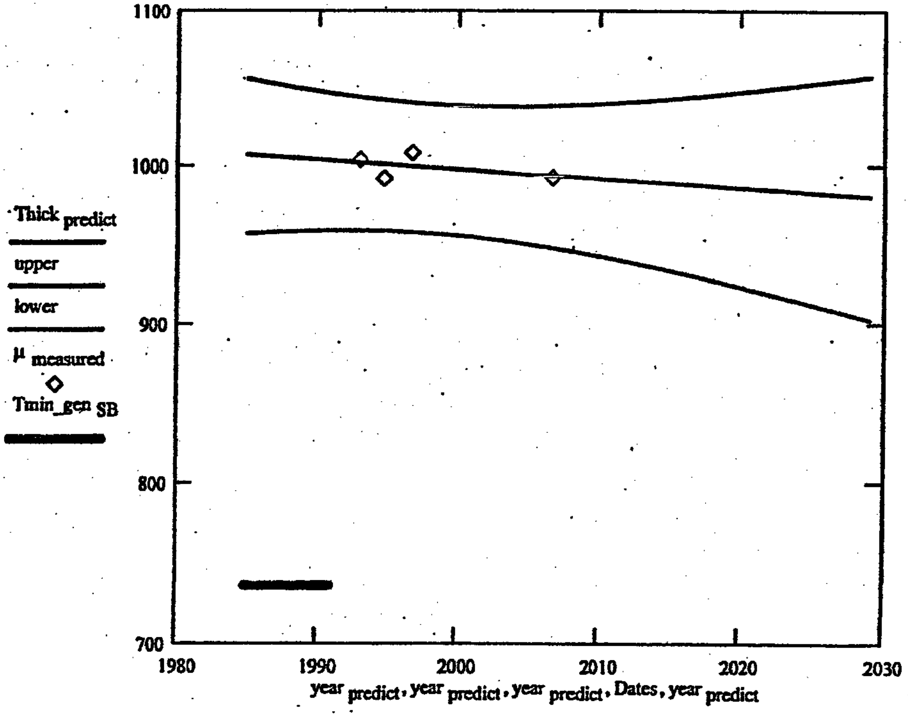
$\mathrm{Thick}_{predict} := m_s \cdot \mathrm{year}_{predict} + y_b$

$\mathrm{Thick}_{actualmean} := \mathrm{mean}(\mathrm{Dates}) \qquad \mathrm{sum} := \sum_i \left(\mathrm{Dates}_d - \mathrm{mean}(\mathrm{Dates})\right)^2$

For the entire grid

$$\mathrm{upper}_f := \mathrm{Thick}_{predict_f} \ldots + \mathrm{qt}\left(1 - \frac{\alpha_t}{2}, \mathrm{Total}_{means} - 2\right) \cdot \mathrm{StGrand}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{predict_f} - \mathrm{Thick}_{actualmean}\right)^2}{\mathrm{sum}}}$$

$$\mathrm{lower}_f := \mathrm{Thick}_{predict_f} \ldots + -\left[\mathrm{qt}\left(1 - \frac{\alpha_t}{2}, \mathrm{Total}_{means} - 2\right) \cdot \mathrm{StGrand}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{predict_f} - \mathrm{Thick}_{actualmean}\right)^2}{\mathrm{sum}}}\right]$$



$m_s = -0.597$

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\mathrm{Rate}_{\mathrm{min\_observed}} := 6.9$$

$$\mathrm{Postulated}_{\mathrm{meanthickness}} := \mu_{\mathrm{measured}_3} - \mathrm{Rate}_{\mathrm{min\_observed}} \cdot (2029 - 2006)$$

$\mathrm{Postulated}_{\mathrm{meanthickness}} = 833.842$ which is greater than $\mathrm{Tmin\_gen}_{\mathrm{SB}_3} = 736$

The following addresses the readings at the lowest single point

The F-Ratio is calculated for the point as follows

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Pit_{15_i} - mean(Pit_{15})\right)^2 \qquad SST_{point} = 346$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Pit_{15_i} - yhat(Dates, Pit_{15})_i\right)^2 \qquad SSE_{point} = 167.47$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, Pit_{15})_i - mean(Pit_{15})\right)^2 \qquad SSR_{point} = 178.53$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 83.735 \qquad MSR_{point} = 178.53 \qquad MST_{point} = 115.333$$

$$StPit_{err} := \sqrt{MSE_{point}} \qquad StPit_{err} = 9.151$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.115$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Therefore this point is not experiencing corrosion

$$m_{point} := slope(Dates, Pit_{15}) \qquad m_{point} = -1.251 \qquad y_{point} := intercept(Dates, Pit_{15}) \qquad y_{point} = 3.264 \cdot 10^3$$

The 95% Confidence curves are calculated

$$Pit_{curve} := m_{point} \cdot year_{predict} + y_{point}$$

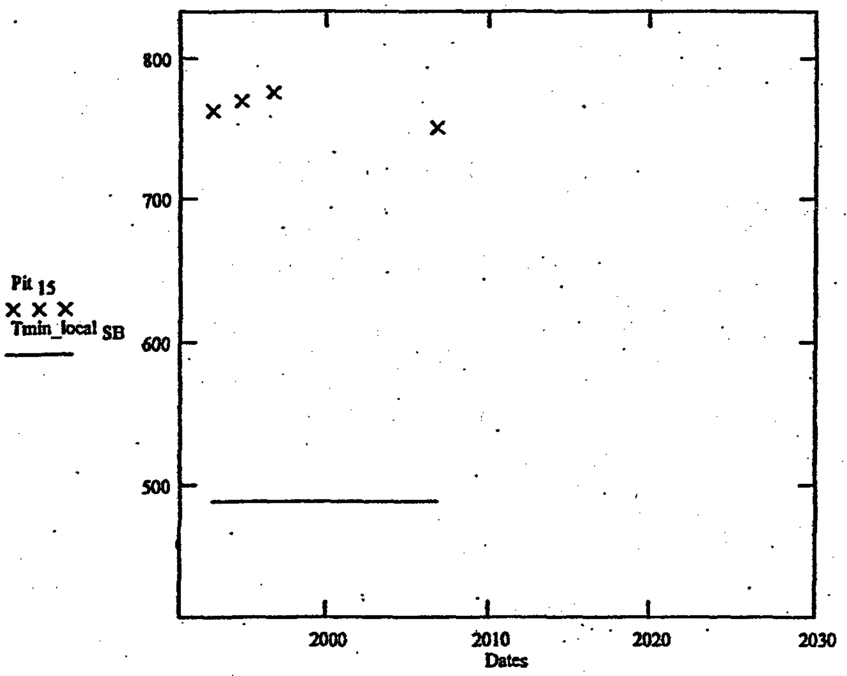
$$Pit_{actualmean} := mean(Dates) \qquad sum := \sum_{i} \left(Dates_d - mean(Dates)\right)^2$$

$$uppoint_f := Pit_{curve_f} \ldots$$
$$+ qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPit_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Pit_{actualmean}\right)^2}{sum}}$$

$$lopoint_f := Pit_{curve_f} \ldots$$
$$+ -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPit_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Pit_{actualmean}\right)^2}{sum}}\right]$$

ocal Tmin for this elevation in the Drywell $Tmin\_local_{SB_f} := 490$ (Ref.3.25)

Curve Fit For Pit 15 Projected to Plant End Of Life



$m_{point} = -1.251$

$lopoint_{22} = 644.413 \qquad year_{predict_{22}} = 2.029 \cdot 10^3$

Therefore based on regression model the above curve shows that this point will not corrode to below minimum required thickness by the plant end of life.

$m_{point} := \mathrm{slope}(Dates, Pit_{15})$ $m_{point} = -1.251$ $y_{point} := \mathrm{intercept}(Dates, Pit_{15})$ $y_{point} = 3.264 \cdot 10^3$

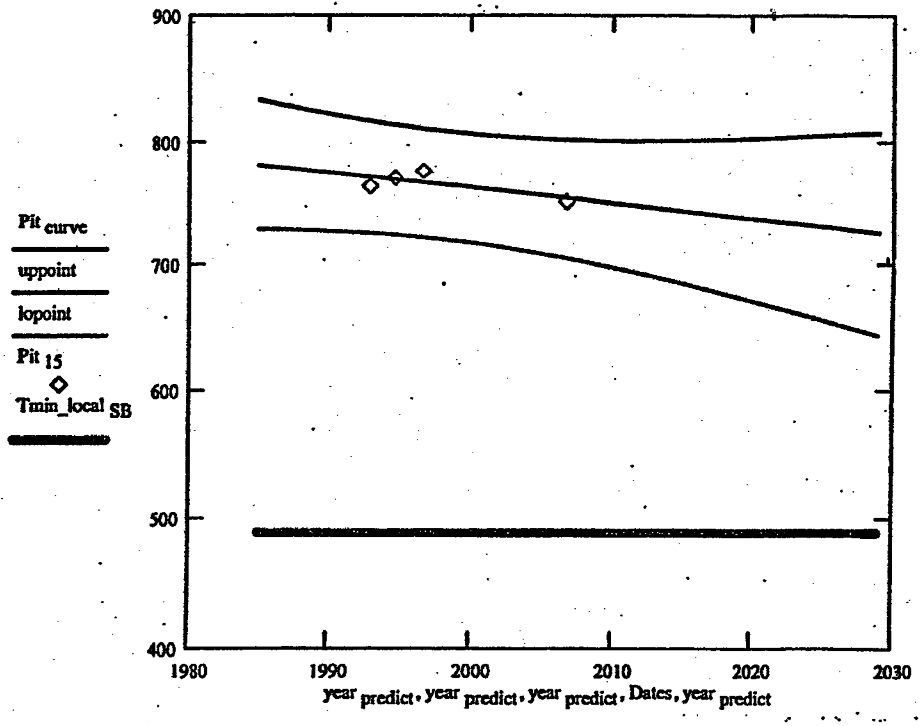
The 95% Confidence curves are calculated

$Pit_{curve} := m_{point} \cdot year_{predict} + y_{point}$

$Pit_{actualmean} := \mathrm{mean}(Dates)$ $sum := \sum_i \left(Dates_d - \mathrm{mean}(Dates)\right)^2$

$$uppoint_f := Pit_{curve_f} \cdots + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPit_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Pit_{actualmean}\right)^2}{sum}}$$

$$lopoint_f := Pit_{curve_f} \cdots + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPit_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Pit_{actualmean}\right)^2}{sum}}\right]$$



$m_{point} = -1.251$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Pit}\ 15_{3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 592.3$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 0.751$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^{3}$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -10.875$ mils per year

Appendix 2 - Sand Bed Elevation Bay 11A

October 2006 Data on 10/18/06

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB11A.txt")

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

$$\text{Points}_{49} = \begin{bmatrix} 0.905 & 0.832 & 0.829 & 0.803 & 0.83 & 0.812 & 0.737 \\ 0.797 & 0.825 & 0.834 & 0.822 & 0.858 & 0.783 & 0.795 \\ 0.72 & 0.766 & 0.858 & 0.731 & 0.762 & 0.669 & 0.764 \\ 0.739 & 1.047 & 1.057 & 0.806 & 0.761 & 0.821 & 0.849 \\ 0.843 & 1.09 & 1.104 & 0.879 & 0.879 & 0.854 & 0.817 \\ 0.741 & 0.897 & 0.818 & 0.89 & 0.907 & 0.833 & 0.826 \\ 0.875 & 0.869 & 0.923 & 0.886 & 0.871 & 0.81 & 0.842 \end{bmatrix}$$

$\text{Cells} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

For this location point 23, 24, 30, and 31 are located on a plug (reference 3.22) and have been omitted from the overall mean calculation for his location.

$\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 23)$ $\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 24)$

$\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 30)$ $\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 31)$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{Cells}, \text{No}_{\text{DataCells}})$

The thinnest point at this location is point 20 and is shown below

$\text{minpoint} := \min(\text{Points}_{49})$ $\text{minpoint} = 0.669$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 821.511$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 56.13$

Standard Error

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

$\text{Standard}_{error} = 8.019$

Skewness

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

$\text{Skewness} = -0.456$

Kurtosis

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

$\text{Kurtosis} = -0.272$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

$$\alpha := .05 \qquad T\alpha := \text{qt}\left[\left(1-\frac{\alpha}{2}\right), \text{No}_{\text{DataCells}}\right] \qquad T\alpha = 2.014$$

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 804.659$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 838.364$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

Distribution =

1
0
3
5
2
9
11
6
6
2
0
0

The mid points of the Bins are calculated

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

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

$$\text{normal}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_1, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

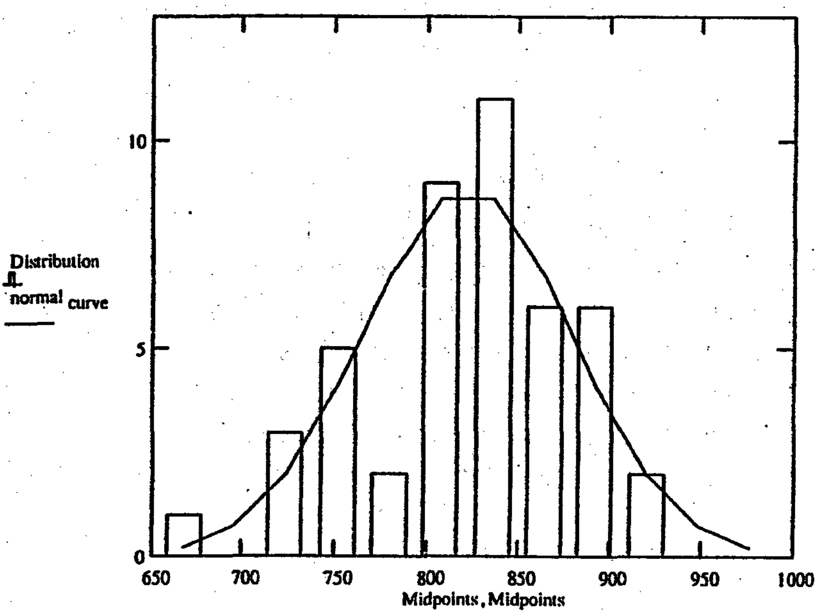
$$\text{normal}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{k+1}, \mu_{\text{actual}}, \sigma_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_k, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

$$\text{normal}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$$

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 821.511$

$\sigma_{actual} = 56.13$

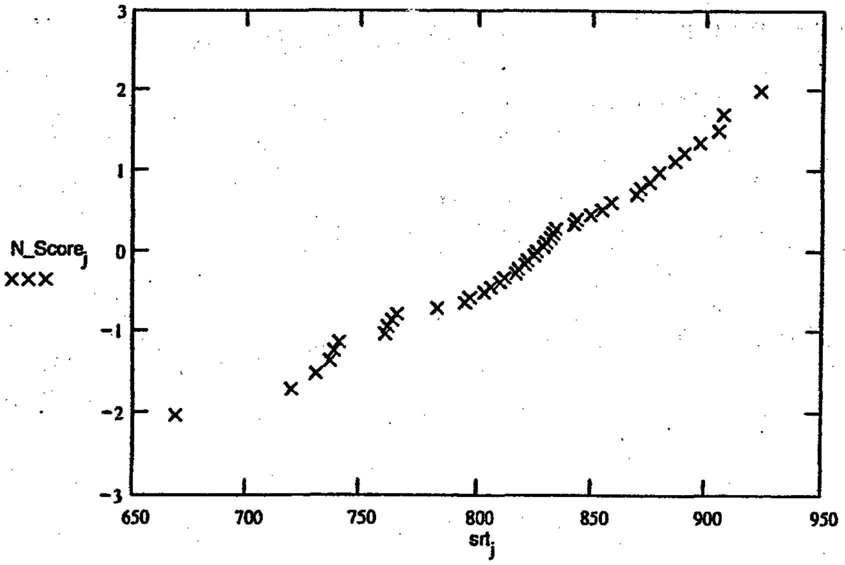
$\text{Standard}_{error} = 8.019$

$\text{Skewness} = -0.456$

$\text{Kurtosis} = -0.272$

$\text{Lower}_{95\%Con} = 804.659$ $\text{Upper}_{95\%Con} = 838.364$

Normal Probability Plot



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

Sandbed Location 11A Trend

$d := 0$

Data from the 1992, 1994 and 1996 is retrieved.

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB11A.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.93 & 0.824 & 0.831 & 0.809 & 0.807 & 0.817 & 0.751 \\ 0.816 & 0.827 & 0.834 & 0.823 & 0.851 & 0.787 & 0.799 \\ 0.733 & 0.762 & 0.866 & 0.762 & 0.771 & 0.677 & 0.764 \\ 0.745 & 0.252 & 0.147 & 0.809 & 0.767 & 0.805 & 0.846 \\ 0.841 & 1.082 & 1.111 & 0.886 & 0.881 & 0.901 & 0.778 \\ 0.755 & 0.896 & 0.804 & 0.805 & 0.898 & 0.844 & 0.823 \\ 0.847 & 0.9 & 0.902 & 0.924 & 0.923 & 0.828 & 0.884 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

For this location point 23, 24, 30, and 31 are located on a plug (reference 3.22) and have been omitted from the overall mean calculation for his location.

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 23\right)$ $\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 24\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 30\right)$ $\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 31\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

The thinnest point is captured

$\text{Point}_{20_d} := \text{Cells}_{19}$ $\text{Point}_{20} = 677$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB11A.txt")

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(9, 14, 1994)$

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.924 & 0.822 & 0.828 & 0.804 & 0.802 & 0.813 & 0.749 \\ 0.805 & 0.826 & 0.836 & 0.823 & 0.824 & 0.791 & 0.79 \\ 0.728 & 0.758 & 0.866 & 0.738 & 0.773 & 0.677 & 0.76 \\ 0.734 & 0.234 & 1.052 & 0.809 & 0.804 & 0.798 & 0.851 \\ 0.811 & 1.091 & 1.106 & 0.888 & 0.881 & 0.878 & 0.79 \\ 0.75 & 0.896 & 0.808 & 0.845 & 0.905 & 0.834 & 0.869 \\ 0.839 & 0.868 & 0.906 & 0.881 & 0.874 & 0.815 & 0.846 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}(\mathrm{Points}_{49}, 7)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

For this location point 23, 24, 30, and 31 are located on a plug (reference 3.22) and have been omitted from the overall mean calculation for his location.

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 23)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 24)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 30)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 31)$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}})$

The thinnest point is captured $\mathrm{Point}_{20_d} := \mathrm{Cells}_{19}$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$

$\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$

$$\mathrm{Standard}_{\mathrm{error}_d} := \frac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB11A.txt")

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(9, 16, 1996)$

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.884 & 0.828 & 0.824 & 0.797 & 0.83 & 0.806 & 0.737 \\ 0.787 & 0.856 & 0.83 & 0.827 & 0.834 & 0.845 & 0.788 \\ 0.711 & 0.758 & 0.856 & 0.724 & 0.756 & 0.668 & 0.8 \\ 0.828 & 0.828 & 1.043 & 0.843 & 0.851 & 0.815 & 0.814 \\ 0.848 & 1.026 & 1.149 & 0.905 & 0.875 & 0.901 & 0.759 \\ 0.79 & 0.941 & 0.809 & 0.892 & 0.904 & 0.802 & 0.8 \\ 0.884 & 0.832 & 0.813 & 0.934 & 0.918 & 0.917 & 0.917 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}(\mathrm{Points}_{49}, 7)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

For this location point 23, 24, 30, and 31 are located on a plug (reference 3.22) and have been omitted from the overall mean calculation for his location.

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 23)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 24)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 30)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 31)$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}})$

The thinnest point is captured $\mathrm{Point}_{20_d} := \mathrm{Cells}_{19}$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$ $\mathrm{Standard}_{\mathrm{error}_d} := \dfrac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB11A.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.905 & 0.832 & 0.829 & 0.803 & 0.83 & 0.812 & 0.737 \\ 0.797 & 0.825 & 0.834 & 0.822 & 0.858 & 0.783 & 0.795 \\ 0.72 & 0.766 & 0.858 & 0.731 & 0.762 & 0.669 & 0.764 \\ 0.739 & 1.047 & 1.057 & 0.806 & 0.761 & 0.821 & 0.849 \\ 0.843 & 1.09 & 1.104 & 0.879 & 0.879 & 0.854 & 0.817 \\ 0.741 & 0.897 & 0.818 & 0.89 & 0.907 & 0.833 & 0.826 \\ 0.875 & 0.869 & 0.923 & 0.886 & 0.871 & 0.81 & 0.842 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

For this location point 23, 24, 30, and 31 are located on a plug (reference 3.22) and have been omitted from the overall mean calculation for his location.

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 23\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 24\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 30\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 31\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

The thinnest point is captured

$\text{Point}_{20_d} := \text{Cells}_{19}$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993\cdot 10^3 \\ 1.995\cdot 10^3 \\ 1.997\cdot 10^3 \\ 2.007\cdot 10^3 \end{bmatrix} \qquad \text{Point}_{20} = \begin{bmatrix} 677 \\ 677 \\ 668 \\ 669 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 825.178 \\ 820.378 \\ 829.733 \\ 821.511 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 8.176 \\ 7.669 \\ 8.698 \\ 8.019 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 57.235 \\ 53.685 \\ 60.885 \\ 56.13 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}})$ $\qquad$ $\text{Total}_{\text{means}} = 4$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SST} = 53.413$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 48.771$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 4.642$$

$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2$ $\qquad$ $\text{DegreeFree}_{\text{reg}} := 1$ $\qquad$ $\text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$\text{MSE} = 24.385$ $\qquad$ $\text{MSR} = 4.642$ $\qquad$ $\text{MST} = 17.804$

$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}}$ $\qquad$ $\text{StGrand}_{\text{err}} = 4.938$

F Test for Corrosion

$\alpha := 0.05$

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

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.01$$

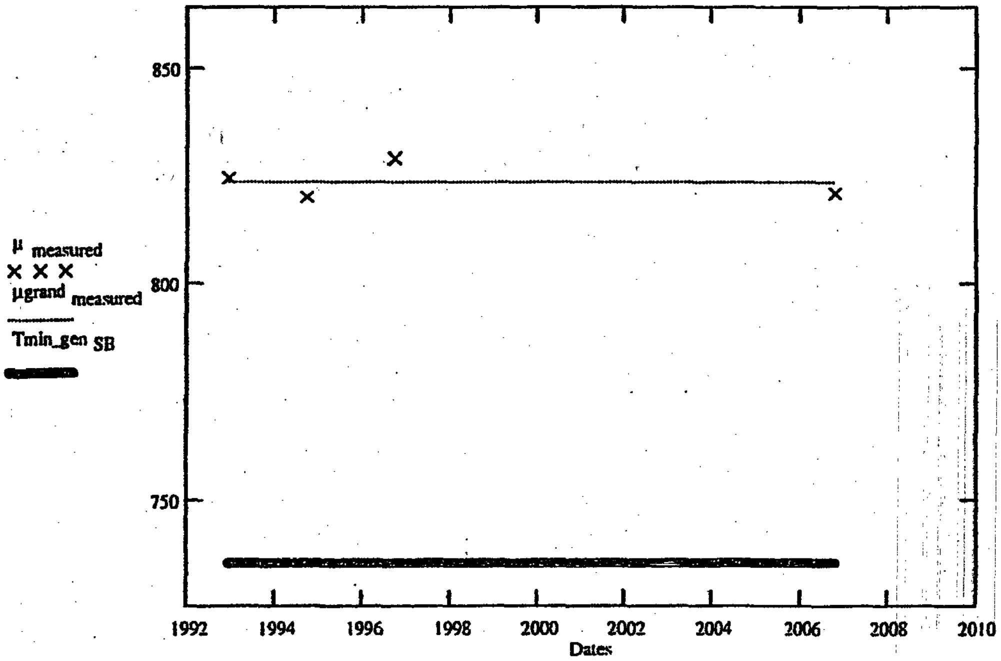
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean .

$i := 0 .. Total_{means} - 1$ $\qquad \mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$ $\qquad GrandStandard_{error_0} := \dfrac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 824.2$ $\qquad GrandStandard_{error} = 2.11$

To conservatively address the location, the apparent corrosion rate will be calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}\left(\text{Dates}, \mu_{\text{measured}}\right)$ $m_s = -0.201$ $y_b := \text{intercept}\left(\text{Dates}, \mu_{\text{measured}}\right)$ $y_b = 1.225 \cdot 10^3$

The 95% Confidence curves are calculated

$\alpha_t := 0.05$ $k := 2029 - 1985$ $f := 0 .. k - 1$

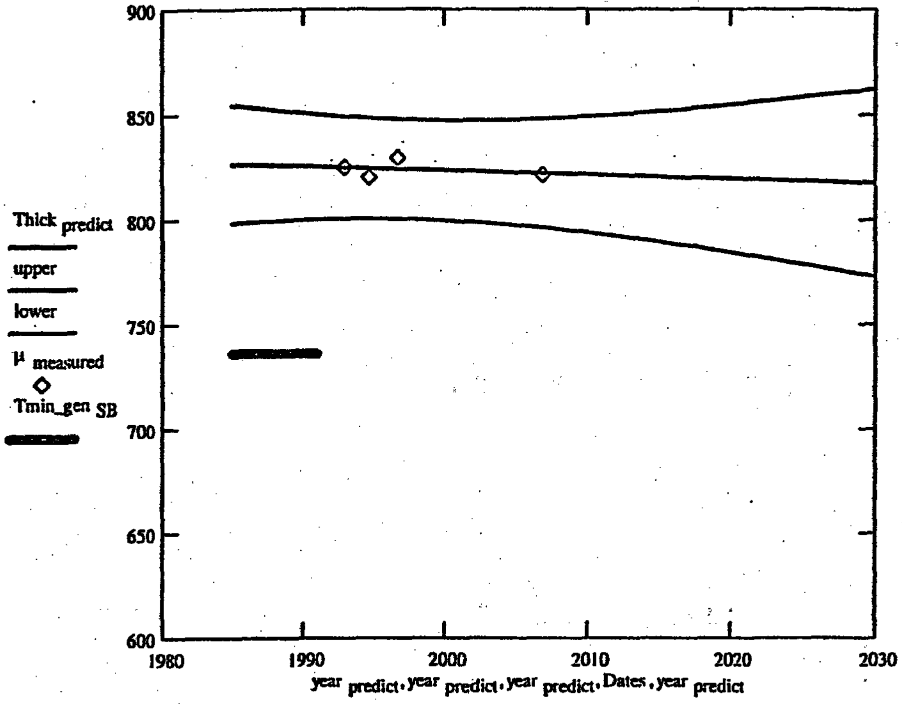
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2$ $\text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean(Dates)}$ $\text{sum} := \sum_i \left(\text{Dates}_d - \text{mean(Dates)}\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = -0.201$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2018 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 738.711$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

$\text{Point}\,20_d := \text{Cells}_{19}$

$\text{SST}_{\text{point}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{Point}\,20_i - \text{mean}(\text{Point}\,20)\right)^2$ $\text{SST}_{\text{point}} = 72.75$

$\text{SSE}_{\text{point}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{Point}\,20_i - \text{yhat}(\text{Dates}, \text{Point}\,20)_i\right)^2$ $\text{SSE}_{\text{point}} = 39.009$

$\text{SSR}_{\text{point}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \text{Point}\,20)_i - \text{mean}(\text{Point}\,20)\right)^2$ $\text{SSR}_{\text{point}} = 33.741$

$\text{MSE}_{\text{point}} := \frac{\text{SSE}_{\text{point}}}{\text{DegreeFree}_{\text{ss}}}$ $\text{MSR}_{\text{point}} := \frac{\text{SSR}_{\text{point}}}{\text{DegreeFree}_{\text{reg}}}$ $\text{MST}_{\text{point}} := \frac{\text{SST}_{\text{point}}}{\text{DegreeFree}_{\text{st}}}$

$\text{MSE}_{\text{point}} = 19.505$ $\text{MSR}_{\text{point}} = 33.741$ $\text{MST}_{\text{point}} = 24.25$

$\text{StPoint}_{\text{err}} := \sqrt{\text{MSE}_{\text{point}}}$ $\text{StPoint}_{\text{err}} = 4.416$

F Test for Corrosion

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

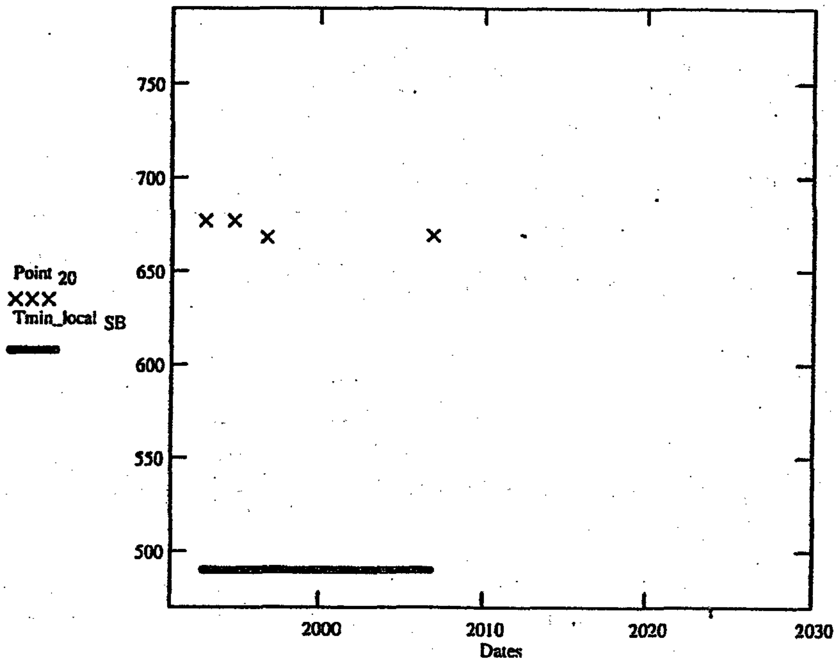
$F_{\text{ratio\_reg}} := \frac{F_{\text{actaul\_Reg}}}{F_{\text{critical\_reg}}}$

$F_{\text{ratio\_reg}} = 0.093$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 20 Projected to Plant End Of Life



Therefore based on regression model the above curve shows that this point will not corrode to below minimum required thickness by the plant end of life.

$m_{point} := \mathrm{slope}(Dates, Point_{20})$ $m_{point} = -0.541$ $y_{point} := \mathrm{intercept}(Dates, Point_{20})$ $y_{point} = 1.754 \cdot 10^3$

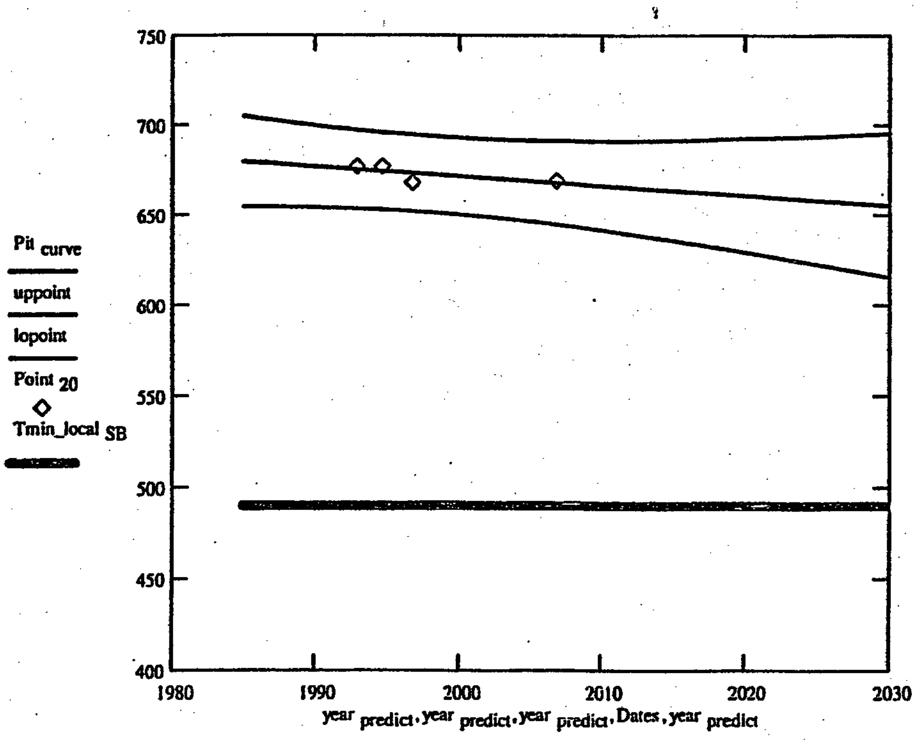
The 95% Confidence curves are calculated

$Pit_{curve} := m_{point} \cdot year_{predict} + y_{point}$

$Pit_{actualmean} := \mathrm{mean}(Dates)$ $sum := \sum_i \left(Dates_d - \mathrm{mean}(Dates)\right)^2$

$$uppoint_f := Pit_{curve_f} \ldots + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Pit_{actualmean}\right)^2}{sum}}$$

$$lopoint_f := Pit_{curve_f} \ldots + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Pit_{actualmean}\right)^2}{sum}}\right]$$



The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\mathrm{Rate}_{\mathrm{min\_observed}} := 6.9$$

$$\mathrm{Postulated}_{\mathrm{thickness}} := \mathrm{Point}_{20_3} - \mathrm{Rate}_{\mathrm{min\_observed}} \cdot (2029 - 2006)$$

$\mathrm{Postulated}_{\mathrm{thickness}} = 510.3$ which is greater than $\mathrm{Tmin\_local}_{\mathrm{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\mathrm{minpoint} = 0.669$ $\mathrm{year}_{\mathrm{predict}_{22}} = 2.029 \cdot 10^3$ $\mathrm{Tmin\_local}_{\mathrm{SB}_{22}} = 490$

$$\mathrm{required}_{\mathrm{rate.}} := \frac{\left(1000 \cdot \mathrm{minpoint} - \mathrm{Tmin\_local}_{\mathrm{SB}_{22}}\right)}{(2005 - 2029)}$$

$\mathrm{required}_{\mathrm{rate.}} = -7.458$ mils per year

Appendix 3 - Sandbed 11C
October 2006 Data
The data shown below was collected on 10/18/06

page := READPRN("U:\MSOFFICE\Drywell Program data\Oct 2006 Data\Sandbed\SB11C.txt")

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

$$\text{Points}_{49} = \begin{bmatrix} 0 & 0.771 & 0.803 & 0.912 & 0.767 & 0.858 & 0.886 \\ 1.056 & 1.046 & 0.984 & 1.094 & 1.036 & 1.118 & 1.029 \\ 1.073 & 1.113 & 1.002 & 0.935 & 0.942 & 0.888 & 0.853 \\ 0.837 & 0.836 & 0.79 & 0.874 & 0.834 & 0.846 & 0.838 \\ 0.85 & 0.825 & 0.869 & 0.889 & 0.833 & 0.866 & 0.875 \\ 0.856 & 0.84 & 0.864 & 0.829 & 0.872 & 0.876 & 0.844 \\ 0.861 & 0.877 & 0.879 & 0.885 & 0.88 & 0.849 & 0.876 \end{bmatrix}$$

$$\text{Cells} := \text{convert}\left(\text{Points}_{49}, 7\right) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

$$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

The thinnest point at this location is point 5 and is shown below

$$\text{minpoint} := \min(\text{Cells}) \qquad \text{minpoint} = 767$$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 898.25$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 89.898$

Standard Error

$$\text{Standard}_{error} := \frac{\sigma_{actual}}{\sqrt{\text{No}_{DataCells}}}$$ $\text{Standard}_{error} = 12.976$

Skewness

$$\text{Skewness} := \frac{(\text{No}_{DataCells}) \cdot \overrightarrow{\Sigma(\text{Cells} - \mu_{actual})^3}}{(\text{No}_{DataCells} - 1) \cdot (\text{No}_{DataCells} - 2) \cdot (\sigma_{actual})^3}$$ $\text{Skewness} = 1.149$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{DataCells} \cdot (\text{No}_{DataCells} + 1) \cdot \overrightarrow{\Sigma(\text{Cells} - \mu_{actual})^4}}{(\text{No}_{DataCells} - 1) \cdot (\text{No}_{DataCells} - 2) \cdot (\text{No}_{DataCells} - 3) \cdot (\sigma_{actual})^4} + -\frac{3 \cdot (\text{No}_{DataCells} - 1)^2}{(\text{No}_{DataCells} - 2) \cdot (\text{No}_{DataCells} - 3)}$$ $\text{Kurtosis} = 0.406$

Normal Probability Plot

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

$r_j := j + 1$ $$\text{rank}_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{\text{srt} = \text{srt}_j}\right) \cdot r}}{\Sigma\overrightarrow{\text{srt} = \text{srt}_j}}$$

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

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

Upper and Lower Confidence Values

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

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

$$Lower_{95\%Con} := \mu_{actual} - T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 872.161$$

$$Upper_{95\%Con} := \mu_{actual} + T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 924.339$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$Distribution = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 4 \\ 13 \\ 18 \\ 3 \\ 1 \\ 2 \\ 4 \\ 3 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

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

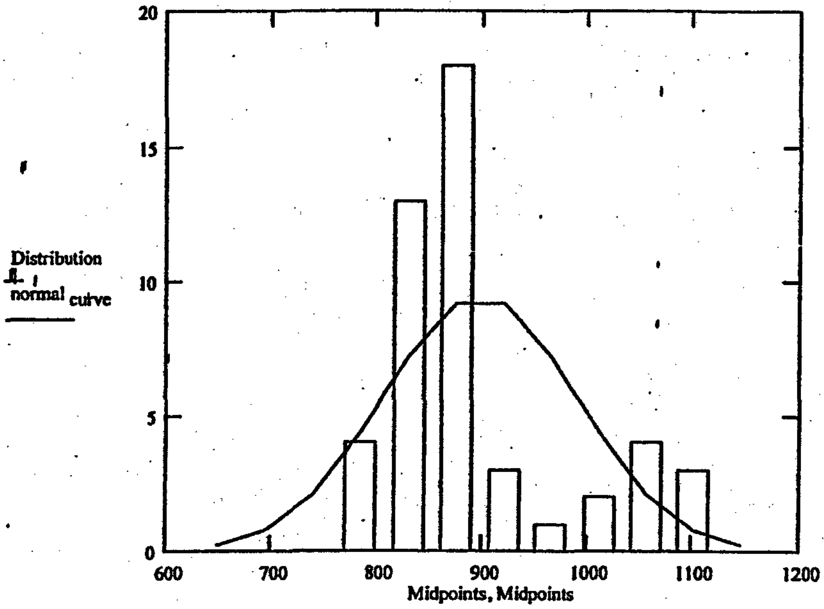
$$normal_{curve_k} := pnorm\left(Bins_{k+1}, \mu_{actual}, \sigma_{actual}\right) - pnorm\left(Bins_k, \mu_{actual}, \sigma_{actual}\right)$$

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

Results For 11C

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values.

Data Distribution



μ_{actual} = 898.25

σ_{actual} = 89.898

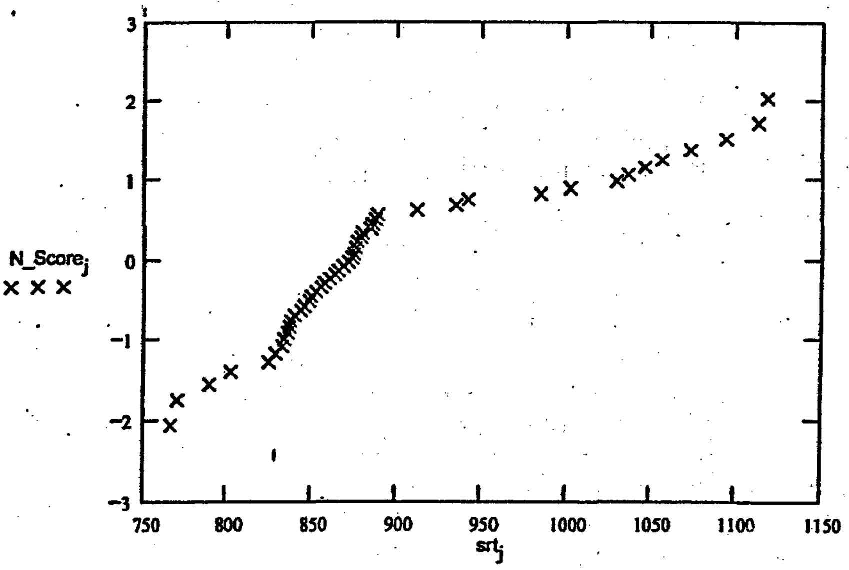
$Standard_{error}$ = 12.976

Skewness = 1.149

Kurtosis = 0.406

$Lower_{95\%Con}$ = 872.161 $Upper_{95\%Con}$ = 924.339

Normal Probability Plot



Past calculation have split this area at the top 3 rows and the bottom 4 rows (ref. 3.22) h In order to be consistent with past calculations this data will be split in two groups and analyzed. The entire data set will also be evaluated.

The two groups are named as follows: $StopCELL := 21$

$low_{points} := LOWROWS(Cells, No_{DataCells}, StopCELL)$ $high_{points} := TOPROWS(Cells, 49, StopCELL)$

Mean and Standard Deviation

$\mu low_{actual} := mean(low_{points})$ $\sigma low_{actual} := Stdev(low_{points})$

$\mu high_{actual} := mean(high_{points})$ $\sigma high_{actual} := Stdev(high_{points})$

Standard Error

$$Standardlow_{error} := \frac{\sigma low_{actual}}{\sqrt{length(low_{points})}} \qquad Standardhigh_{error} := \frac{\sigma high_{actual}}{\sqrt{length(high_{points})}}$$

Skewness

$Nolow_{DataCells} := length(low_{points})$

$$Skewness_{low} := \frac{(Nolow_{DataCells}) \cdot \Sigma\overrightarrow{(low_{points} - \mu low_{actual})^{3}}}{(Nolow_{DataCells} - 1) \cdot (Nolow_{DataCells} - 2) \cdot (\sigma low_{actual})^{3}}$$

$Nohigh_{DataCells} := length(high_{points})$

$$Skewness_{high} := \frac{(Nohigh_{DataCells}) \cdot \Sigma\overrightarrow{(high_{points} - \mu high_{actual})^{3}}}{(Nohigh_{DataCells} - 1) \cdot (Nohigh_{DataCells} - 2) \cdot (\sigma high_{actual})^{3}}$$

Kurtosis

$$Kurtosis_{low} := \frac{Nolow_{DataCells}\cdot\left(Nolow_{DataCells}+1\right)\cdot\overrightarrow{\Sigma\left(low_{points}-\mu low_{actual}\right)^{4}}}{\left(Nolow_{DataCells}-1\right)\cdot\left(Nolow_{DataCells}-2\right)\cdot\left(Nolow_{DataCells}-3\right)\cdot\left(\sigma low_{actual}\right)^{4}} \cdots$$

$$+ -\frac{3\cdot\left(Nolow_{DataCells}-1\right)^{2}}{\left(Nolow_{DataCells}-2\right)\cdot\left(Nolow_{DataCells}-3\right)}$$

$$Kurtosis_{high} := \frac{Nohigh_{DataCells}\cdot\left(Nohigh_{DataCells}+1\right)\cdot\overrightarrow{\Sigma\left(high_{points}-\mu high_{actual}\right)^{4}}}{\left(Nohigh_{DataCells}-1\right)\cdot\left(Nohigh_{DataCells}-2\right)\cdot\left(Nohigh_{DataCells}-3\right)\cdot\left(\sigma high_{actual}\right)^{4}} \cdots$$

$$+ -\frac{3\cdot\left(Nohigh_{DataCells}-1\right)^{2}}{\left(Nohigh_{DataCells}-2\right)\cdot\left(Nohigh_{DataCells}-3\right)}$$

Normal Probability Plot - Low points

$l := 0 .. last\left(low_{points}\right) \qquad srt_{low} := sort\left(low_{points}\right)$

$$L_{l} := l + 1 \qquad rank_{low_{l}} := \frac{\Sigma\overrightarrow{\left(\overrightarrow{srt_{low}=srt_{low_{l}}}\right)\cdot L}}{\Sigma\overrightarrow{srt_{low}=srt_{low_{l}}}} \qquad p_{low_{l}} := \frac{rank_{low_{l}}}{rows\left(low_{points}\right)+1}$$

$x := 1 \qquad N\_Score_{low_{l}} := root\left[cnorm(x) - \left(p_{low_{l}}\right), x\right]$

Normal Probability Plot - High points

$h := 0 .. last\left(high_{points}\right) \qquad srt_{high} := sort\left(high_{points}\right)$

$$H_{h} := h + 1 \qquad rank_{high_{h}} := \frac{\Sigma\overrightarrow{\left(\overrightarrow{srt_{high}=srt_{high_{h}}}\right)\cdot H}}{\Sigma\overrightarrow{srt_{high}=srt_{high_{h}}}} \qquad p_{high_{h}} := \frac{rank_{high_{h}}}{rows\left(high_{points}\right)+1}$$

$x := 1 \qquad N\_Score_{high_{h}} := root\left[cnorm(x) - \left(p_{high_{h}}\right), x\right]$

Upper and Lower Confidence Values

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

$$\text{Lowerhigh}_{95\%\text{Con}} := \mu\text{high}_{\text{actual}} - T\alpha \cdot \frac{\sigma\text{high}_{\text{actual}}}{\sqrt{\text{Nohigh}_{\text{DataCells}}}}$$

$$\text{Upperhigh}_{95\%\text{Con}} := \mu\text{high}_{\text{actual}} + T\alpha \cdot \frac{\sigma\text{high}_{\text{actual}}}{\sqrt{\text{Nohigh}_{\text{DataCells}}}}$$

$$\text{Lowerlow}_{95\%\text{Con}} := \mu\text{low}_{\text{actual}} - T\alpha \cdot \frac{\sigma\text{low}_{\text{actual}}}{\sqrt{\text{Nolow}_{\text{DataCells}}}}$$

$$\text{Upperlow}_{95\%\text{Con}} := \mu\text{low}_{\text{actual}} + T\alpha \cdot \frac{\sigma\text{low}_{\text{actual}}}{\sqrt{\text{Nolow}_{\text{DataCells}}}}$$

Graphical Representation of Low Points

$\text{Bins}_{\text{low}} := \text{Make}_{\text{bins}}\left(\mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$

$\text{Distribution}_{\text{low}} := \text{hist}\left(\text{Bins}_{\text{low}}, \text{low}_{\text{points}}\right)$

$$\text{Distribution}_{\text{low}} = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 2 \\ 6 \\ 4 \\ 3 \\ 8 \\ 3 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

$$\text{normallow}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_{\text{low}_1}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$$

$$\text{normallow}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{\text{low}_{k+1}}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_{\text{low}_k}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$$

$$\text{normallow}_{\text{curve}} := \text{Nolow}_{\text{DataCells}} \cdot \text{normallow}_{\text{curve}}$$

Graphical Representation of High Points

$$\mathrm{Bins}_{high} := \mathrm{Make}_{bins}\left(\mu high_{actual}, \sigma high_{actual}\right)$$

$$\mathrm{Distribution}_{high} := \mathrm{hist}\left(\mathrm{Bins}_{high}, high_{points}\right)$$

$$\mathrm{Distribution}_{high} = \begin{pmatrix} 0 \\ 0 \\ 2 \\ 2 \\ 4 \\ 3 \\ 2 \\ 4 \\ 4 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

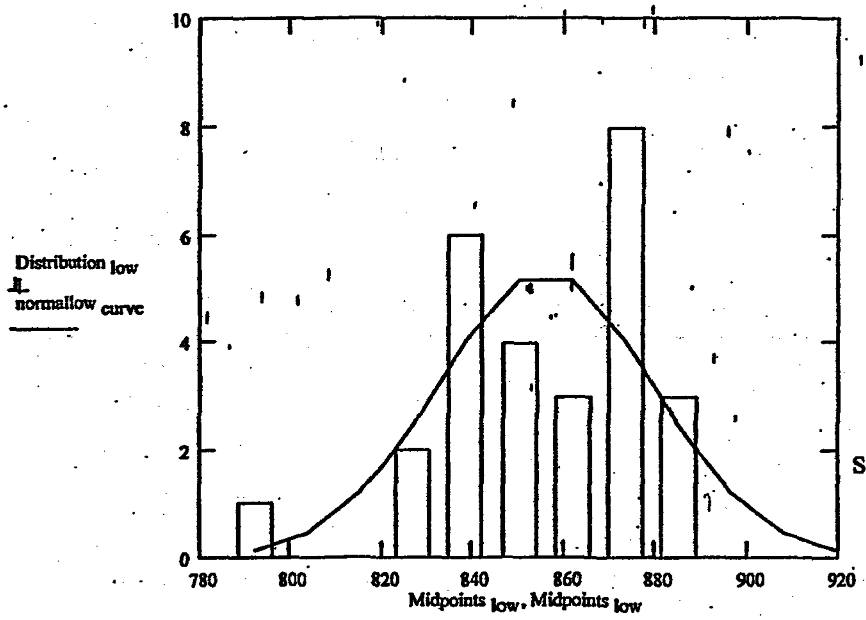
$$k := 0 .. 11 \qquad \mathrm{Midpoints}_{high_k} := \frac{\left(\mathrm{Bins}_{high_k} + \mathrm{Bins}_{high_{k+1}}\right)}{2}$$

$$\mathrm{normalhigh}_{curve_0} := \mathrm{pnorm}\left(\mathrm{Bins}_{high_1}, \mu high_{actual}, \sigma high_{actual}\right)$$

$$\mathrm{normalhigh}_{curve_k} := \mathrm{pnorm}\left(\mathrm{Bins}_{high_{k+1}}, \mu high_{actual}, \sigma high_{actual}\right) - \mathrm{pnorm}\left(\mathrm{Bins}_{high_k}, \mu high_{actual}, \sigma high_{actual}\right)$$

$$\mathrm{normalhigh}_{curve} := \mathrm{Nohigh}_{DataCells} \cdot \mathrm{normalhigh}_{curve}$$

Results For Sandbed 11C Thinner Points



$\mu low_{actual} = 856.037$

$\sigma low_{actual} = 23.157$

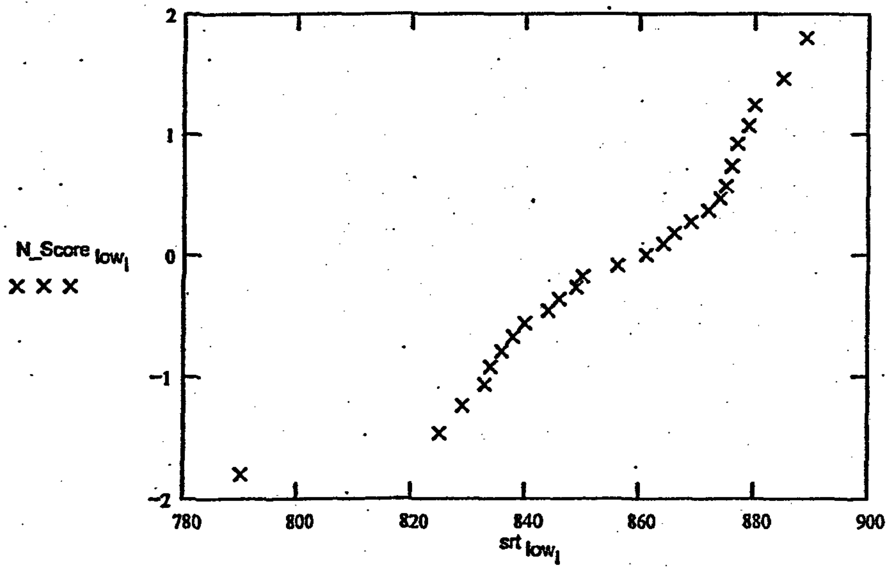
$Kurtosis_{low} = 0.784$

$Skewness_{low} = -0.837$

$Standardlow_{error} = 4.457$

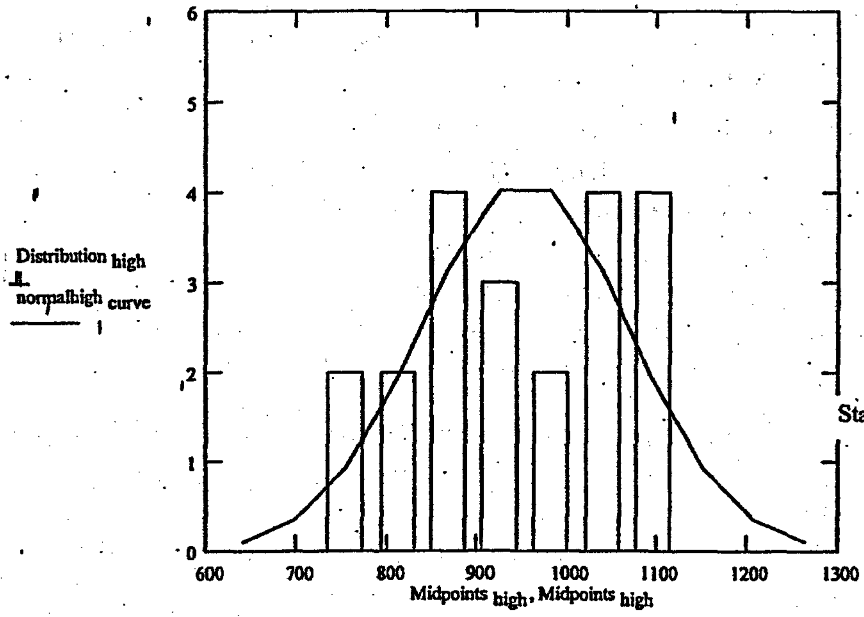
$Nolow_{DataCells} = 27$

$Lowerlow_{95\%Con} = 847.076$ $Upperlow_{95\%Con} = 864.998$



The above plots indicates that the thinner area is more normally distributed than the entire population.

Results Sandbed 11C Thicker Points



$\mu high_{actual} = 952.524$

$\sigma high_{actual} = 113.121$

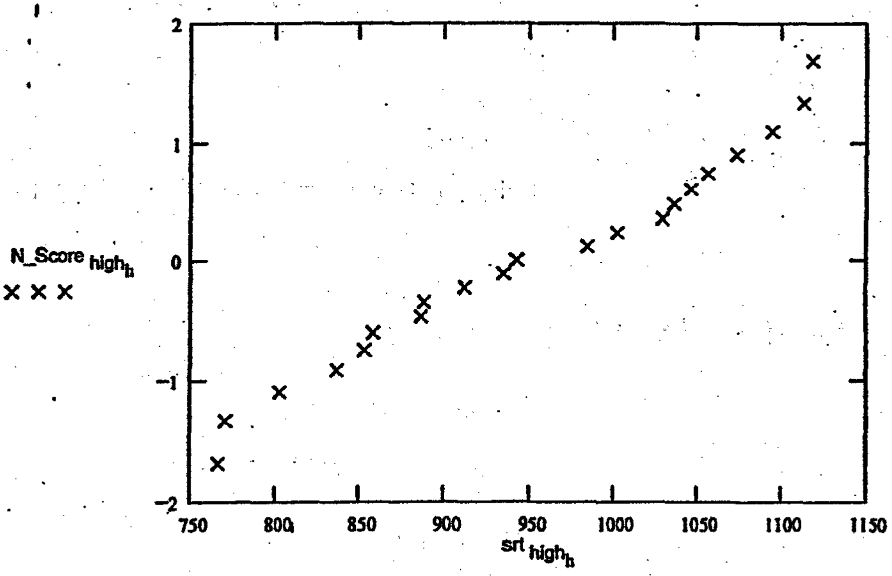
$Skewness_{high} = -0.129$

$Kurtosis_{high} = -1.252$

$Standardhigh_{error} = 24.685$

$Nohigh_{DataCells} = 21$

$Lower_{95\%Con} = 872.161$ $Upper_{95\%Con} = 924.339$



The above plots indicates that the thicker areas are normally distributed.

Sandbed 11C

Data from 1992 to 2006 is retrieved. $d := 0$

For Dec 31 1992

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\DATA ONLY\SB11C.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(12, 31, 1992)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.941 & 0.839 & 0.806 & 0.917 & 0.776 & 0.86 & 0.926 \\ 1.105 & 1.044 & 0.997 & 0.975 & 1.076 & 1.12 & 1.045 \\ 1.091 & 1.175 & 1.018 & 0.942 & 0.94 & 0.874 & 0.896 \\ 0.847 & 0.845 & 0.794 & 0.833 & 0.838 & 0.838 & 0.87 \\ 0.845 & 0.829 & 0.863 & 0.87 & 0.85 & 0.85 & 0.827 \\ 0.941 & 0.817 & 0.858 & 0.839 & 0.876 & 0.879 & 0.854 \\ 0.603 & 0.893 & 0.905 & 0.901 & 0.913 & 0.877 & 0.845 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$ $\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 43)$

The thinnest point is captured $\text{Point}_{5_d} := \text{nnn}_4$ $\text{Point}_5 = 776$

The two groups are named as follows: $\text{StopCELL} := 21$ $\text{No}_{\text{Cells}} := \text{length}(\text{Cells})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$ $\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$ $\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\mu_{\text{measured}} = 908.83$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$ $\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$ $\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$\text{Standardhigh}_{\text{error}_d} := \dfrac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$ $\text{Standardlow}_{\text{error}_d} := \dfrac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$

For 1994 $d := d + 1$

$page := READPRN(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Sept.1994 Data\textbackslash sandbed\textbackslash DATA ONLY\textbackslash SB11C.txt"})$

$Points_{49} := showcells(page, 7, 0)$ $Dates_d := Day_{year}(9, 26, 1994)$

Data

$$Points_{49} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0.855 & 0.866 \\ 0 & 0 & 1.042 & 1.095 & 1.036 & 1.093 & 1.032 \\ 1.042 & 1.085 & 0.945 & 0.938 & 0.938 & 0.895 & 0.889 \\ 0.836 & 0.846 & 0.795 & 0.828 & 0.833 & 0.843 & 0.869 \\ 0.823 & 0.842 & 0.873 & 0.872 & 0.837 & 0.822 & 0.879 \\ 0.855 & 0.836 & 0.862 & 0.824 & 0.872 & 0.857 & 0.823 \\ 0.86 & 0.874 & 0.899 & 0.876 & 0.88 & 0.84 & 0.851 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$

The thinnest point is captured $Point5_d := nnn_4$

The two groups are named as follows: $StopCELL := 21$ $No_{Cells} := length(nnn)$

$low_{points} := LOWROWS(nnn, No_{Cells}, StopCELL)$ $high_{points} := TOPROWS(nnn, No_{Cells}, StopCELL)$

$No_{lowCells} := length(low_{points})$ $No_{highCells} := length(high_{points})$

$Cells := deletezero_{cells}(nnn, No_{Cells})$

$low_{points} := deletezero_{cells}(low_{points}, No_{lowCells})$

$high_{points} := deletezero_{cells}(high_{points}, No_{highCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$\mu high_{measured_d} := mean(high_{points})$ $\mu low_{measured_d} := mean(low_{points})$

$\sigma high_{measured_d} := Stdev(high_{points})$ $\sigma low_{measured_d} := Stdev(low_{points})$

$Standardhigh_{error_d} := \dfrac{\sigma high_{measured_d}}{\sqrt{length(high_{points})}}$ $Standardlow_{error_d} := \dfrac{\sigma low_{measured_d}}{\sqrt{length(low_{points})}}$

For 1996 $d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\DATA ONLY\SB11C.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(9, 23, 1996)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.038 & 0.928 & 1.002 & 0.942 & 1.14 & 1.077 & 1.035 \\ 1.058 & 1.195 & 1.075 & 1.168 & 1.16 & 1.112 & 0.962 \\ 1.031 & 1.104 & 1.169 & 0.983 & 0.965 & 0.889 & 0.845 \\ 0.855 & 0.903 & 0.85 & 0.786 & 0.913 & 0.778 & 0.839 \\ 0.869 & 0.927 & 0.922 & 0.894 & 0.896 & 0.91 & 0.837 \\ 0.928 & 0.878 & 0.874 & 0.878 & 0.862 & 0.915 & 0.906 \\ 0.917 & 0.924 & 0.899 & 0.89 & 0.874 & 0.884 & 0.917 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

The thinnest point is captured $\text{Point}_{5_d} := \text{nnn}_4$

The two groups are named as follows: $\text{StopCELL} := 21$ $\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$ $\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$ $\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$ $\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$ $\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$ $\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$\text{Standardhigh}_{\text{error}_d} := \dfrac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$ $\text{Standardlow}_{\text{error}_d} := \dfrac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Oct 2006 Data\Sandbed\SB11C.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 18, 2006)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0 & 0.771 & 0.803 & 0.912 & 0.767 & 0.858 & 0.886 \\ 1.056 & 1.046 & 0.984 & 1.094 & 1.036 & 1.118 & 1.029 \\ 1.073 & 1.113 & 1.002 & 0.935 & 0.942 & 0.888 & 0.853 \\ 0.837 & 0.836 & 0.79 & 0.874 & 0.834 & 0.846 & 0.838 \\ 0.85 & 0.825 & 0.869 & 0.889 & 0.833 & 0.866 & 0.875 \\ 0.856 & 0.84 & 0.864 & 0.829 & 0.872 & 0.876 & 0.844 \\ 0.861 & 0.877 & 0.879 & 0.885 & 0.88 & 0.849 & 0.876 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

The thinnest point is captured

$\text{Point}_{5_d} := \text{nnn}_4$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{high}_{\text{points}} := \text{TOPROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{No}_{\text{lowCells}} := \text{length}\left(\text{low}_{\text{points}}\right)$

$\text{No}_{\text{highCells}} := \text{length}\left(\text{high}_{\text{points}}\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{Cells}}\right)$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}}\right)$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{high}_{\text{points}}, \text{No}_{\text{highCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}\left(\text{high}_{\text{points}}\right)$

$\mu\text{low}_{\text{measured}_d} := \text{mean}\left(\text{low}_{\text{points}}\right)$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}\left(\text{high}_{\text{points}}\right)$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}\left(\text{low}_{\text{points}}\right)$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{high}_{\text{points}}\right)}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{low}_{\text{points}}\right)}}$$

Below are the results

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^{3} \\ 1.995 \cdot 10^{3} \\ 1.997 \cdot 10^{3} \\ 2.007 \cdot 10^{3} \end{bmatrix} \qquad \text{Point}_{5} = \begin{bmatrix} 776 \\ 0 \\ 1.14 \cdot 10^{3} \\ 767 \end{bmatrix}$$

$$\text{Standard}_{\text{error}} = \begin{bmatrix} 13.414 \\ 11.742 \\ 15.102 \\ 12.843 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 908.83 \\ 894.238 \\ 951.082 \\ 898.25 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 93.897 \\ 82.191 \\ 105.715 \\ 89.898 \end{bmatrix}$$

$$\text{Standardhigh}_{\text{error}} = \begin{bmatrix} 23.832 \\ 23.365 \\ 21.44 \\ 24.623 \end{bmatrix}$$

$$\mu\text{high}_{\text{measured}} = \begin{bmatrix} 969.667 \\ 982.214 \\ 1.042 \cdot 10^{3} \\ 958.3 \end{bmatrix} \qquad \sigma\text{high}_{\text{measured}} = \begin{bmatrix} 109.211 \\ 87.424 \\ 98.251 \\ 112.838 \end{bmatrix}$$

$$\mu\text{low}_{\text{measured}} = \begin{bmatrix} 859.692 \\ 850.25 \\ 883.036 \\ 855.357 \end{bmatrix} \qquad \sigma\text{low}_{\text{measured}} = \begin{bmatrix} 32.576 \\ 23.629 \\ 38.902 \\ 23.008 \end{bmatrix} \qquad \text{Standardlow}_{\text{error}} = \begin{bmatrix} 6.389 \\ 4.466 \\ 7.352 \\ 4.348 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}\left(\mu_{\text{measured}}\right)$ $\text{Total}_{\text{means}} = 4$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2$$

$$\text{SST}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{mean}\left(\mu\text{low}_{\text{measured}}\right)\right)^2$$

$$\text{SST}_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{mean}\left(\mu\text{high}_{\text{measured}}\right)\right)^2$$

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

$$\text{SSE}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu\text{low}_{\text{measured}}\right)_i\right)^2$$

$$\text{SSE}_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu\text{high}_{\text{measured}}\right)_i\right)^2$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2$$

$$\text{SSR}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu\text{low}_{\text{measured}}\right)_i - \text{mean}\left(\mu\text{low}_{\text{measured}}\right)\right)^2$$

$$\text{SSR}_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu\text{high}_{\text{measured}}\right)_i - \text{mean}\left(\mu\text{high}_{\text{measured}}\right)\right)^2$$

$DegreeFree_{ss} := Total_{means} - 2$ $DegreeFree_{reg} := 1$ $DegreeFree_{st} := Total_{means} - 1$

$MSE := \frac{SSE}{DegreeFree_{ss}}$ $MSE_{low} := \frac{SSE_{low}}{DegreeFree_{ss}}$ $MSE_{high} := \frac{SSE_{high}}{DegreeFree_{ss}}$

$Standard_{error} := \sqrt{MSE}$ $Standard_{lowerror} := \sqrt{MSE_{low}}$ $Standard_{higherror} := \sqrt{MSE_{high}}$

$MSR := \frac{SSR}{DegreeFree_{reg}}$ $MSR_{low} := \frac{SSR_{low}}{DegreeFree_{reg}}$ $MSR_{high} := \frac{SSR_{high}}{DegreeFree_{reg}}$

$MST := \frac{SST}{DegreeFree_{st}}$ $MST_{low} := \frac{SST_{low}}{DegreeFree_{st}}$ $MST_{high} := \frac{SST_{high}}{DegreeFree_{st}}$

Test the means with all points

F Test for Corrosion

$\alpha := 0.05$ $F_{actaul\_Reg} := \frac{MSR}{MSE}$

$F_{critical\_reg} := qF(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss})$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 4.446 \cdot 10^{-3}$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

the low points

F Test for Corrosion

$$F_{\mathrm{actaul\_Reg.low}} := \frac{\mathrm{MSR}_{\mathrm{low}}}{\mathrm{MSE}_{\mathrm{low}}}$$

$$F_{\mathrm{critical\_reg}} := \mathrm{qF}\left(1 - \alpha, \mathrm{DegreeFree}_{\mathrm{reg}}, \mathrm{DegreeFree}_{\mathrm{ss}}\right)$$

$$F_{\mathrm{ratio\_reg.low}} := \frac{F_{\mathrm{actaul\_Reg.low}}}{F_{\mathrm{critical\_reg}}}$$

$$F_{\mathrm{ratio\_reg.low}} = 1.892 \cdot 10^{-3}$$

The conclusion can not be made that the low points best fit the regression model. The figure below provides a trend of the data and the grandmean

Test the high points

F Test for Corrosion

$$F_{\mathrm{actaul\_Reg.high}} := \frac{\mathrm{MSR}_{\mathrm{high}}}{\mathrm{MSE}_{\mathrm{high}}}$$

$$F_{\mathrm{critical\_reg}} := \mathrm{qF}\left(1 - \alpha, \mathrm{DegreeFree}_{\mathrm{reg}}, \mathrm{DegreeFree}_{\mathrm{ss}}\right)$$

$$F_{\mathrm{ratio\_reg.high}} := \frac{F_{\mathrm{actaul\_Reg.high}}}{F_{\mathrm{critical\_reg}}}$$

$$F_{\mathrm{ratio\_reg.high}} = 0.012$$

herefore no conclusion can be made as to whether the data best fits the regression model. The figure elow provides a trend of the data and the grandmean wing will plot the results for the overall mean, the mean of thinner points, and the mean of thicker it.

$i := 0 .. Total_{means} - 1$

$\mu grand_{measured_i} := mean(\mu_{measured})$ $\sigma grand_{measured} := Stdev(\mu_{measured})$

$$GrandStandard_{error} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$$

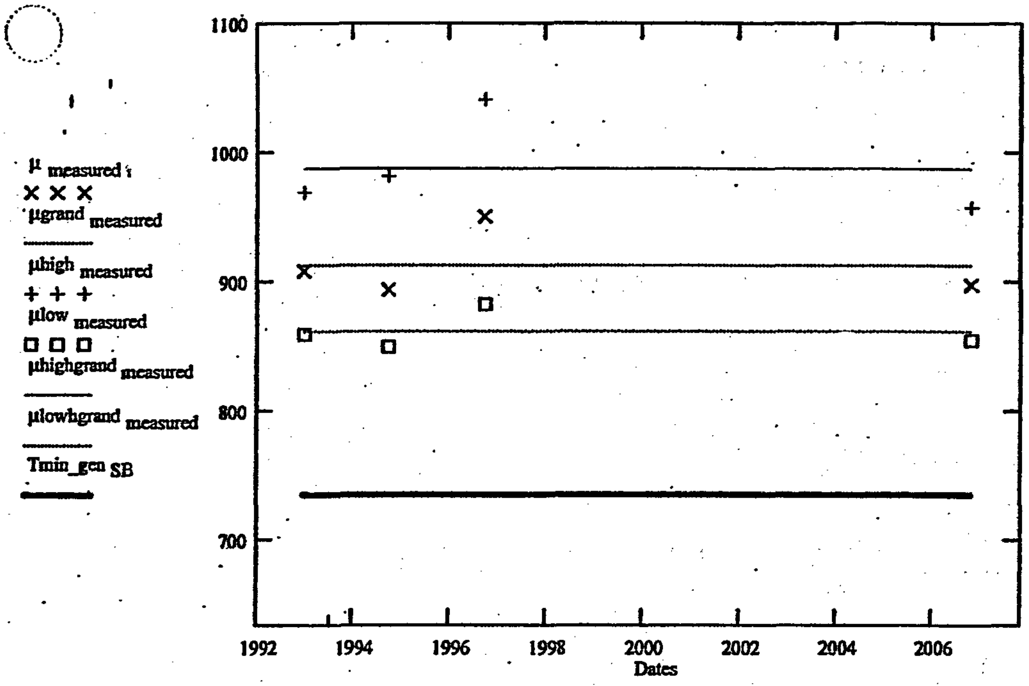
$\sigma grand_{lowmeasured} := Stdev(\mu low_{measured})$ $\mu lowhgrand_{measured_i} := mean(\mu low_{measured})$

$$GrandStandard_{lowerror} := \frac{\sigma grand_{lowmeasured}}{\sqrt{Total_{means}}}$$

$\sigma grand_{highmeasured} := Stdev(\mu high_{measured})$ $\mu highgrand_{measured_i} := mean(\mu high_{measured})$

$$GrandStandard_{higherror} := \frac{\sigma grand_{highmeasured}}{\sqrt{Total_{means}}}$$

e minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)



$\mu grand_{measured_0} = 913.1$ $GrandStandard_{error} = 13.029$

$mean(\mu low_{measured}) = 862.084$ $GrandStandard_{lowerror} = 7.246$

$mean(\mu high_{measured}) = 987.998$ $GrandStandard_{higherror} = 18.59$

The F Test indicates that the regression model does not hold for any of the data sets. However for conservatism the slopes and 95% confidence curves are generated for all three cases.

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

$m_{\text{lows}} := \text{slope}(\text{Dates}, \mu\text{low}_{\text{measured}})$ $y_{\text{lowb}} := \text{intercept}(\text{Dates}, \mu\text{low}_{\text{measured}})$

$m_{\text{highs}} := \text{slope}(\text{Dates}, \mu\text{high}_{\text{measured}})$ $y_{\text{highb}} := \text{intercept}(\text{Dates}, \mu\text{high}_{\text{measured}})$

$\alpha_t := 0.05 \quad k := 23 \quad f := 0..k-1$

$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2$

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

$\text{Thick}_{\text{lowpredict}} := m_{\text{lows}} \cdot \text{year}_{\text{predict}} + y_{\text{lowb}}$

$\text{Thick}_{\text{highpredict}} := m_{\text{highs}} \cdot \text{year}_{\text{predict}} + y_{\text{highb}}$

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

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

For the entire grid

$$\mathrm{upper}_f := \mathrm{Thick}_{\mathrm{predict}_f} \ldots$$

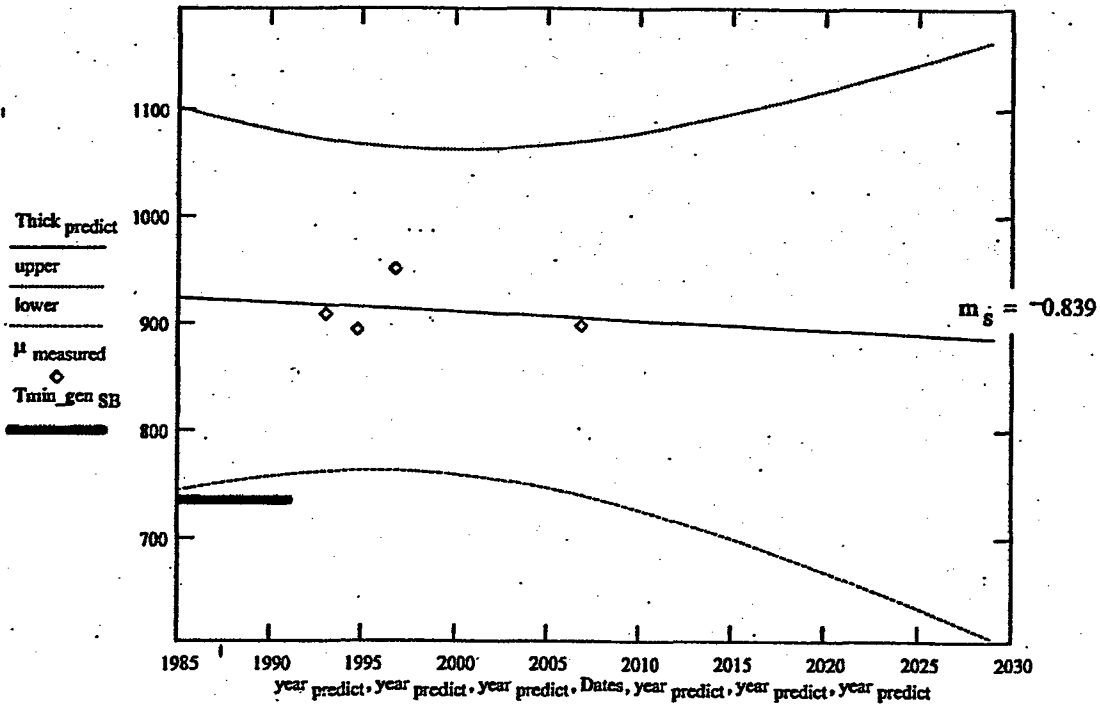
$$+\ \mathrm{qt}\left(1 - \frac{\alpha_t}{2}, \mathrm{Total}_{\mathrm{means}} - 2\right) \cdot \mathrm{Standard}_{\mathrm{error}} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{\mathrm{predict}_f} - \mathrm{Thick}_{\mathrm{actualmean}}\right)^2}{\mathrm{sum}}}$$

$$\mathrm{lower}_f := \mathrm{Thick}_{\mathrm{predict}_f} \ldots$$

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

General area Tmin for this elevation in the Drywell

(Ref. 3.25)



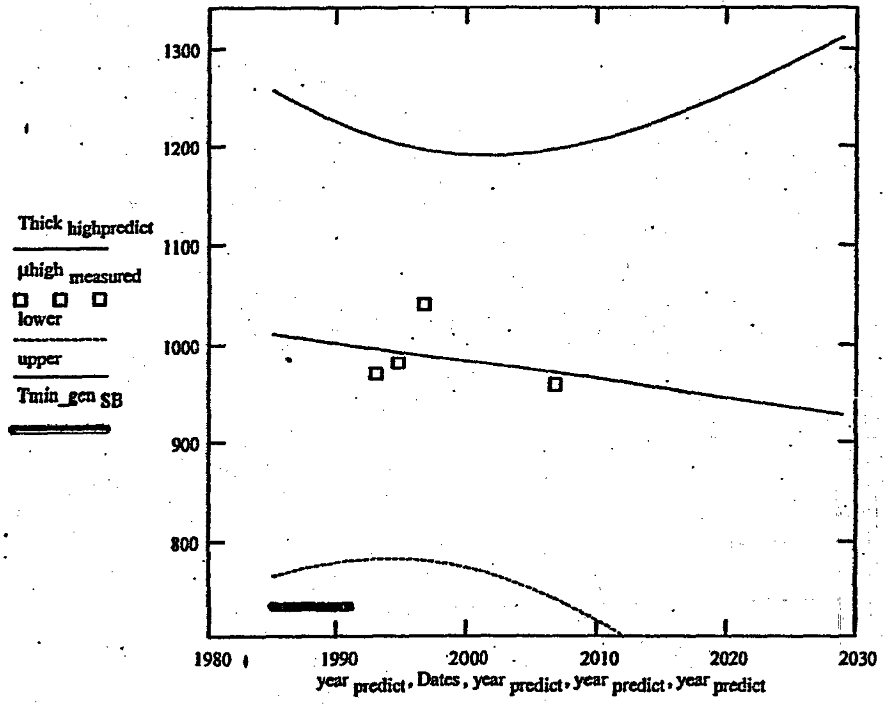
For the points which are thicker

$$\mathrm{upper}_f := \mathrm{Thick}_{\mathrm{highpredict}_f} \ldots$$

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

$$\mathrm{lower}_f := \mathrm{Thick}_{\mathrm{highpredict}_f} \ldots$$

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

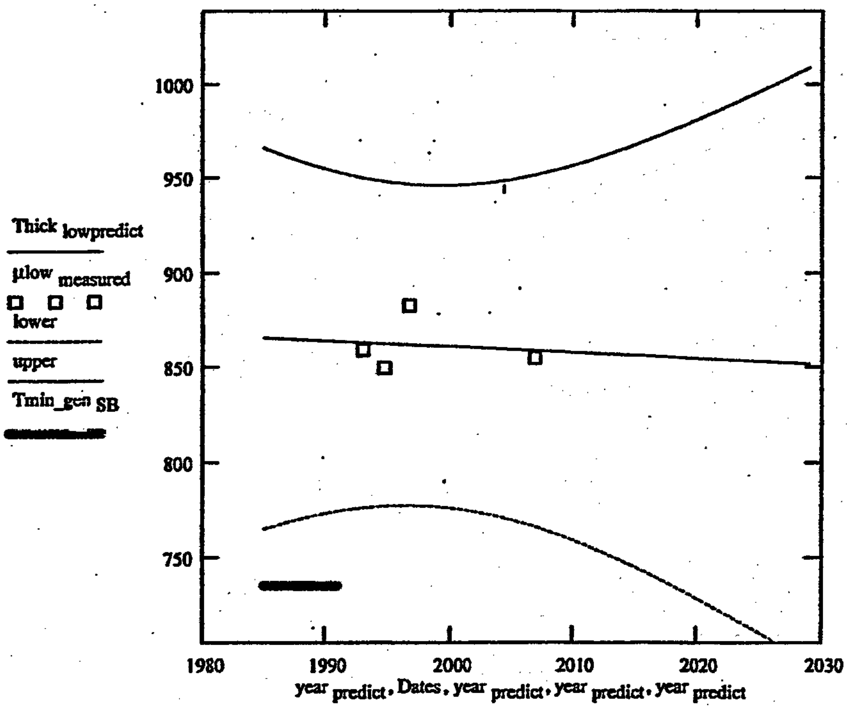


$m_{\mathrm{highs}} = -1.914$

For the points which are thinner

$$upper_f := Thick_{lowpredict_f} \ldots$$
$$+ qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Standard_{lowerror} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Thick_{actualmean}\right)^2}{sum}}$$

$$lower_f := Thick_{lowpredict_f} \ldots$$
$$+ -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Standard_{lowerror} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Thick_{actualmean}\right)^2}{sum}}\right]$$



$m_{lows} = -0.308$

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\mathrm{Rate}_{\mathrm{min\_observed}} := 6.9$$

$$\mathrm{Postulated}_{\mathrm{meanthickness}} := \mu_{\mathrm{measured}_3} - \mathrm{Rate}_{\mathrm{min\_observed}} \cdot (2029 - 2006)$$

$\mathrm{Postulated}_{\mathrm{meanthickness}} = 739.55$ which is greater than $\mathrm{Tmin\_gen}_{\mathrm{SB}_3} = 736$

The following addresses the readings at the lowest single point

$$\mathrm{SST}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{Point}_{5_i} - \mathrm{mean}\left(\mathrm{Point}_5\right)\right)^2 \qquad \mathrm{SST}_{\mathrm{point}} = 6.904 \cdot 10^5$$

$$\mathrm{SSE}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{Point}_{5_i} - \mathrm{yhat}\left(\mathrm{Dates}, \mathrm{Point}_5\right)_i\right)^2 \qquad \mathrm{SSE}_{\mathrm{point}} = 6.585 \cdot 10^5$$

$$\mathrm{SSR}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{yhat}\left(\mathrm{Dates}, \mathrm{Point}_5\right)_i - \mathrm{mean}\left(\mathrm{Point}_5\right)\right)^2 \qquad \mathrm{SSR}_{\mathrm{point}} = 3.194 \cdot 10^4$$

$$\mathrm{MSE}_{\mathrm{point}} := \frac{\mathrm{SSE}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{ss}}} \qquad \mathrm{MSR}_{\mathrm{point}} := \frac{\mathrm{SSR}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{reg}}} \qquad \mathrm{MST}_{\mathrm{point}} := \frac{\mathrm{SST}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{st}}}$$

$$\mathrm{StPit}_{\mathrm{err}} := \sqrt{\mathrm{MSE}_{\mathrm{point}}} \qquad \mathrm{StPit}_{\mathrm{err}} = 573.803$$

$$\mathrm{MSE}_{\mathrm{point}} = 3.292 \cdot 10^5 \qquad \mathrm{MSR}_{\mathrm{point}} = 3.194 \cdot 10^4 \qquad \mathrm{MST}_{\mathrm{point}} = 2.301 \cdot 10^5$$

F Test for Corrosion

$$F_{\mathrm{actaul\_Reg}} := \frac{\mathrm{MSR}_{\mathrm{point}}}{\mathrm{MSE}_{\mathrm{point}}}$$

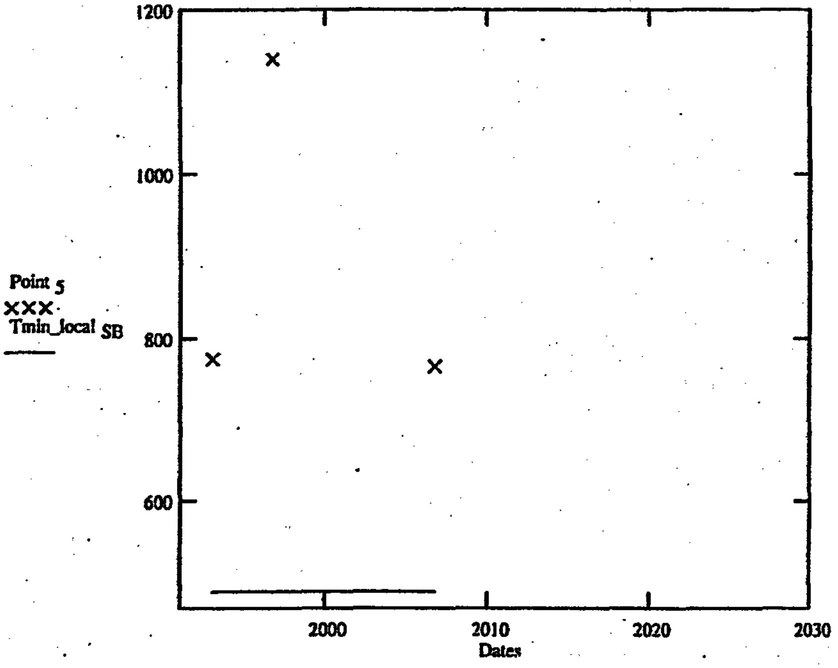
$$F_{\mathrm{ratio\_reg}} := \frac{F_{\mathrm{actaul\_Reg}}}{F_{\mathrm{critical\_reg}}}$$

$$F_{\mathrm{ratio\_reg}} = 5.241 \cdot 10^{-3}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Local Tmin for this elevation in the Drywell $\text{Tmin\_local}_{SB_7} := 490$ (Ref. 3.25)

Curve Fit For Point 5 Projected to Plant End Of Life



$\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point}_{5_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 608.3$ which is greater than $\text{Tmin\_local}_{SB_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 767$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{SB_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(\text{minpoint} - \text{Tmin\_local}_{SB_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -11.542$ mils per year

Appendix 4 - Sand Bed Elevation Bay 13A

October 2006 Data

The data shown below was collected on 10/20/06.

$$page := READPRN(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Oct 2006 Data\textbackslash Sandbed\textbackslash SB13A.txt"})$$

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

$$Points_{49} = \begin{bmatrix} 0.887 & 0.833 & 0.887 & 0.908 & 1.046 & 0.951 & 0.922 \\ 0.823 & 0.883 & 0.774 & 0.826 & 0.897 & 0.87 & 0.783 \\ 0.76 & 0.913 & 0.798 & 0.823 & 0.746 & 0.759 & 0.768 \\ 0.845 & 0.895 & 0.875 & 0.848 & 0.788 & 0.799 & 0.852 \\ 0.88 & 0.811 & 0.861 & 0.869 & 0.798 & 0.846 & 0.84 \\ 0.816 & 0.813 & 0.869 & 0.924 & 0.824 & 0.785 & 0.87 \\ 0.801 & 0.834 & 0.763 & 0.838 & 0.895 & 0.885 & 0.863 \end{bmatrix}$$

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

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

The thinnest point at this location is at point 15 shown below

$$minpoint := min(Points_{49})$$

$$minpoint = 0.746$$

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

Point 5 is much thicker than the mean of the rest of distribution. Therefore the distribution of the grid without this point will also be investigated:

$$Cells_{min5} := Cells$$

$$Cells_{min5_4} := 0$$

$$Cells_{min5} := deletezero_{cells}(Cells_{min5}, No_{DataCells})$$

$$No_{DataCells.min5} := length(Cells_{min5})$$

Mean and Standard Deviation

$\mu_{actual} := \mathrm{mean}(Cells)$ $\mu_{actual} = 845.796$ $\sigma_{actual} := \mathrm{Stdev}(Cells)$ $\sigma_{actual} = 57.413$

$\mu_{actual.min5} := \mathrm{mean}\left(Cells_{min5}\right)$ $\sigma_{actual.min5} := \mathrm{Stdev}\left(Cells_{min5}\right)$

Standard Error

$$Standard_{error} := \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Standard_{error} = 8.202$$

$$Standard_{error.min5} := \frac{\sigma_{actual.min5}}{\sqrt{No_{DataCells.min5}}} \qquad Standard_{error.min5} = 7.211$$

Skewness

$$Skewness := \frac{\left(No_{DataCells}\right)\cdot\overrightarrow{\Sigma\left(Cells - \mu_{actual}\right)^{3}}}{\left(No_{DataCells} - 1\right)\cdot\left(No_{DataCells} - 2\right)\cdot\left(\sigma_{actual}\right)^{3}} \qquad Skewness = 0.745$$

$$Skewness_{min5} := \frac{\left(No_{DataCells.min5}\right)\cdot\overrightarrow{\Sigma\left(Cells_{min5} - \mu_{actual.min5}\right)^{3}}}{\left(No_{DataCells.min5} - 1\right)\cdot\left(No_{DataCells.min5} - 2\right)\cdot\left(\sigma_{actual.min5}\right)^{3}} \qquad Skewness_{min5} = -0.011$$

Kurtosis

$$Kurtosis := \frac{No_{DataCells}\cdot\left(No_{DataCells} + 1\right)\cdot\overrightarrow{\Sigma\left(Cells - \mu_{actual}\right)^{4}}}{\left(No_{DataCells} - 1\right)\cdot\left(No_{DataCells} - 2\right)\cdot\left(No_{DataCells} - 3\right)\cdot\left(\sigma_{actual}\right)^{4}} \ldots + -\frac{3\cdot\left(No_{DataCells} - 1\right)^{2}}{\left(No_{DataCells} - 2\right)\cdot\left(No_{DataCells} - 3\right)} \qquad Kurtosis = 1.696$$

$$Kurtosis_{5} := \frac{No_{DataCells.min5}\cdot\left(No_{DataCells.min5} + 1\right)\cdot\overrightarrow{\Sigma\left(Cells_{min5} - \mu_{actual.min5}\right)^{4}}}{\left(No_{DataCells.min5} - 1\right)\cdot\left(No_{DataCells.min5} - 2\right)\cdot\left(No_{DataCells.min5} - 3\right)\cdot\left(\sigma_{actual.min5}\right)^{4}} \ldots + -\frac{3\cdot\left(No_{DataCells.min5} - 1\right)^{2}}{\left(No_{DataCells.min5} - 2\right)\cdot\left(No_{DataCells.min5} - 3\right)} \qquad Kurtosis_{5} = -0.748$$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{Cells})$$

$$\alpha := .05 \qquad T\alpha := \mathrm{qt}\left[\left(1-\frac{\alpha}{2}\right), \mathrm{No}_{\mathrm{DataCells}}\right] \qquad T\alpha = 2.01$$

$$\mathrm{Lower}_{95\%\mathrm{Con}} := \mu_{\mathrm{actual}} - T\alpha \cdot \frac{\sigma_{\mathrm{actual}}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}} \qquad \mathrm{Lower}_{95\%\mathrm{Con}} = 829.314$$

$$\mathrm{Upper}_{95\%\mathrm{Con}} := \mu_{\mathrm{actual}} + T\alpha \cdot \frac{\sigma_{\mathrm{actual}}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}} \qquad \mathrm{Upper}_{95\%\mathrm{Con}} = 862.278$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

$$\mathrm{Bins} := \mathrm{Make}_{\mathrm{bins}}\left(\mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right)$$

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

Distribution =

0
0
2
7
7
9
9
9
4
1
0
0

The mid points of the Bins are calculated

$$k := 0..11 \qquad \mathrm{Midpoints}_k := \frac{\left(\mathrm{Bins}_k + \mathrm{Bins}_{k+1}\right)}{2}$$

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

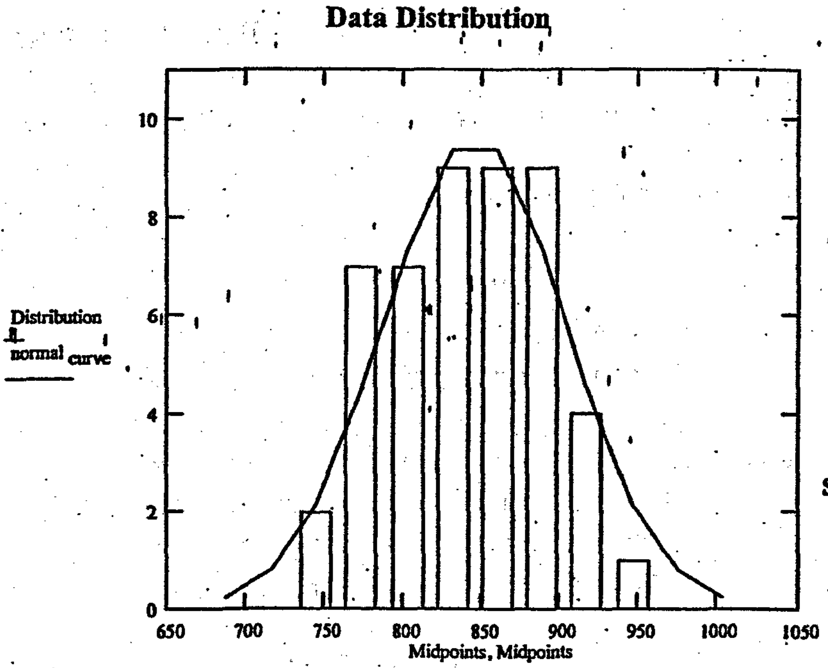
$$\mathrm{normal}_{\mathrm{curve}_0} := \mathrm{pnorm}\left(\mathrm{Bins}_1, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right)$$

$$\mathrm{normal}_{\mathrm{curve}_k} := \mathrm{pnorm}\left(\mathrm{Bins}_{k+1}, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right) - \mathrm{pnorm}\left(\mathrm{Bins}_k, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right)$$

$$\mathrm{normal}_{\mathrm{curve}} := \mathrm{No}_{\mathrm{DataCells}} \cdot \mathrm{normal}_{\mathrm{curve}}$$

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.



$\mu_{actual} = 845.796$

$\sigma_{actual} = 57.413$

$\text{Standard}_{error} = 8.202$

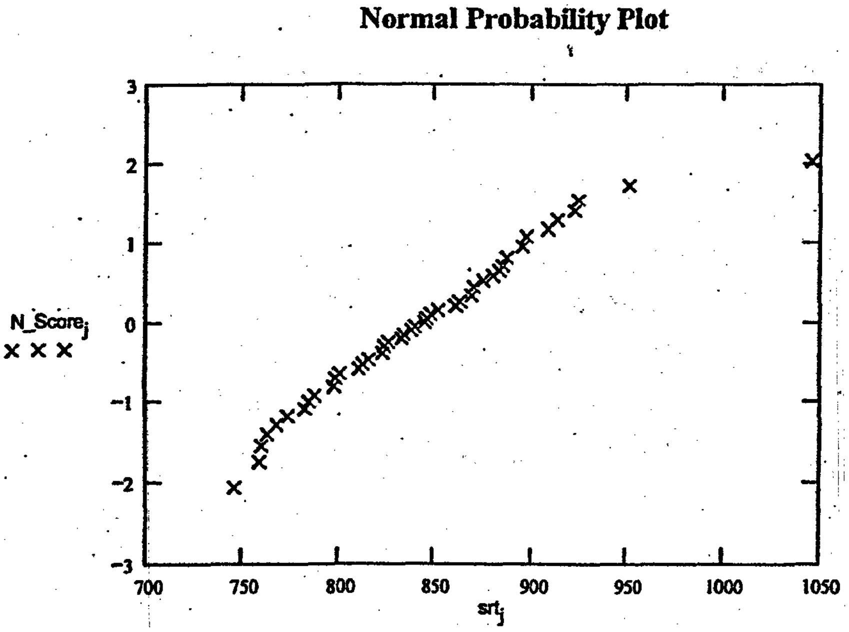
$\text{Skewness} = 0.745$

$\text{Kurtosis} = 1.696$

$\text{Skewness}_{min5} = -0.011$

$\text{Kurtosis}_5 = -0.748$

$\text{Lower}_{95\%Con} = 829.314$ $\text{Upper}_{95\%Con} = 862.278$



This distribution is not normal when Point 5 (1.046 inch) is included. However when this point is excluded form the distribution the remaining grid is normal as illustrated by the Kurtosis and skewness values.

Sandbed Location 13A Trend

$d := 0$

Data from the 1992, 1994 and 1996 is retrieved.

For 1992

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB13A.txt")

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.885 & 0.979 & 0.857 & 0.886 & 1.013 & 1.041 & 1.069 \\ 0.814 & 0.856 & 0.778 & 0.829 & 0.898 & 0.871 & 0.794 \\ 0.762 & 0.903 & 0.813 & 0.827 & 0.761 & 0.771 & 0.826 \\ 0.86 & 0.884 & 0.872 & 0.923 & 0.79 & 0.798 & 0.876 \\ 0.869 & 0.807 & 0.854 & 0.892 & 0.805 & 0.858 & 0.84 \\ 0.827 & 0.813 & 0.878 & 0.925 & 0.828 & 0.784 & 0.868 \\ 0.815 & 0.84 & 0.77 & 0.842 & 0.914 & 0.879 & 0.879 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}\left(\mathrm{Points}_{49}, 7\right)$ $\qquad$ $\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

The thinnest point is captured $\qquad$ $\mathrm{Point}_{18_d} := \mathrm{nnn}_{18}$ $\qquad$ $\mathrm{Point}_{18} = 761$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\qquad$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$

$$\mathrm{Standard}_{\mathrm{error}_d} := \frac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$$

For 1994

$d := d + 1$

$\text{page} := \text{READPRN}(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Sept.1994 Data\textbackslash sandbed\textbackslash Data Only\textbackslash SB13A.txt"})$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.869 & 0.842 & 0.856 & 0.845 & 1.019 & 0.987 & 0.926 \\ 0.805 & 0.826 & 0.771 & 0.823 & 0.858 & 0.847 & 0.79 \\ 0.745 & 0.896 & 0.803 & 0.764 & 0.752 & 0.764 & 0.819 \\ 0.851 & 0.873 & 0.861 & 0.853 & 0.787 & 0.793 & 0.845 \\ 0.868 & 0.793 & 0.849 & 0.877 & 0.799 & 0.847 & 0.83 \\ 0.822 & 0.798 & 0.866 & 0.918 & 0.825 & 0.775 & 0.843 \\ 0.84 & 0.834 & 0.762 & 0.793 & 0.879 & 0.865 & 0.862 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

The thinnest point is captured $\text{Point}_{18_d} := \text{nnn}_{18}$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB13A.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.873 & 0.838 & 0.866 & 0.839 & 1.049 & 0.999 & 0.958 \\ 0.823 & 0.83 & 0.756 & 0.809 & 0.867 & 0.943 & 0.794 \\ 0.743 & 0.897 & 0.838 & 0.769 & 0.774 & 0.778 & 0.809 \\ 0.848 & 0.864 & 0.857 & 0.865 & 0.825 & 0.793 & 0.861 \\ 0.893 & 0.859 & 0.851 & 0.878 & 0.794 & 0.843 & 0.821 \\ 0.828 & 0.865 & 0.871 & 0.951 & 0.828 & 0.771 & 0.838 \\ 0.927 & 0.913 & 0.767 & 0.86 & 0.885 & 0.917 & 0.875 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

The thinnest point is captured

$\text{Point}_{18_d} := \text{nnn}_{18}$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$d := d + 1$

For 2006

page := READPRN("U:\MSOFFICE\Drywell Program data\Oct 2006 Data\Sandbed\SB13A.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.887 & 0.833 & 0.887 & 0.908 & 1.046 & 0.951 & 0.922 \\ 0.823 & 0.883 & 0.774 & 0.826 & 0.897 & 0.87 & 0.783 \\ 0.76 & 0.913 & 0.798 & 0.823 & 0.746 & 0.759 & 0.768 \\ 0.845 & 0.895 & 0.875 & 0.848 & 0.788 & 0.799 & 0.852 \\ 0.88 & 0.811 & 0.861 & 0.869 & 0.798 & 0.846 & 0.84 \\ 0.816 & 0.813 & 0.869 & 0.924 & 0.824 & 0.785 & 0.87 \\ 0.801 & 0.834 & 0.763 & 0.838 & 0.895 & 0.885 & 0.863 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

The thinnest point is captured

$\text{Point}_{18_d} := \text{nnn}_{18}$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\mathrm{Dates} = \begin{bmatrix} 1.993\cdot10^3 \\ 1.995\cdot10^3 \\ 1.997\cdot10^3 \\ 2.007\cdot10^3 \end{bmatrix} \qquad \mathrm{Point}_{18} = \begin{bmatrix} 761 \\ 752 \\ 774 \\ 746 \end{bmatrix}$$

$$\mu_{\mathrm{measured}_i} = \begin{bmatrix} 857.612 \\ 837.041 \\ 853.061 \\ 845.796 \end{bmatrix} \qquad \mathrm{Standard}_{\mathrm{error}} = \begin{bmatrix} 9.554 \\ 7.763 \\ 8.831 \\ 8.202 \end{bmatrix} \qquad \sigma_{\mathrm{measured}} = \begin{bmatrix} 66.876 \\ 54.344 \\ 61.819 \\ 57.413 \end{bmatrix}$$

$$\mathrm{Total}_{\mathrm{means}} := \mathrm{rows}(\mu_{\mathrm{measured}}) \qquad \mathrm{Total}_{\mathrm{means}} = 4$$

$$\mathrm{SST} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{mean}(\mu_{\mathrm{measured}})\right)^2 \qquad \mathrm{SST} = 242.403$$

$$\mathrm{SSE} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{yhat}(\mathrm{Dates}, \mu_{\mathrm{measured}})_i\right)^2 \qquad \mathrm{SSE} = 229.789$$

$$\mathrm{SSR} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{yhat}(\mathrm{Dates}, \mu_{\mathrm{measured}})_i - \mathrm{mean}(\mu_{\mathrm{measured}})\right)^2 \qquad \mathrm{SSR} = 12.614$$

$$\mathrm{DegreeFree}_{ss} := \mathrm{Total}_{\mathrm{means}} - 2 \qquad \mathrm{DegreeFree}_{\mathrm{reg}} := 1 \qquad \mathrm{DegreeFree}_{st} := \mathrm{Total}_{\mathrm{means}} - 1$$

$$\mathrm{MSE} := \frac{\mathrm{SSE}}{\mathrm{DegreeFree}_{ss}} \qquad \mathrm{MSR} := \frac{\mathrm{SSR}}{\mathrm{DegreeFree}_{\mathrm{reg}}} \qquad \mathrm{MST} := \frac{\mathrm{SST}}{\mathrm{DegreeFree}_{st}}$$

$$\mathrm{StGrand}_{\mathrm{err}} := \sqrt{\mathrm{MSE}} \qquad \mathrm{StGrand}_{\mathrm{err}} = 10.719$$

F Test for Corrosion

$$\alpha := 0.05 \qquad F_{\mathrm{actaul\_Reg}} := \frac{\mathrm{MSR}}{\mathrm{MSE}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 5.93 \cdot 10^{-3}$$

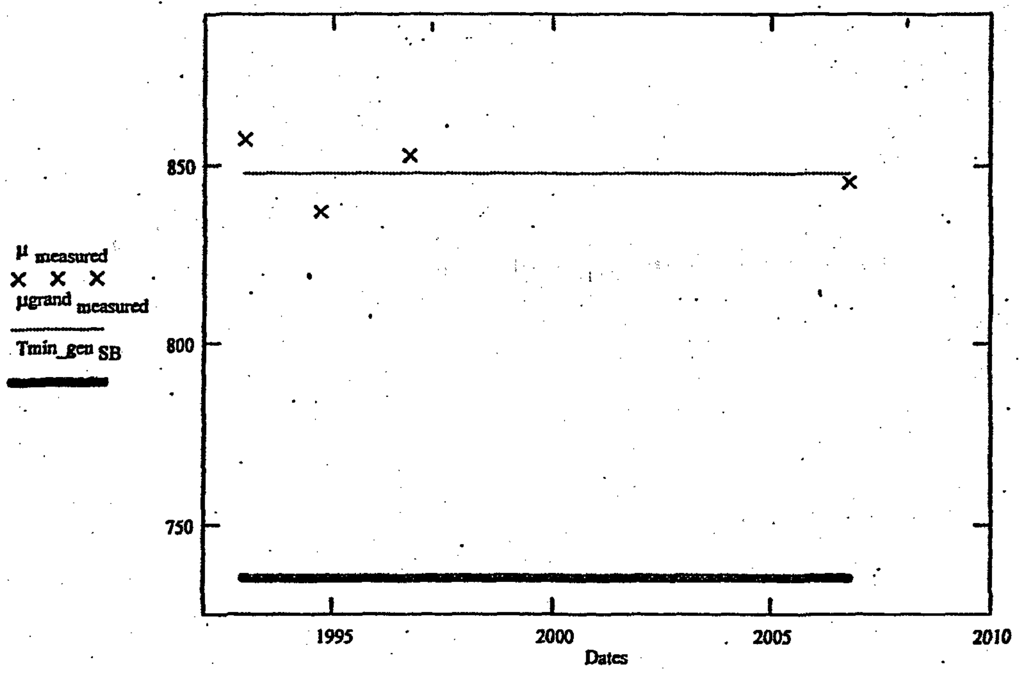
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$ $GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 848.378$ $GrandStandard_{error} = 4.494$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}\left(\text{Dates}, \mu_{\text{measured}}\right) \quad m_s = -0.331 \quad y_b := \text{intercept}\left(\text{Dates}, \mu_{\text{measured}}\right) \quad y_b = 1.509 \cdot 10^3$

The 95% Confidence curves are calculated

$\alpha_t := 0.05 \quad k := 2029 - 1985 \qquad f := 0..k - 1$

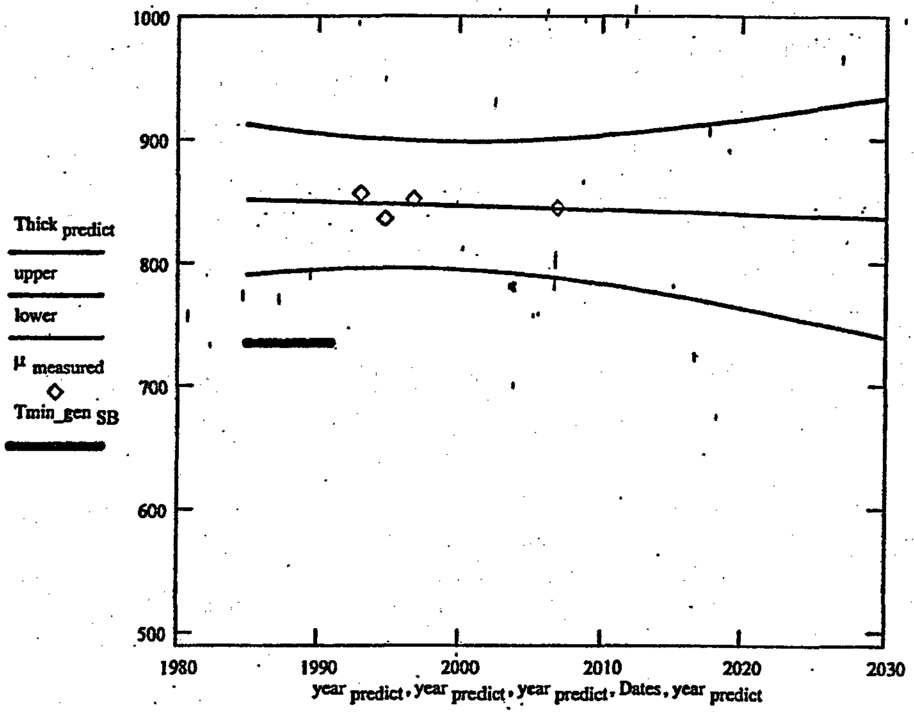
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2 \quad \text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates}) \qquad \text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = -0.331$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2020 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 749.196$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

The F-Ratio is calculated for the point as follows

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point18_i - mean(Point18)\right)^2 \qquad SST_{point} = 444.75$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Point18_i - yhat(Dates, Point18)_i\right)^2 \qquad SSE_{point} = 317.009$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, Point18)_i - mean(Point18)\right)^2 \qquad SSR_{point} = 127.741$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 158.505 \qquad MSR_{point} = 127.741 \qquad MST_{point} = 148.25$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 12.59$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.044$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \mathrm{slope}(Dates, Point_{18})$ $m_{point} = -1.053$ ▪ $y_{point} := \mathrm{intercept}(Dates, Point_{18})$ $y_{point} = 2.861 \cdot 10^{3}$

The 95% Confidence curves are calculated

$Point_{curve} := m_{point} \cdot year_{predict} + y_{point}$

$Point_{actualmean} := \mathrm{mean}(Dates)$ $sum := \sum_{i} \left(Dates_{d} - \mathrm{mean}(Dates)\right)^{2}$

$$uppoint_{f} := Point_{curve_{f}} \cdots$$

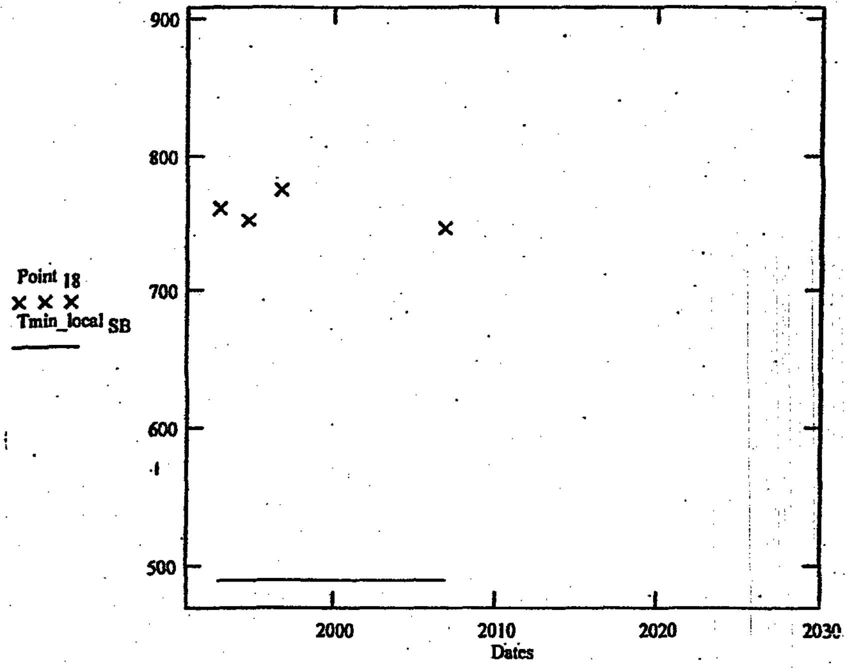
$$+ \mathrm{qt}\left(1 - \frac{\alpha_{t}}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_{f}} - Point_{actualmean}\right)^{2}}{sum}}$$

$$lopoint_{f} := Point_{curve_{f}} \cdots$$

$$+ -\left[\mathrm{qt}\left(1 - \frac{\alpha_{t}}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_{f}} - Point_{actualmean}\right)^{2}}{sum}}\right]$$

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_{f}} := 490$ (Ref. 3.25)

Curve Fit For Point 18 Projected to Plant End Of Life



$m_{point} = -1.053$

$lopoint_{22} = 613.676$ $year_{predict_{22}} = 2.029 \cdot 10^{3}$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point}_{18_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 587.3$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 0.746$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -10.667$ mils per year

pendix 5- Sandbed 13D

t 2006 Data

data shown below was collected on 10/18/2006

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB13C-D.txt")

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

$$\text{Points}_{49} = \begin{bmatrix} 1.114 & 1.117 & 1.132 & 1.083 & 1.068 & 1.106 & 1.119 \\ 0.95 & 1.041 & 0.999 & 1.061 & 1.007 & 1.117 & 1.1 \\ 0.986 & 0.95 & 0.837 & 0.833 & 0.949 & 1.088 & 1.085 \\ 1.005 & 0.977 & 0.878 & 0.851 & 0.911 & 0.958 & 0.997 \\ 0.96 & 0.907 & 0.874 & 0.874 & 0.915 & 0.916 & 0.905 \\ 0.944 & 0.947 & 0.897 & 0.887 & 0.92 & 0.865 & 0.892 \\ 0.996 & 0.939 & 0.929 & 0.958 & 0.944 & 0.832 & 0.821 \end{bmatrix}$$

$\text{Cells} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

thinnest point at this location is point 49 shown below

$\text{minpoint} := \min\left(\text{Points}_{49}\right)$ $\text{minpoint} = 0.821$

$$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$$

$$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

Mean and Standard Deviation

$\mu_{\text{actual}} := \text{mean}(\text{Cells})$ $\mu_{\text{actual}} = 968.184$ $\sigma_{\text{actual}} := \text{Stdev}(\text{Cells})$ $\sigma_{\text{actual}} = 90.136$

Standard Error

$$\text{Stindard}_{\text{error}} := \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\text{Standard}_{\text{error}} = 12.877$

Skewness

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

$\text{Skewness} = 0.342$

Kurtosis

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

$\text{Kurtosis} = -0.964$

Normal Probability Plot

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

$r_j := j + 1$ $$\text{rank}_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{\text{srt}=\text{srt}_j}\right)\cdot r}}{\Sigma\overrightarrow{\text{srt}=\text{srt}_j}}$$

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

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

oe d Lower Confidence Values

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

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

$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 942.294$

$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 994.074$

se values represent a range on the calculated mean in which there is 95% confidence.

phical Representation

ribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard ations

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

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

Distribution =

0
0
2
7
9
11
7
1
6
6
0
0

mid points of the Bins are calculated

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

$\text{rmal}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_1, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$

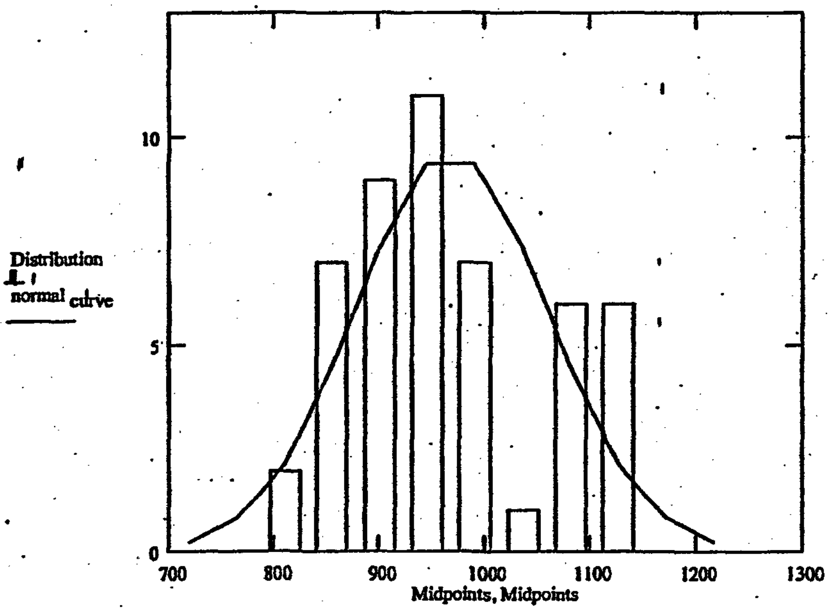
$\text{rmal}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{k+1}, \mu_{\text{actual}}, \sigma_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_k, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$

$\text{}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$

Results For 13D

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values.

Data Distribution



μ_{actual} = 968.184

σ_{actual} = 90.136

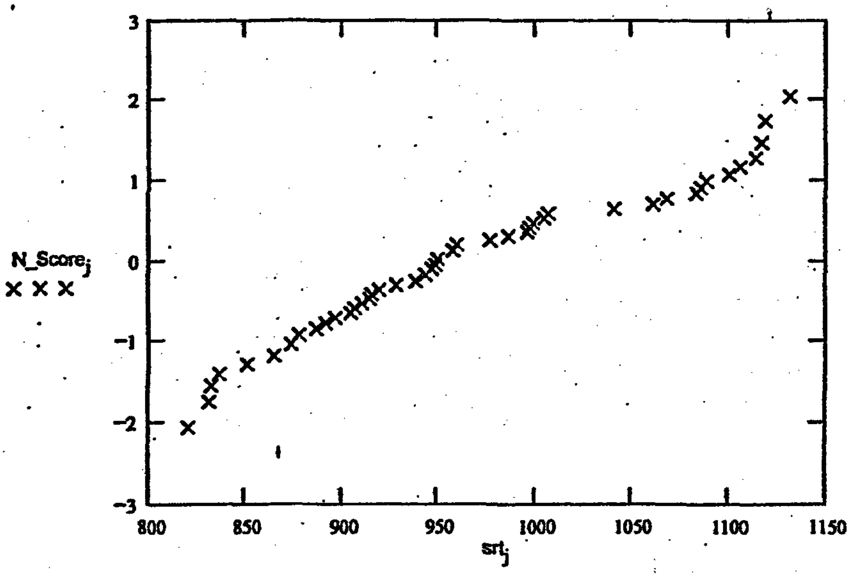
$Standard_{error}$ = 12.877

Skewness = 0.342

Kurtosis = −0.964

$Lower_{95\%Con}$ = 942.294 $Upper_{95\%Con}$ = 994.074

Normal Probability Plot



There is a slightly thinner area of 16 points near the center of this location. Past calculations (ref. 3.22) have split this area out as a separate groups and performed analysis on both groups. In order to be consistent with past calculations this data will be split in two groups and analyzed. The entire data set will also be evaluated.

The two groups are named as follows: $\text{Stoptop} := 16$ $\text{Botstar} := 28$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{Cells}, \text{No}_{\text{DataCells}}, \text{Botstar}\right)$ $\text{high}_{\text{points}} := \text{TOPROWS}(\text{Cells}, 49, \text{Stoptop})$

$\text{No}_{\text{lowCells}} := \text{length}\left(\text{low}_{\text{points}}\right)$ $\text{No}_{\text{lowCells}} = 21$

$\text{high}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 19, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 20, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 21, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 22, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 27, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 28, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{length}\left(\text{high}_{\text{points}}\right) = 22$

$\text{low}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 17, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$

$\text{low}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 18, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$

$\text{low}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 23, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$

$\text{low}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 24, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$

$\text{low}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 25, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$

$\text{low}_{\text{points}} := \text{Add}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 26, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$

$\text{length}\left(\text{low}_{\text{points}}\right) = 27$

[illegible] and Standard Deviation

$$\mu low_{actual} := mean(low_{points}) \qquad \sigma low_{actual} := Stdev(low_{points})$$

$$\mu high_{actual} := mean(high_{points}) \qquad \sigma high_{actual} := Stdev(high_{points})$$

Standard Error

$$Standardlow_{error} := \frac{\sigma low_{actual}}{\sqrt{length(low_{points})}} \qquad Standardhigh_{error} := \frac{\sigma high_{actual}}{\sqrt{length(high_{points})}}$$

Skewness

$$Nolow_{DataCells} := length(low_{points})$$

$$S\text{[illegible]}ess_{low} := \frac{(Nolow_{DataCells})\cdot\Sigma\overrightarrow{(low_{points} - \mu low_{actual})^3}}{(Nolow_{DataCells} - 1)\cdot(Nolow_{DataCells} - 2)\cdot(\sigma low_{actual})^3}$$

$$Nohigh_{DataCells} := length(high_{points})$$

$$Skewness_{high} := \frac{(Nohigh_{DataCells})\cdot\Sigma\overrightarrow{(high_{points} - \mu high_{actual})^3}}{(Nohigh_{DataCells} - 1)\cdot(Nohigh_{DataCells} - 2)\cdot(\sigma high_{actual})^3}$$

Kurtosis

$$\text{Kurtosis}_{low} := \frac{Nolow_{DataCells}\cdot\left(Nolow_{DataCells}+1\right)\cdot\overrightarrow{\Sigma\left(low_{points}-\mu low_{actual}\right)^{4}}}{\left(Nolow_{DataCells}-1\right)\cdot\left(Nolow_{DataCells}-2\right)\cdot\left(Nolow_{DataCells}-3\right)\cdot\left(\sigma low_{actual}\right)^{4}} \cdots + -\frac{3\cdot\left(Nolow_{DataCells}-1\right)^{2}}{\left(Nolow_{DataCells}-2\right)\cdot\left(Nolow_{DataCells}-3\right)}$$

$$\text{Kurtosis}_{high} := \frac{Nohigh_{DataCells}\cdot\left(Nohigh_{DataCells}+1\right)\cdot\overrightarrow{\Sigma\left(high_{points}-\mu high_{actual}\right)^{4}}}{\left(Nohigh_{DataCells}-1\right)\cdot\left(Nohigh_{DataCells}-2\right)\cdot\left(Nohigh_{DataCells}-3\right)\cdot\left(\sigma high_{actual}\right)^{4}} \cdots + -\frac{3\cdot\left(Nohigh_{DataCells}-1\right)^{2}}{\left(Nohigh_{DataCells}-2\right)\cdot\left(Nohigh_{DataCells}-3\right)}$$

Normal Probability Plot - Low points

$l := 0..\text{last}\left(low_{points}\right) \quad srt_{low} := \text{sort}\left(low_{points}\right)$

$L_{l} := l + 1$

$$rank_{low_{l}} := \frac{\Sigma\overrightarrow{\left(\overrightarrow{srt_{low}=srt_{low_{l}}}\right)\cdot L}}{\Sigma\overrightarrow{srt_{low}=srt_{low_{l}}}} \qquad p_{low_{l}} := \frac{rank_{low_{l}}}{\text{rows}\left(low_{points}\right)+1}$$

$x := 1 \qquad N\_Score_{low_{l}} := \text{root}\left[\text{cnorm}(x)-\left(p_{low_{l}}\right), x\right]$

Normal Probability Plot - High points

$h := 0..\text{last}\left(high_{points}\right) \qquad srt_{high} := \text{sort}\left(high_{points}\right)$

$H_{h} := h + 1$

$$rank_{high_{h}} := \frac{\Sigma\overrightarrow{\left(\overrightarrow{srt_{high}=srt_{high_{h}}}\right)\cdot H}}{\Sigma\overrightarrow{srt_{high}=srt_{high_{h}}}} \qquad p_{high_{h}} := \frac{rank_{high_{h}}}{\text{rows}\left(high_{points}\right)+1}$$

$x := 1 \qquad N\_Score_{high_{h}} := \text{root}\left[\text{cnorm}(x)-\left(p_{high_{h}}\right), x\right]$

Upper and Lower Confidence Values

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

$$\text{Lowerhigh}_{95\%\text{Con}} := \mu\text{high}_{\text{actual}} - T\alpha \cdot \frac{\sigma\text{high}_{\text{actual}}}{\sqrt{\text{Nohigh}_{\text{DataCells}}}}$$

$$\text{Upperhigh}_{95\%\text{Con}} := \mu\text{high}_{\text{actual}} + T\alpha \cdot \frac{\sigma\text{high}_{\text{actual}}}{\sqrt{\text{Nohigh}_{\text{DataCells}}}}$$

$$\text{Lowerlow}_{95\%\text{Con}} := \mu\text{low}_{\text{actual}} - T\alpha \cdot \frac{\sigma\text{low}_{\text{actual}}}{\sqrt{\text{Nolow}_{\text{DataCells}}}}$$

$$\text{Upperlow}_{95\%\text{Con}} := \mu\text{low}_{\text{actual}} + T\alpha \cdot \frac{\sigma\text{low}_{\text{actual}}}{\sqrt{\text{Nolow}_{\text{DataCells}}}}$$

Graphical Representation of Low Points

$$\text{Bins}_{\text{low}} := \text{Make}_{\text{bins}}\left(\mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$$

$$\text{Distribution}_{\text{low}} := \text{hist}\left(\text{Bins}_{\text{low}}, \text{low}_{\text{points}}\right)$$

$$\text{Distribution}_{\text{low}} = \begin{pmatrix} 0 \\ 0 \\ 3 \\ 2 \\ 4 \\ 3 \\ 6 \\ 5 \\ 2 \\ 2 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

$$\text{normallow}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_{\text{low}_1}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$$

$$\text{normallow}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{\text{low}_{k+1}}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_{\text{low}_k}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$$

$$\text{normallow}_{\text{curve}} := \text{Nolow}_{\text{DataCells}} \cdot \text{normallow}_{\text{curve}}$$

Graphical Representation of High Points

$$\text{Bins}_{\text{high}} := \text{Make}_{\text{bins}}\left(\mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$$

$$\text{Distribution}_{\text{high}} := \text{hist}\left(\text{Bins}_{\text{high}}, \text{high}_{\text{points}}\right)$$

$$\text{Distribution}_{\text{high}} = \begin{pmatrix} 0 \\ 0 \\ 3 \\ 1 \\ 5 \\ 1 \\ 2 \\ 5 \\ 5 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

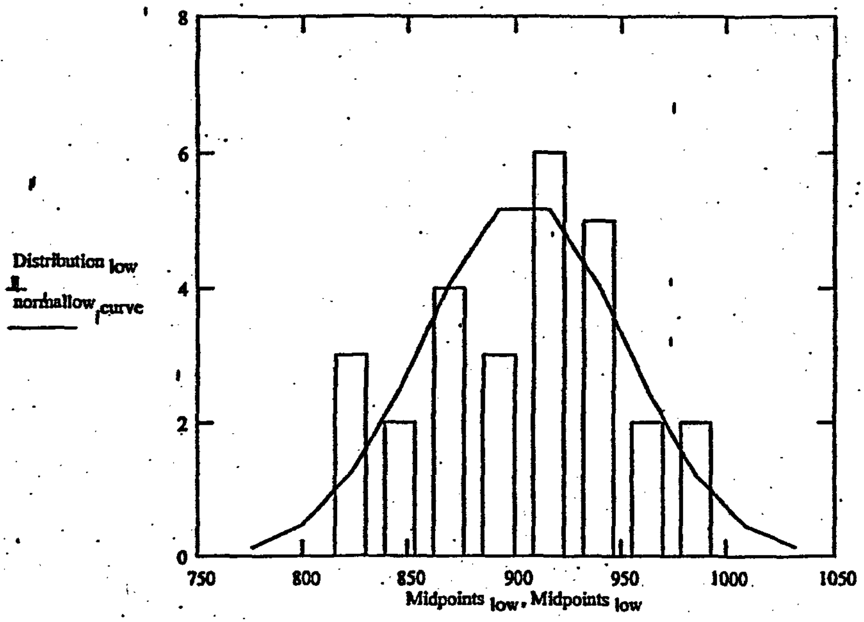
$$k := 0..11 \qquad \text{Midpoints}_{\text{high}_k} := \frac{\left(\text{Bins}_{\text{high}_k} + \text{Bins}_{\text{high}_{k+1}}\right)}{2}$$

$$\text{normalhigh}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_{\text{high}_1}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$$

$$\text{normalhigh}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{\text{high}_{k+1}}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_{\text{high}_k}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$$

$$\text{normalhigh}_{\text{curve}} := \text{Nohigh}_{\text{DataCells}} \cdot \text{normalhigh}_{\text{curve}}$$

Results For Sandbed Location 13D Thinner point



$\mu low_{actual} = 904.037$

$\sigma low_{actual} = 46.499$

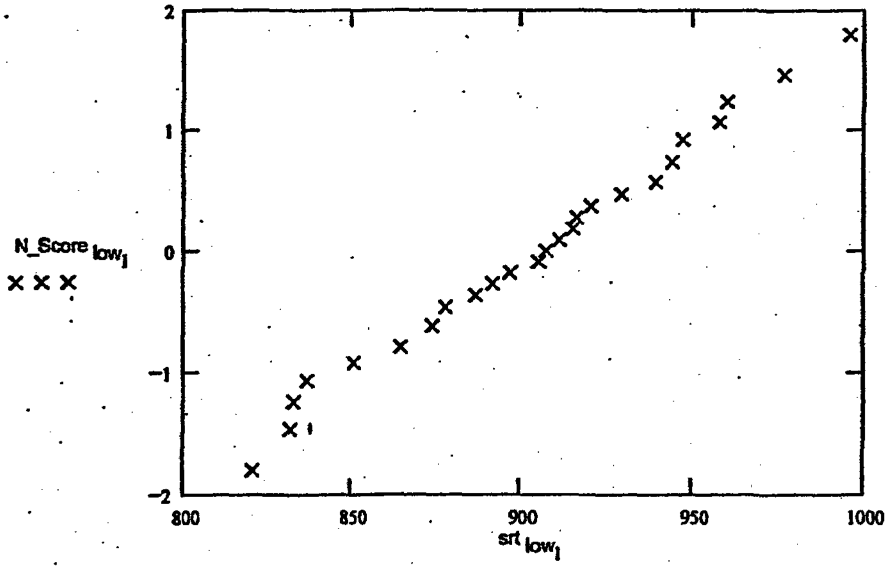
$Kurtosis_{low} = -0.672$

$Skewness_{low} = -0.051$

$Standardlow_{error} = 8.949$

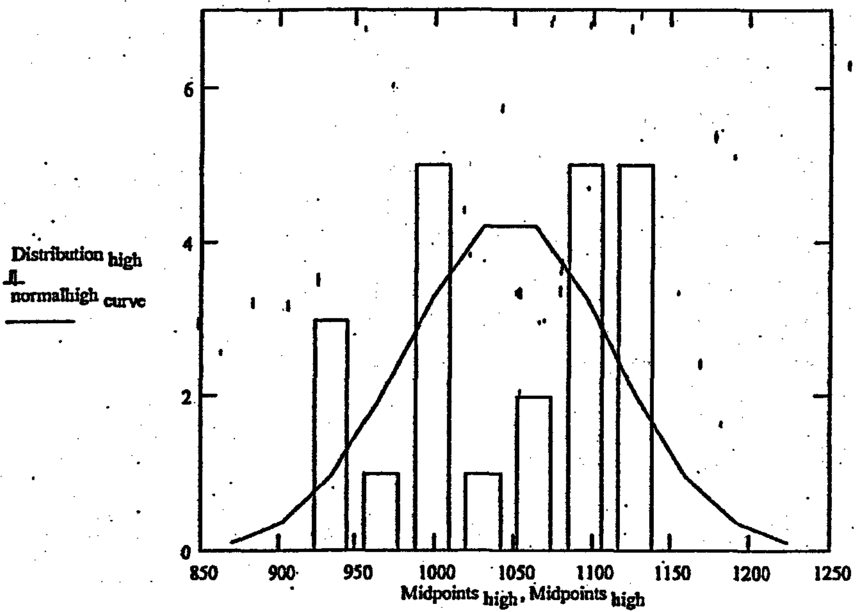
$Nolow_{DataCells} = 27$

$Lowerlow_{95\%Con} = 886.045$ $Upperlow_{95\%Con} = 922.029$



The above plots indicates that the thinner area is more normally distributed than the entire population.

Results For Sandbed Location 13D Thicker Points



$\mu high_{actual} = 1.047 \cdot 10^3$

$\sigma high_{actual} = 64.111$

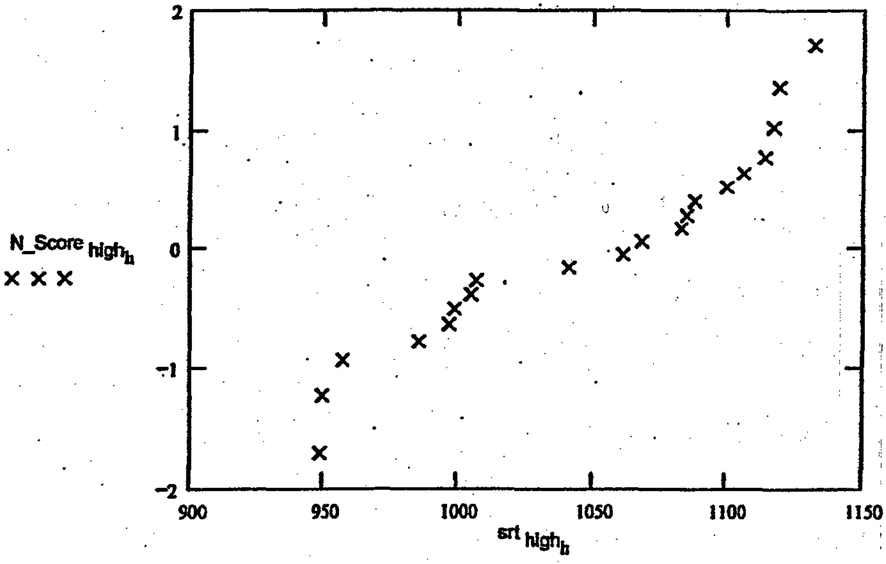
$Skewness_{high} = -0.306$

$Kurtosis_{high} = -1.467$

$Standardhigh_{error} = 13.668$

$Nohigh_{DataCells} = 22$

$Lower_{95\%Con} = 942.294$ $Upper_{95\%Con} = 994.074$



The above plots indicates that the thicker areas are some what normally distributed.

Sandbed 13D

Data fromV. 1992 to 2006 is retrieved. $d := 0$

For Dec 31 1992

$page := \text{READPRN}(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Dec. 1992 Data\textbackslash sandbed\textbackslash DATA ONLY\textbackslash SB13C-D.txt"})$

$Points_{49} := \text{showcells}(page, 7, 0)$ $Dates_d := Day_{year}(12, 31, 1992)$

Data

$$Points_{49} = \begin{bmatrix} 1.064 & 1.117 & 1.134 & 1.103 & 1.105 & 1.106 & 1.117 \\ 0.949 & 1.081 & 1 & 1.054 & 1.151 & 1.118 & 1.121 \\ 0.984 & 0.948 & 0.868 & 0.834 & 0.979 & 1.048 & 1.067 \\ 0.963 & 0.98 & 0.893 & 0.855 & 0.913 & 0.981 & 1.012 \\ 0.957 & 0.958 & 0.869 & 0.879 & 0.917 & 0.913 & 0.911 \\ 0.963 & 0.948 & 0.895 & 0.88 & 0.915 & 0.862 & 0.905 \\ 1.016 & 0.918 & 0.927 & 0.92 & 0.918 & 0.825 & 0.824 \end{bmatrix}$$

$nnn := \text{convert}(Points_{49}, 7)$ $No_{Cells} := \text{length}(nnn)$

$Point_{49_d} := nnn_{48}$ $Point_{49} = 824$

The two groups are named as follows: $Botstar := 28$ $Stoptop := 16$

$low_{points} := \text{LOWROWS}(nnn, No_{DataCells}, Botstar)$ $high_{points} := \text{TOPROWS}(nnn, No_{DataCells}, Stoptop)$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 19, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 20, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 21, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 22, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 27, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 28, \text{length}(high_{points}), high_{points})$

$low_{points} := \text{Add}(nnn, No_{DataCells}, 17, \text{length}(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 18, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 23, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 24, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 25, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 26, length(low_{points}), low_{points})$

$Cells := deletezero_{cells}(nnn, No_{Cells})$

$high_{points} := deletezero_{cells}(high_{points}, length(high_{points}))$

$low_{points} := deletezero_{cells}(low_{points}, length(low_{points}))$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$\mu high_{measured_d} := mean(high_{points})$ $\mu low_{measured_d} := mean(low_{points})$

$\sigma high_{measured_d} := Stdev(high_{points})$ $\sigma low_{measured_d} := Stdev(low_{points})$

$Standardhigh_{error_d} := \frac{\sigma high_{measured_d}}{\sqrt{length(high_{points})}}$ $Standardlow_{error_d} := \frac{\sigma low_{measured_d}}{\sqrt{length(low_{points})}}$

$d := d + 1$

For 1994

$page := \text{READPRN}(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Sept.1994 Data\textbackslash sandbed\textbackslash DATA ONLY\textbackslash SB13C-D.txt"})$

$Points_{49} := \text{showcells}(page, 7, 0)$ $Dates_d := Day_{year}(9, 26, 1994)$

Data

$$Points_{49} = \begin{bmatrix} 1.1 & 1.114 & 1.11 & 1.078 & 1.062 & 1.103 & 1.113 \\ 0.944 & 1.075 & 0.995 & 1.015 & 1.003 & 1.112 & 1.125 \\ 0.977 & 0.941 & 0.834 & 0.827 & 0.992 & 1.033 & 1.028 \\ 0.943 & 0.973 & 0.879 & 0.847 & 0.915 & 0.974 & 0.986 \\ 0.951 & 0.911 & 0.871 & 0.873 & 0.923 & 0.903 & 0.889 \\ 0.938 & 0.942 & 0.894 & 0.875 & 0.915 & 0.859 & 0.877 \\ 0.956 & 0.911 & 0.922 & 0.924 & 0.918 & 0.825 & 0.811 \end{bmatrix}$$

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

$Point_{49_d} := nnn_{48}$ $No_{Cells} := \text{length}(nnn)$

The two groups are named as follows: $Botstar := 28$ $Stoptop := 16$

$low_{points} := \text{LOWROWS}(nnn, No_{DataCells}, Botstar)$ $high_{points} := \text{TOPROWS}(nnn, No_{DataCells}, Stoptop)$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 19, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 20, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 21, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 22, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 27, \text{length}(high_{points}), high_{points})$

$high_{points} := \text{Add}(nnn, No_{DataCells}, 28, \text{length}(high_{points}), high_{points})$

$$\text{low}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 17, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$$

$$\text{low}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 18, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$$

$$\text{low}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 23, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$$

$$\text{low}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 24, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$$

$$\text{low}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 25, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$$

$$\text{low}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 26, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$$

$$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{Cells}}\right)$$

$$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{high}_{\text{points}}, \text{length}\left(\text{high}_{\text{points}}\right)\right)$$

$$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{low}_{\text{points}}, \text{length}\left(\text{low}_{\text{points}}\right)\right)$$

$$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$$\mu\text{high}_{\text{measured}_d} := \text{mean}\left(\text{high}_{\text{points}}\right) \qquad \mu\text{low}_{\text{measured}_d} := \text{mean}\left(\text{low}_{\text{points}}\right)$$

$$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}\left(\text{high}_{\text{points}}\right) \qquad \sigma\text{low}_{\text{measured}_d} := \text{Stdev}\left(\text{low}_{\text{points}}\right)$$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{high}_{\text{points}}\right)}} \qquad \text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{low}_{\text{points}}\right)}}$$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\DATA ONLY\SB13C-D.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 23, 1996)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.095 & 1.118 & 1.128 & 1.098 & 1.08 & 1.115 & 1.125 \\ 1.035 & 1.069 & 0.996 & 1.057 & 1.008 & 1.131 & 1.105 \\ 0.975 & 1.025 & 0.896 & 0.848 & 0.992 & 1.086 & 1.054 \\ 1.015 & 0.987 & 0.966 & 1.032 & 0.942 & 0.968 & 1.03 \\ 0.936 & 0.94 & 0.875 & 0.926 & 0.961 & 0.959 & 1.005 \\ 0.965 & 0.94 & 0.988 & 0.937 & 0.912 & 0.868 & 0.932 \\ 0.931 & 0.939 & 0.936 & 0.97 & 0.941 & 0.837 & 0.822 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{49_d} := \text{nnn}_{48}$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

The two groups are named as follows:

$\text{Botstar} := 28$

$\text{Stoptop} := 16$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{DataCells}}, \text{Botstar})$

$\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{DataCells}}, \text{Stoptop})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 19, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 20, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 21, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 22, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 27, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 28, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$$low_{points} := Add\left(nnn, No_{DataCells}, 17, length\left(low_{points}\right), low_{points}\right)$$

$$low_{points} := Add\left(nnn, No_{DataCells}, 18, length\left(low_{points}\right), low_{points}\right)$$

$$low_{points} := Add\left(nnn, No_{DataCells}, 23, length\left(low_{points}\right), low_{points}\right)$$

$$low_{points} := Add\left(nnn, No_{DataCells}, 24, length\left(low_{points}\right), low_{points}\right)$$

$$low_{points} := Add\left(nnn, No_{DataCells}, 25, length\left(low_{points}\right), low_{points}\right)$$

$$low_{points} := Add\left(nnn, No_{DataCells}, 26, length\left(low_{points}\right), low_{points}\right)$$

$$Cells := deletezero_{cells}\left(nnn, No_{Cells}\right)$$

$$high_{points} := deletezero_{cells}\left(high_{points}, length\left(high_{points}\right)\right)$$

$$low_{points} := deletezero_{cells}\left(low_{points}, length\left(low_{points}\right)\right)$$

$$\mu_{measured_d} := mean(Cells) \qquad \sigma_{measured_d} := Stdev(Cells) \qquad Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$$

$$\mu high_{measured_d} := mean\left(high_{points}\right) \qquad \mu low_{measured_d} := mean\left(low_{points}\right)$$

$$\sigma high_{measured_d} := Stdev\left(high_{points}\right) \qquad \sigma low_{measured_d} := Stdev\left(low_{points}\right)$$

$$Standardhigh_{error_d} := \frac{\sigma high_{measured_d}}{\sqrt{length\left(high_{points}\right)}} \qquad Standardlow_{error_d} := \frac{\sigma low_{measured_d}}{\sqrt{length\left(low_{points}\right)}}$$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB13C-D.txt")

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

$\mathrm{Dates}_{d} := \mathrm{Day}_{\mathrm{year}}(9, 23, 2006)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 1.114 & 1.117 & 1.132 & 1.083 & 1.068 & 1.106 & 1.119 \\ 0.95 & 1.041 & 0.999 & 1.061 & 1.007 & 1.117 & 1.1 \\ 0.986 & 0.95 & 0.837 & 0.833 & 0.949 & 1.088 & 1.085 \\ 1.005 & 0.977 & 0.878 & 0.851 & 0.911 & 0.958 & 0.997 \\ 0.96 & 0.907 & 0.874 & 0.874 & 0.915 & 0.916 & 0.905 \\ 0.944 & 0.947 & 0.897 & 0.887 & 0.92 & 0.865 & 0.892 \\ 0.996 & 0.939 & 0.929 & 0.958 & 0.944 & 0.832 & 0.821 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}(\mathrm{Points}_{49}, 7)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

$\mathrm{Point}_{49_{d}} := \mathrm{nnn}_{48}$

The two groups are named as follows:

$\mathrm{Botstar} := 28$

$\mathrm{Stoptop} := 16$

$\mathrm{low}_{\mathrm{points}} := \mathrm{LOWROWS}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, \mathrm{Botstar})$

$\mathrm{high}_{\mathrm{points}} := \mathrm{TOPROWS}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, \mathrm{Stoptop})$

$\mathrm{high}_{\mathrm{points}} := \mathrm{Add}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 19, \mathrm{length}(\mathrm{high}_{\mathrm{points}}), \mathrm{high}_{\mathrm{points}})$

$\mathrm{high}_{\mathrm{points}} := \mathrm{Add}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 20, \mathrm{length}(\mathrm{high}_{\mathrm{points}}), \mathrm{high}_{\mathrm{points}})$

$\mathrm{high}_{\mathrm{points}} := \mathrm{Add}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 21, \mathrm{length}(\mathrm{high}_{\mathrm{points}}), \mathrm{high}_{\mathrm{points}})$

$\mathrm{high}_{\mathrm{points}} := \mathrm{Add}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 22, \mathrm{length}(\mathrm{high}_{\mathrm{points}}), \mathrm{high}_{\mathrm{points}})$

$\mathrm{high}_{\mathrm{points}} := \mathrm{Add}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 27, \mathrm{length}(\mathrm{high}_{\mathrm{points}}), \mathrm{high}_{\mathrm{points}})$

$\mathrm{high}_{\mathrm{points}} := \mathrm{Add}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 28, \mathrm{length}(\mathrm{high}_{\mathrm{points}}), \mathrm{high}_{\mathrm{points}})$

$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 17, \mathrm{length}(\mathrm{low}_{\mathrm{points}}), \mathrm{low}_{\mathrm{points}})$

$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 18, \mathrm{length}(\mathrm{low}_{\mathrm{points}}), \mathrm{low}_{\mathrm{points}})$

$low_{points} := Add\left(nnn, No_{DataCells}, 23, length\left(low_{points}\right), low_{points}\right)$

$low_{points} := Add\left(nnn, No_{DataCells}, 24, length\left(low_{points}\right), low_{points}\right)$

$low_{points} := Add\left(nnn, No_{DataCells}, 25, length\left(low_{points}\right), low_{points}\right)$

$low_{points} := Add\left(nnn, No_{DataCells}, 26, length\left(low_{points}\right), low_{points}\right)$

$Cells := deletezero_{cells}\left(nnn, No_{Cells}\right)$

$high_{points} := deletezero_{cells}\left(high_{points}, length\left(high_{points}\right)\right)$

$low_{points} := deletezero_{cells}\left(low_{points}, length\left(low_{points}\right)\right)$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$\mu high_{measured_d} := mean\left(high_{points}\right)$

$\sigma high_{measured_d} := Stdev\left(high_{points}\right)$

$\mu low_{measured_d} := mean\left(low_{points}\right)$

$\sigma low_{measured_d} := Stdev\left(low_{points}\right)$

$Standardhigh_{error_d} := \frac{\sigma high_{measured_d}}{\sqrt{length\left(high_{points}\right)}}$

$Standardlow_{error_d} := \frac{\sigma low_{measured_d}}{\sqrt{length\left(low_{points}\right)}}$

Below are the results

$$\text{Dates} = \begin{bmatrix} 1.993\cdot 10^3 \\ 1.995\cdot 10^3 \\ 1.997\cdot 10^3 \\ 2.007\cdot 10^3 \end{bmatrix} \qquad \text{Point}_{49} = \begin{bmatrix} 824 \\ 811 \\ 822 \\ 821 \end{bmatrix}$$

$$\text{Standard}_{\text{error}} = \begin{bmatrix} 13.307 \\ 12.681 \\ 11.589 \\ 12.877 \end{bmatrix}$$

$$\text{measured} = \begin{bmatrix} 972.755 \\ 958.898 \\ 989.714 \\ 968.184 \end{bmatrix}$$

$$\sigma_{\text{measured}} = \begin{bmatrix} 93.149 \\ 88.766 \\ 81.122 \\ 90.136 \end{bmatrix}$$

$$\text{high}_{\text{measured}} = \begin{bmatrix} 1.055\cdot 10^3 \\ 1.037\cdot 10^3 \\ 1.059\cdot 10^3 \\ 1.047\cdot 10^3 \end{bmatrix} \qquad \sigma\text{high}_{\text{measured}} = \begin{bmatrix} 66.239 \\ 63.573 \\ 52.578 \\ 64.111 \end{bmatrix} \qquad \text{Standardhigh}_{\text{error}} = \begin{bmatrix} 14.122 \\ 13.554 \\ 11.21 \\ 13.99 \end{bmatrix}$$

$$\text{low}_{\text{measured}} = \begin{bmatrix} 906.037 \\ 894.926 \\ 933 \\ 904.037 \end{bmatrix} \qquad \sigma\text{low}_{\text{measured}} = \begin{bmatrix} 46.682 \\ 42.624 \\ 49.767 \\ 46.499 \end{bmatrix} \qquad \text{Standardlow}_{\text{error}} = \begin{bmatrix} 8.984 \\ 8.203 \\ 9.578 \\ 8.949 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}\left(\mu_{\text{measured}}\right)$ $\text{Total}_{\text{means}} = 4$

$$SST := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2$$

$$SST_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{mean}\left(\mu\text{low}_{\text{measured}}\right)\right)^2$$

$$SST_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{mean}\left(\mu\text{high}_{\text{measured}}\right)\right)^2$$

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

$$SSE_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu\text{low}_{\text{measured}}\right)_i\right)^2$$

$$SSE_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu\text{high}_{\text{measured}}\right)_i\right)^2$$

$$SSR := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2$$

$$SSR_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu\text{low}_{\text{measured}}\right)_i - \text{mean}\left(\mu\text{low}_{\text{measured}}\right)\right)^2$$

$$SSR_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu\text{high}_{\text{measured}}\right)_i - \text{mean}\left(\mu\text{high}_{\text{measured}}\right)\right)^2$$

$DegreeFree_{ss} := Total_{means} - 2 \qquad DegreeFree_{reg} := 1 \qquad DegreeFree_{st} := Total_{means} - 1$

$$MSE := \frac{SSE}{DegreeFree_{ss}} \qquad MSE_{low} := \frac{SSE_{low}}{DegreeFree_{ss}} \qquad MSE_{high} := \frac{SSE_{high}}{DegreeFree_{ss}}$$

$$Standard_{error} := \sqrt{MSE} \qquad Standard_{lowerror} := \sqrt{MSE_{low}} \qquad Standard_{higherror} := \sqrt{MSE_{high}}$$

$$MSR := \frac{SSR}{DegreeFree_{reg}} \qquad MSR_{low} := \frac{SSR_{low}}{DegreeFree_{reg}} \qquad MSR_{high} := \frac{SSR_{high}}{DegreeFree_{reg}}$$

$$MST := \frac{SST}{DegreeFree_{st}} \qquad MST_{low} := \frac{SST_{low}}{DegreeFree_{st}} \qquad MST_{high} := \frac{SST_{high}}{DegreeFree_{st}}$$

Test the means with all points

F Test for Corrosion

$$\alpha := 0.05 \qquad F_{actaul\_Reg} := \frac{MSR}{MSE}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 5.244 \cdot 10^{-4}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Test the low points

F Test for Corrosion

$$F := \frac{MSR_{low}}{}$$

$\text{actaul\_Reg.low} \qquad \text{MSE}_{\text{low}}$

$$F_{\text{critical\_reg}} := qF\left(1-\alpha, \text{DegreeFree}_{\text{reg}}, \text{DegreeFree}_{\text{ss}}\right)$$

$$F_{\text{ratio\_reg.low}} := \frac{F_{\text{actaul\_Reg.low}}}{F_{\text{critical\_reg}}}$$

$$F_{\text{ratio\_reg.low}} = 1.907 \cdot 10^{-4}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Test the high points

F Test for Corrosion

$$F_{\text{actaul\_Reg.high}} := \frac{\text{MSR}_{\text{high}}}{\text{MSE}_{\text{high}}}$$

$$F_{\text{critical\_reg}} := qF\left(1-\alpha, \text{DegreeFree}_{\text{reg}}, \text{DegreeFree}_{\text{ss}}\right)$$

$$F_{\text{ratio\_reg.high}} := \frac{F_{\text{actaul\_Reg.high}}}{F_{\text{critical\_reg}}}$$

$$F_{\text{ratio\_reg.high}} = 1.588 \cdot 10^{-3}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

The following will plot the results for the overall mean, the mean of thinner points, and the mean of thicker points

$$i := 0 .. Total_{means} - 1$$

$$\mu grand_{measured_i} := mean(\mu_{measured}) \qquad \sigma grand_{measured} := Stdev(\mu_{measured})$$

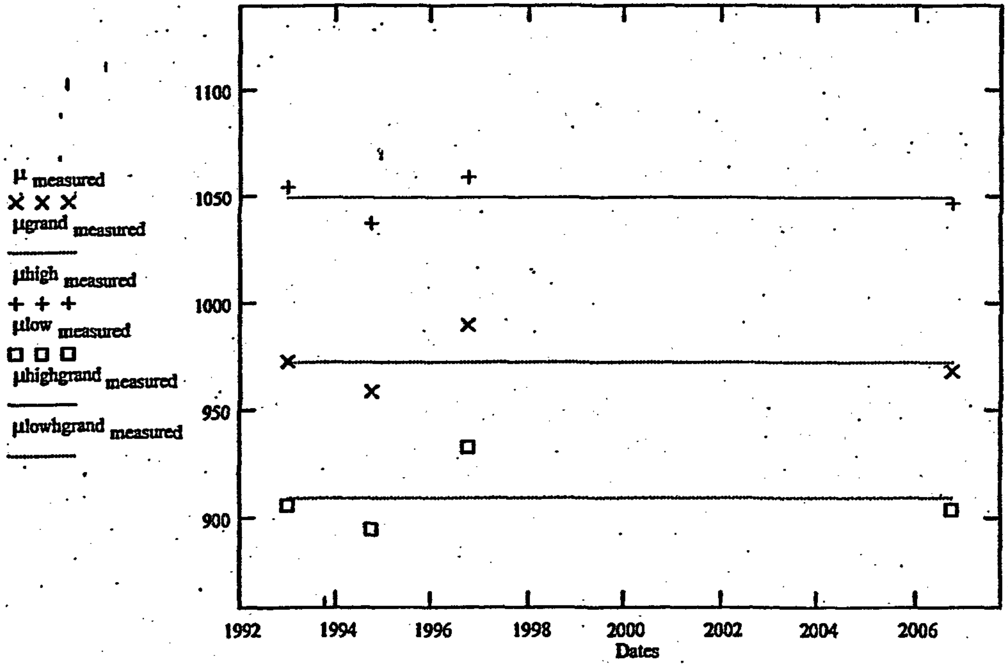
$$GrandStandard_{error} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$$

$$\sigma grand_{lowmeasured} := Stdev(\mu low_{measured}) \qquad \mu lowhgrand_{measured_i} := mean(\mu low_{measured})$$

$$GrandStandard_{lowerror} := \frac{\sigma grand_{lowmeasured}}{\sqrt{Total_{means}}}$$

$$\sigma grand_{highmeasured} := Stdev(\mu high_{measured}) \qquad \mu highgrand_{measured_i} := mean(\mu high_{measured})$$

$$GrandStandard_{higherror} := \frac{\sigma grand_{highmeasured}}{\sqrt{Total_{means}}}$$



$$\mu grand_{measured_0} = 972.388 \qquad GrandStandard_{error} = 6.455$$

$$mean(\mu low_{measured}) = 909.5 \qquad GrandStandard_{lowerror} = 8.198$$

$$mean(\mu high_{measured}) = 1.05 \cdot 10^{3} \qquad GrandStandard_{higherror} = 4.793$$

ie st indicates that the regression model does not hold for any of the data sets. However, the slopes d 95% Confidence curves are generated for all three cases.

$m_s := \mathrm{slope}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)$ $y_b := \mathrm{intercept}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)$

$m_{\mathrm{lows}} := \mathrm{slope}\left(\mathrm{Dates}, \mu\mathrm{low}_{\mathrm{measured}}\right)$ $y_{\mathrm{lowb}} := \mathrm{intercept}\left(\mathrm{Dates}, \mu\mathrm{low}_{\mathrm{measured}}\right)$

$m_{\mathrm{highs}} := \mathrm{slope}\left(\mathrm{Dates}, \mu\mathrm{high}_{\mathrm{measured}}\right)$ $y_{\mathrm{highb}} := \mathrm{intercept}\left(\mathrm{Dates}, \mu\mathrm{high}_{\mathrm{measured}}\right)$

$\alpha_t := 0.05 \qquad k := 23 \qquad f := 0..k-1$

$\mathrm{year}_{\mathrm{predict}_f} := 1985 + f\cdot 2$

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

$\mathrm{Thick}_{\mathrm{lowpredict}} := m_{\mathrm{lows}}\cdot \mathrm{year}_{\mathrm{predict}} + y_{\mathrm{lowb}}$

$\mathrm{Thick}_{\mathrm{highpredict}} := m_{\mathrm{highs}}\cdot \mathrm{year}_{\mathrm{predict}} + y_{\mathrm{highb}}$

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

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

For the entire grid

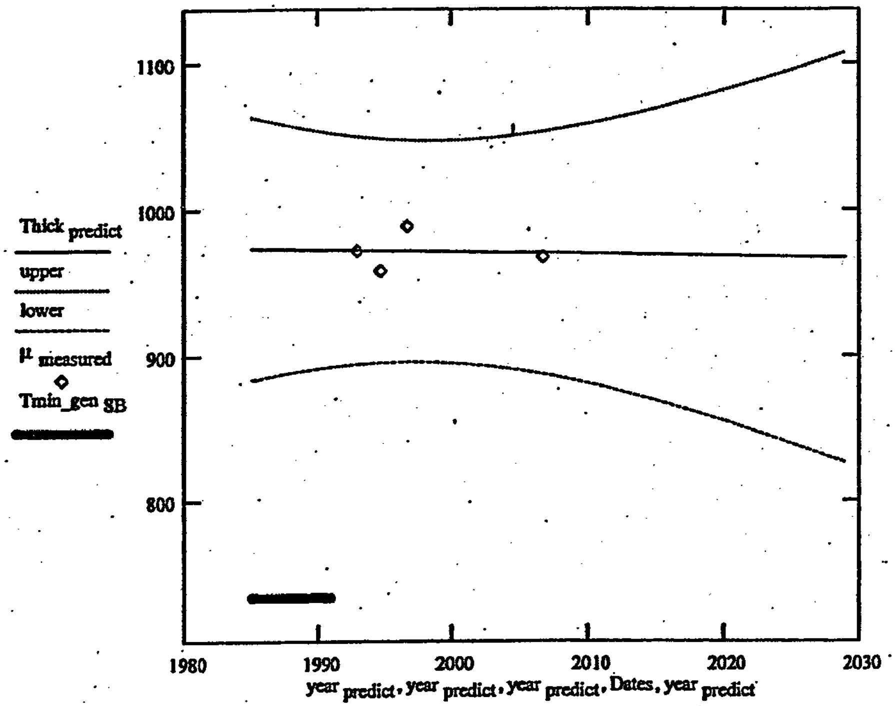
$$\text{upper}_f := \text{Thick}_{\text{predict}_f} -$$

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

$$\text{ower}_f := \text{Thick}_{\text{predict}_f} -$$

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

minimum required thickness at this elevation is $\text{Tmin\_gen}_{\text{SB}_i} := 736$ (Ref. 3.25)

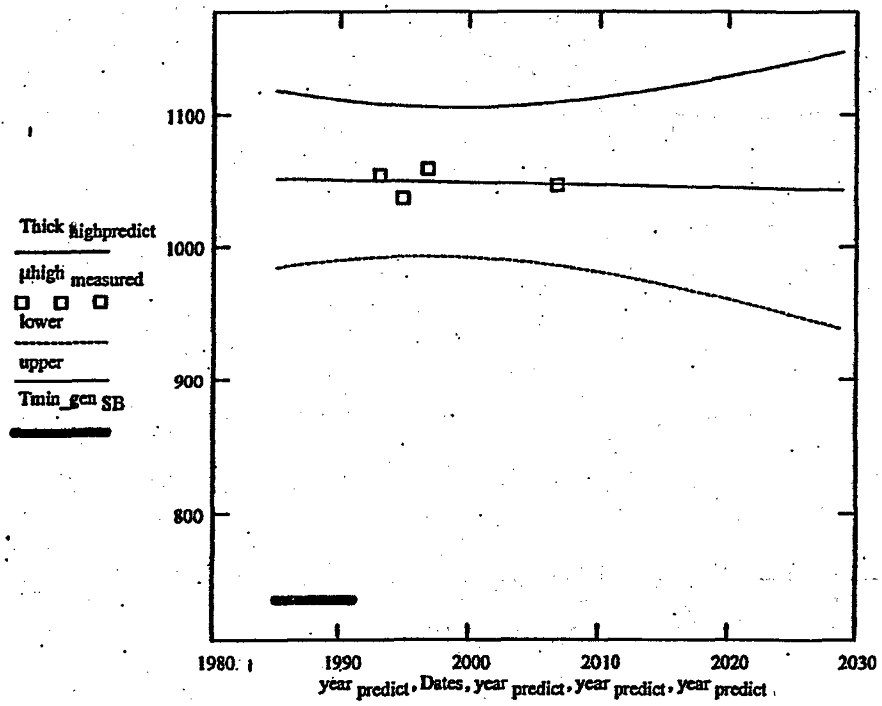


$m_s = -0.146$

d points which are thicker

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

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



$m_{\mathrm{highs}} = -0.188$

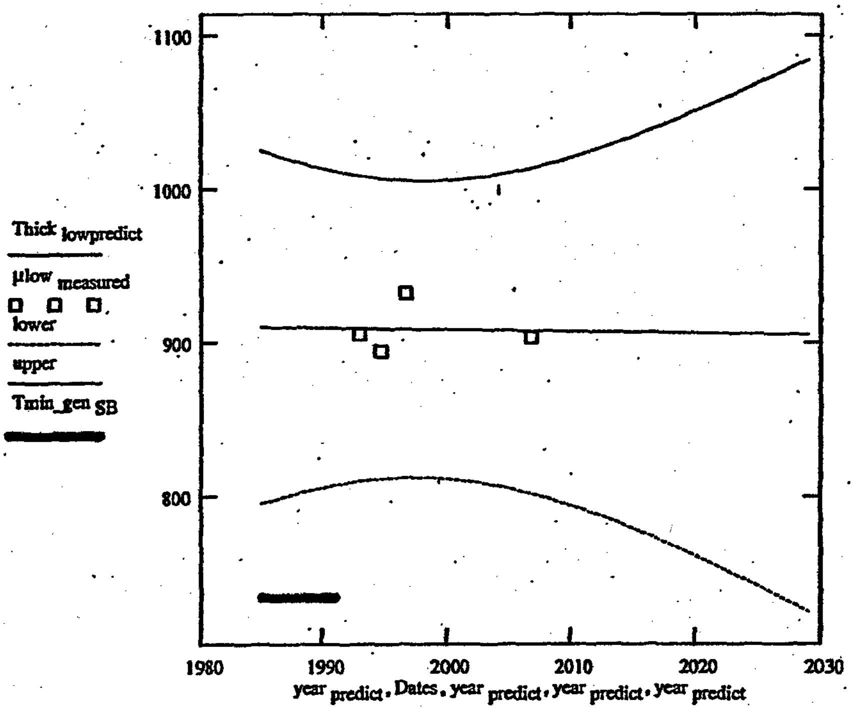
For the points which are thinner

$$upper_f := Thick_{lowpredict_f} \cdots$$

$$+\,qt\left(1-\frac{\alpha_t}{2}, Total_{means}-2\right)\cdot Standard_{lowerror}\cdot\sqrt{1+\frac{1}{(d+1)}+\frac{\left(year_{predict_f}-Thick_{actualmean}\right)^2}{sum}}$$

$$lower_f := Thick_{lowpredict_f} \cdots$$

$$+\,-\left[qt\left(1-\frac{\alpha_t}{2}, Total_{means}-2\right)\cdot Standard_{lowerror}\cdot\sqrt{1+\frac{1}{(d+1)}+\frac{\left(year_{predict_f}-Thick_{actualmean}\right)^2}{sum}}\right]$$



$m_{lows} = -0.112$

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 809.484$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

following addresses the readings at the lowest single point

$$\text{point} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{Point}_{49_i} - \text{mean}\left(\text{Point}_{49}\right)\right)^2 \qquad \text{SST}_{\text{point}} = 101$$

$$\text{point} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{Point}_{49_i} - \text{yhat}\left(\text{Dates}, \text{Point}_{49}\right)_i\right)^2 \qquad \text{SSE}_{\text{point}} = 98.974$$

$$\text{point} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \text{Point}_{49}\right)_i - \text{mean}\left(\text{Point}_{49}\right)\right)^2 \qquad \text{SSR}_{\text{point}} = 2.026$$

$$\text{ISE}_{\text{point}} := \frac{\text{SSE}_{\text{point}}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR}_{\text{point}} := \frac{\text{SSR}_{\text{point}}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST}_{\text{point}} := \frac{\text{SST}_{\text{point}}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{ISE}_{\text{point}} = 49.487 \qquad \text{MSR}_{\text{point}} = 2.026 \qquad \text{MST}_{\text{point}} = 33.667$$

$$\text{StPoint}_{\text{err}} := \sqrt{\text{MSE}_{\text{point}}} \qquad \text{StPoint}_{\text{err}} = 7.035$$

F Test for Corrosion

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

$$F_{\text{ratio\_reg}} := \frac{F_{\text{actaul\_Reg}}}{F_{\text{critical\_reg}}}$$

$$F_{\text{ratio\_reg}} = 2.212 \cdot 10^{-3}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Therefore this point is not experiencing corrosion

$m_{ponit} := \text{slope}(\text{Dates}, \text{Point}_{49})$ $m_{ponit} = 0.134$ $y_{ponit} := \text{intercept}(\text{Dates}, \text{Point}_{49}$ $y_{ponit} = 552.333$

The 95% Confidence curves are calculated

$\text{Point}_{curve} := m_{ponit} \cdot \text{year}_{predict} + y_{ponit}$

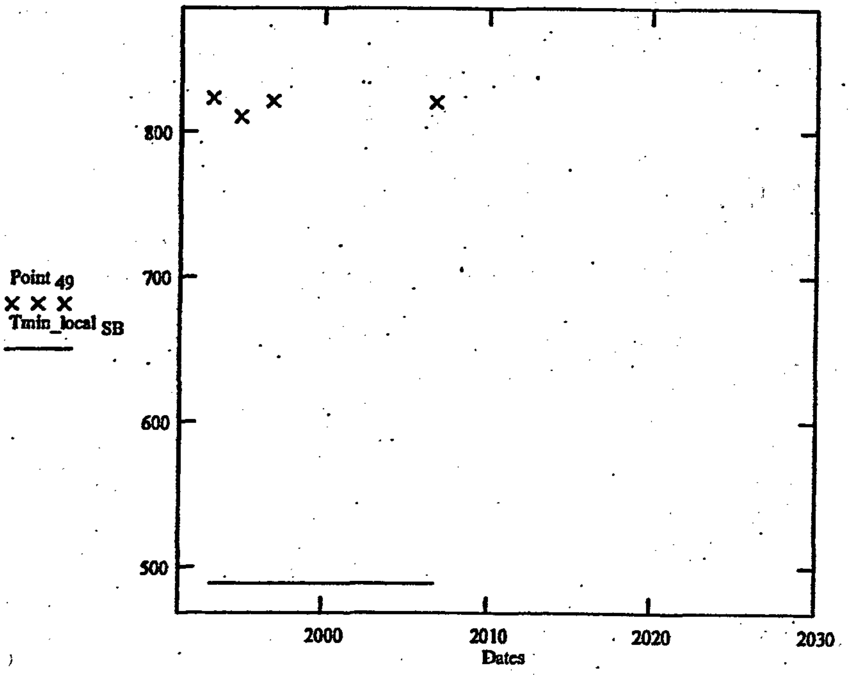
$\text{Point}_{actualmean} := \text{mean}(\text{Dates})$ $\text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

$$\text{upponit}_f := \text{Point}_{curve_f} + qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{predict_f} - \text{Point}_{actualmean}\right)^2}{\text{sum}}}$$

$$\text{loponit}_f := \text{Point}_{curve_f} + -\left[qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{predict_f} - \text{Point}_{actualmean}\right)^2}{\text{sum}}}\right]$$

Local Tmin for this elevation in the Drywell $\text{Tmin\_local}_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 49 Projected to Plant End Of Life



$m_{ponit} = 0.134$

$\text{loponit}_{22} = 760.894$ $\text{year}_{predict_{22}} = 2.029 \cdot 10^3$

Therefore based on regression model the above curve shows that this point will not corrode to below minimum required thickness by the plant end of life.

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point}_{49_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 662.3$ which is greater than $\text{Tmin\_local}_{SB_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 0.821$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{SB_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{SB_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -13.792$ mils per year

Appendix 6 - Sand Bed Elevation Bay 15D

October 2006 Data

The data shown below was collected on 10/18/06

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB15D.txt")

$$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$$

$$\mathrm{Points}_{49} = \begin{bmatrix} 1.133 & 1.133 & 1.133 & 1.141 & 1.145 & 1.145 & 1.144 \\ 1.094 & 1.109 & 1.087 & 1.142 & 1.129 & 1.119 & 1.131 \\ 1.04 & 1.026 & 1.043 & 1.081 & 1.095 & 1.085 & 1.096 \\ 0.978 & 0.948 & 0.975 & 1.029 & 1.03 & 1.096 & 1.068 \\ 0.976 & 0.969 & 0.977 & 1.069 & 1.013 & 1.067 & 1.041 \\ 0.93 & 0.979 & 1.031 & 1.037 & 1.017 & 1.059 & 1.051 \\ 0.922 & 0.972 & 0.996 & 1.031 & 1.005 & 1.033 & 1.052 \end{bmatrix}$$

$\mathrm{Cells} := \mathrm{convert}(\mathrm{Points}_{49}, 7)$ $\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{Cells})$

The thinnest point at this location is shown below

For this location the thinnest point is number 43 (reference 3.22).

$$\mathrm{minpoint} := \min(\mathrm{Points}_{49})$$

$$\mathrm{minpoint} = 0.922$$

$$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}(\mathrm{Cells}, \mathrm{No}_{\mathrm{DataCells}})$$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(Cells)$ $\mu_{actual} = 1.0531 \cdot 10^3$ $\sigma_{actual} := \text{Stdev}(Cells)$ $\sigma_{actual} = 62.649$

Standard Error

$$Standard_{error} := \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}}$$

$Standard_{error} = 8.95$

Skewness

$$Skewness := \frac{(No_{DataCells}) \cdot \Sigma\overrightarrow{(Cells - \mu_{actual})^3}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (\sigma_{actual})^3}$$

$Skewness = -0.187$

Kurtosis

$$Kurtosis := \frac{No_{DataCells} \cdot (No_{DataCells} + 1) \cdot \Sigma\overrightarrow{(Cells - \mu_{actual})^4}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (No_{DataCells} - 3) \cdot (\sigma_{actual})^4} + -\frac{3 \cdot (No_{DataCells} - 1)^2}{(No_{DataCells} - 2) \cdot (No_{DataCells} - 3)}$$

$Kurtosis = -0.898$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

$$\alpha := .05 \qquad T\alpha := \text{qt}\left[\left(1 - \frac{\alpha}{2}\right), \text{No}_{\text{DataCells}}\right] \qquad T\alpha = 2.01$$

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 1.035 \cdot 10^{3}$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 1.071 \cdot 10^{3}$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$\text{Distribution} = \begin{pmatrix} 0 \\ 1 \\ 2 \\ 7 \\ 4 \\ 12 \\ 5 \\ 7 \\ 11 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

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

$$\text{normal}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_{1}, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

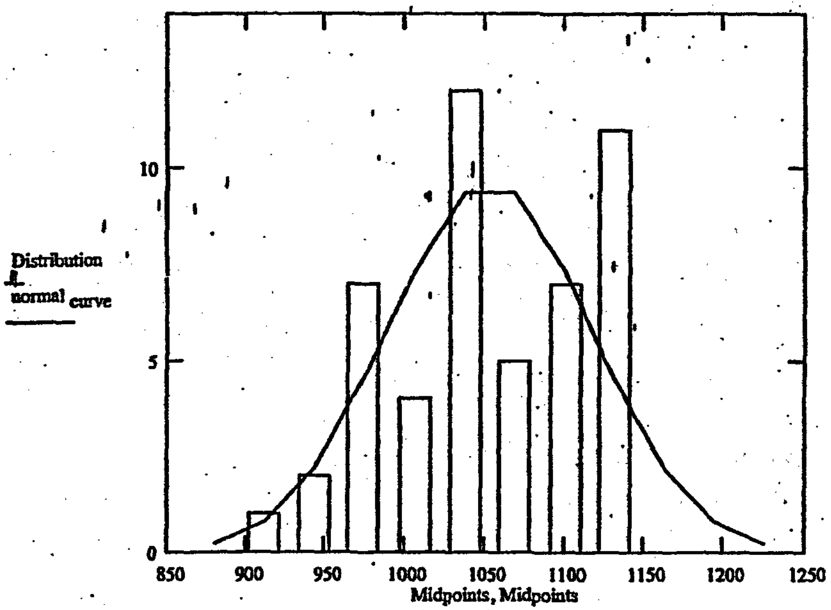
$$\text{normal}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{k+1}, \mu_{\text{actual}}, \sigma_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_{k}, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

$$\text{normal}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$$

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 1.053 \cdot 10^3$

$\sigma_{actual} = 62.649$

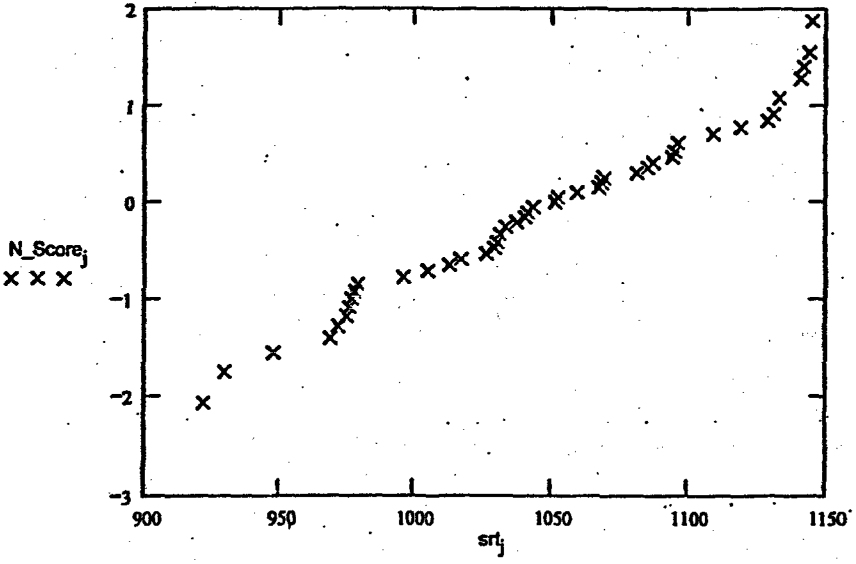
$Standard_{error} = 8.95$

$Skewness = -0.187$

$Kurtosis = -0.898$

$Lower_{95\%Con} = 1.035 \cdot 10^3$ $Upper_{95\%Con} = 1.071 \cdot 10^3$

Normal Probability Plot



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

Sandbed Location 15D Trend

$d := 0$

Data from the 1992, 1994 and 1996 is retrieved.

For 1992

$Dates_d := Day_{year}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB15D.txt")

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

Data

$$Points_{49} = \begin{bmatrix} 1.131 & 1.133 & 1.133 & 1.141 & 1.145 & 1.134 & 1.142 \\ 1.096 & 1.111 & 1.088 & 1.091 & 1.126 & 1.118 & 1.133 \\ 1.066 & 1.031 & 1.048 & 1.067 & 1.094 & 1.079 & 1.09 \\ 0.98 & 0.923 & 0.989 & 1.038 & 1.036 & 1.092 & 1.081 \\ 0.99 & 0.985 & 0.894 & 1.054 & 1.048 & 1.065 & 1.091 \\ 0.925 & 1.019 & 1.041 & 1.051 & 1.064 & 1.075 & 1.055 \\ 0.98 & 0.958 & 0.991 & 1.036 & 1.027 & 1.074 & 1.069 \end{bmatrix}$$

$nnn := convert\left(Points_{49}, 7\right)$

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

$point_{42_d} := nnn_{42}$

$point_{42} = 980$

$Cells := deletezero_{cells}\left(nnn, No_{DataCells}\right)$

$\mu_{measured_d} := mean(Cells)$

$\sigma_{measured_d} := Stdev(Cells)$

$$Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$$

For 1994

$d := d + 1$

$page := READPRN("U:\backslash MSOFFICE\backslash Drywell Program data\backslash Sept.1994 Data\backslash sandbed\backslash Data Only\backslash SB15D.txt")$

$Dates_d := Day_{year}(9, 14, 1994)$

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

Data

$$Points_{49} = \begin{bmatrix} 1.126 & 1.132 & 1.133 & 1.14 & 1.142 & 1.131 & 1.14 \\ 1.097 & 1.106 & 1.089 & 1.141 & 1.129 & 1.119 & 1.129 \\ 1.063 & 1.025 & 1.046 & 1.067 & 1.096 & 1.08 & 1.097 \\ 0.979 & 0.947 & 0.966 & 1.018 & 1.035 & 1.097 & 1.068 \\ 0.973 & 0.971 & 1.001 & 1.05 & 1.05 & 1.066 & 1.029 \\ 0.92 & 0.972 & 1.03 & 1.049 & 1.009 & 1.058 & 1.036 \\ 0.903 & 0.958 & 1.013 & 1.031 & 1.004 & 1.052 & 1.076 \end{bmatrix}$$

$nnn := convert\left(Points_{49}, 7\right)$ $No_{DataCells} := length(nnn)$

$point42_d := nnn_{42}$

$Cells := deletezero_{cells}\left(nnn, No_{DataCells}\right)$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 1996

$d := d + 1$

$page := READPRN(\text{"U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB15D.txt"})$

$Dates_d := Day_{year}(9, 16, 1996)$

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

Data

$$Points_{49} = \begin{bmatrix} 1.134 & 1.128 & 1.13 & 1.136 & 1.143 & 1.13 & 1.146 \\ 1.089 & 1.105 & 1.09 & 1.145 & 1.13 & 1.124 & 1.136 \\ 1.071 & 1.027 & 1.049 & 1.062 & 1.128 & 1.08 & 1.095 \\ 0.982 & 0.959 & 1.01 & 1.069 & 1.061 & 1.128 & 1.128 \\ 0.989 & 0.987 & 1.016 & 1.052 & 1.032 & 1.074 & 1.09 \\ 0.945 & 0.972 & 1.031 & 1.062 & 1.064 & 1.07 & 1.07 \\ 0.94 & 0.968 & 0.984 & 1.048 & 1.034 & 1.076 & 1.114 \end{bmatrix}$$

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

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

$point\,42_d := nnn_{42}$

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

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB15D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.133 & 1.133 & 1.133 & 1.141 & 1.145 & 1.145 & 1.144 \\ 1.094 & 1.109 & 1.087 & 1.142 & 1.129 & 1.119 & 1.131 \\ 1.04 & 1.026 & 1.043 & 1.081 & 1.095 & 1.085 & 1.096 \\ 0.978 & 0.948 & 0.975 & 1.029 & 1.03 & 1.096 & 1.068 \\ 0.976 & 0.969 & 0.977 & 1.069 & 1.013 & 1.067 & 1.041 \\ 0.93 & 0.979 & 1.031 & 1.037 & 1.017 & 1.059 & 1.051 \\ 0.922 & 0.972 & 0.996 & 1.031 & 1.005 & 1.033 & 1.052 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{point}_{42_d} := \text{nnn}_{42}$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993\cdot10^3 \\ 1.995\cdot10^3 \\ 1.997\cdot10^3 \\ 2.007\cdot10^3 \end{bmatrix} \qquad \text{point}_{42} = \begin{bmatrix} 980 \\ 903 \\ 940 \\ 922 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.0577\cdot10^3 \\ 1.0528\cdot10^3 \\ 1.066\cdot10^3 \\ 1.0531\cdot10^3 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 8.741 \\ 9.002 \\ 8.466 \\ 8.95 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 61.188 \\ 63.017 \\ 59.263 \\ 62.649 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}}) \qquad \text{Total}_{\text{means}} = 4$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SST} = 113.004$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 102.131$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 10.872$$

$$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{MSE} = 51.066 \qquad \text{MSR} = 10.872 \qquad \text{MST} = 37.668$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 7.146$$

F Test for Corrosion

$\alpha := 0.05$ $\qquad F_{actaul\_Reg} := \frac{MSR}{MSE}$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.012$$

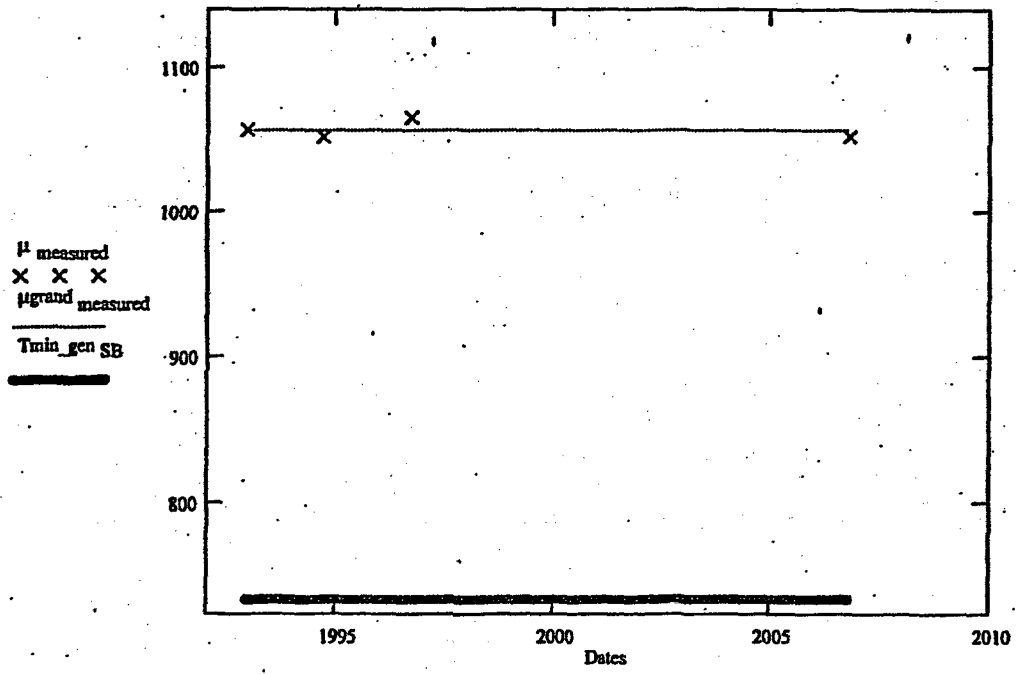
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\qquad \mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$ $\qquad GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 1.057 \cdot 10^3$ $\qquad GrandStandard_{error} = 3.069$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}\left(\text{Dates}, \mu_{\text{measured}}\right) \quad m_s = -0.307 \quad y_b := \text{intercept}\left(\text{Dates}, \mu_{\text{measured}}\right) \quad y_b = 1.671 \cdot 10^3$

The 95% Confidence curves are calculated

$\alpha_t := 0.05 \quad k := 2029 - 1985 \qquad f := 0 .. k - 1$

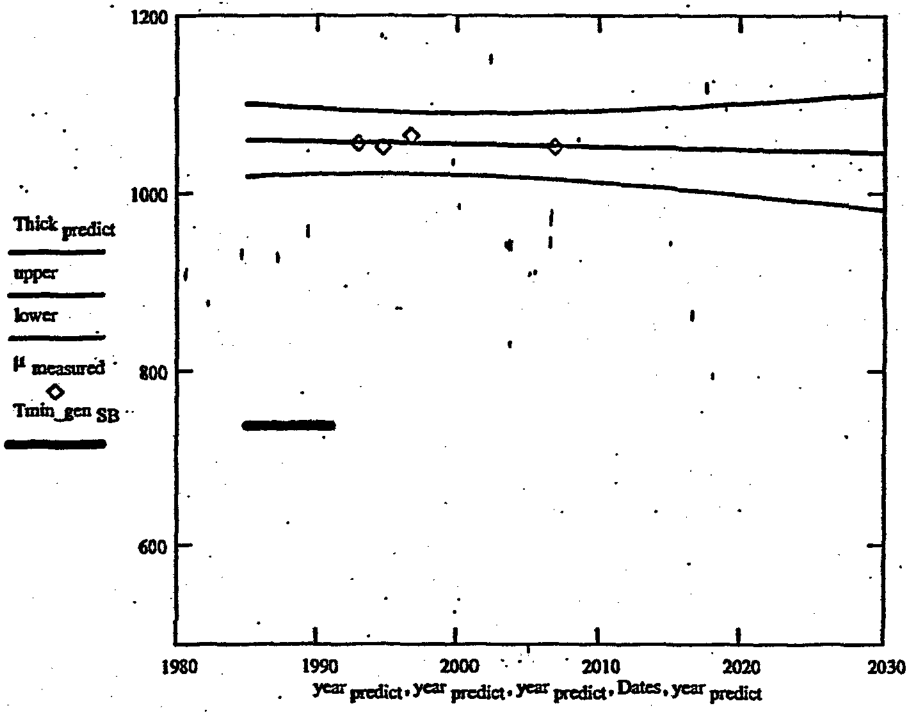
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2 \quad \text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates}) \qquad \text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s' = -0.307$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 894.402$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

The F-Ratio is calculated for the point as follows

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(point_{42_i} - mean\left(point_{42}\right)\right)^2 \qquad SST_{point} = 3.237 \cdot 10^3$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(point_{42_i} - yhat\left(Dates, point_{42}\right)_i\right)^2 \qquad SSE_{point} = 2.729 \cdot 10^3$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, point_{42}\right)_i - mean\left(point_{42}\right)\right)^2 \qquad SSR_{point} = 508.213$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 1.364 \cdot 10^3 \qquad MSR_{point} = 508.213 \qquad MST_{point} = 1.079 \cdot 10^3$$

$$Stpoint_{err} := \sqrt{MSE_{point}} \qquad Stpoint_{err} = 36.936$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.02$$

Therefore no conclusion can be made as to whether the data best fits the regression. The figure below provides a trend of the data and the grandmean

$m_{point} := slope(Dates, point_{42})$ $m_{point} = -2.1$ $y_{point} := intercept(Dates, point_{42})$ $y_{point} = 5.131 \cdot 10^3$

The 95% Confidence curves are calculated

$point_{curve} := m_{point} \cdot year_{predict} + y_{point}$

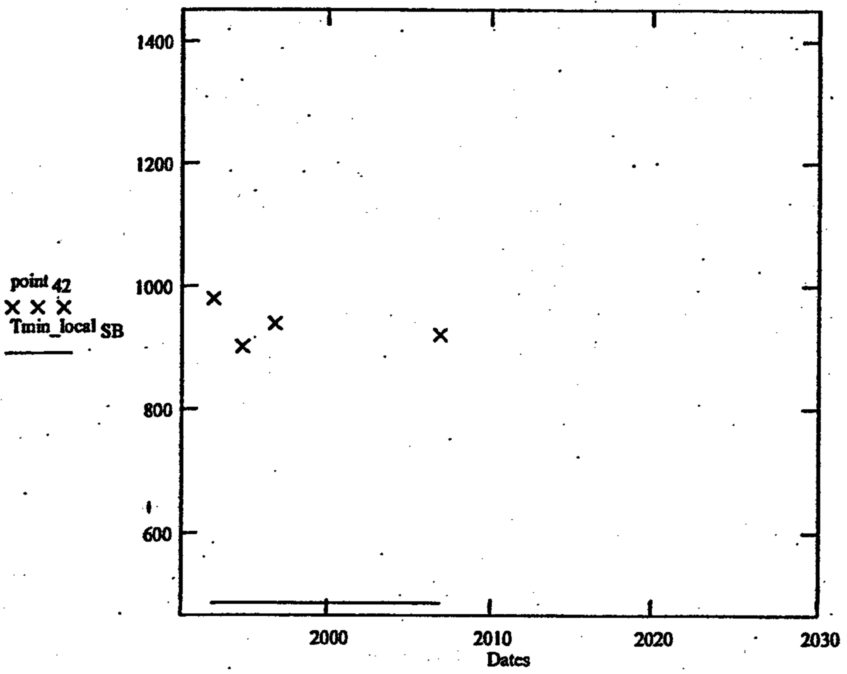
$point_{actualmean} := mean(Dates)$ $sum := \sum_i (Dates_d - mean(Dates))^2$

$$uppoint_f := point_{curve_f} \dots + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Stpoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(year_{predict_f} - point_{actualmean})^2}{sum}}$$

$$lopoint_f := point_{curve_f} \dots + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Stpoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(year_{predict_f} - point_{actualmean})^2}{sum}}\right]$$

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For point 42 Projected to Plant End Of Life



$m_{point} = -2.1$

$lopoint_{22} = 542.962$ $year_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{point}_{42_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 763.3$ which is greater than $\text{Tmin\_local}_{SB_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 0.922$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{SB_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{SB_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -18$ mils per year

Appendix 7 - Sandbed 17A
October 2006 Data

The data shown below was collected on 10/18/06

$$\text{page} := \text{READPRN}(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Oct 2006 Data\textbackslash Sandbed\textbackslash SB17A.txt"})$$

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

$$\text{Points}_{49} = \begin{bmatrix} 1.11 & 1.149 & 1.154 & 1.138 & 1.13 & 1.17 & 1.169 \\ 1.121 & 1.159 & 1.114 & 1.144 & 1.134 & 1.148 & 1.123 \\ 1.068 & 1.073 & 1.111 & 1.114 & 1.094 & 1.083 & 1.053 \\ 0.976 & 0.991 & 0.98 & 1.03 & 1.046 & 0.994 & 0.95 \\ 0.962 & 0.926 & 0.909 & 0.95 & 0.869 & 0.938 & 0.967 \\ 0.903 & 0.956 & 0.891 & 0.835 & 0.802 & 0.95 & 0.963 \\ 0.954 & 0.972 & 0.877 & 0.89 & 0.875 & 0.891 & 0.945 \end{bmatrix}$$

$$\text{Cells} := \text{convert}\left(\text{Points}_{49}, 7\right) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

The thinnest point at this location is point 40 which shown below

$$\text{minpoint} := \min\left(\text{Points}_{49}\right)$$

$$\text{minpoint} = 0.802$$

$$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$$

$$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 1.015 \cdot 10^{3}$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 104.378$

$\text{minpoint} = 0.802$

Standard Error

$$\text{Standard}_{error} := \frac{\sigma_{actual}}{\sqrt{\text{No}_{DataCells}}} \qquad \text{Standard}_{error} = 14.911$$

Skewness

$$\text{Skewness} := \frac{\left(\text{No}_{DataCells}\right)\cdot\overrightarrow{\Sigma\left(\text{Cells} - \mu_{actual}\right)^{3}}}{\left(\text{No}_{DataCells} - 1\right)\cdot\left(\text{No}_{DataCells} - 2\right)\cdot\left(\sigma_{actual}\right)^{3}} \qquad \text{Skewness} = -0.073$$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{DataCells}\cdot\left(\text{No}_{DataCells} + 1\right)\cdot\overrightarrow{\Sigma\left(\text{Cells} - \mu_{actual}\right)^{4}}}{\left(\text{No}_{DataCells} - 1\right)\cdot\left(\text{No}_{DataCells} - 2\right)\cdot\left(\text{No}_{DataCells} - 3\right)\cdot\left(\sigma_{actual}\right)^{4}} + -\frac{3\cdot\left(\text{No}_{DataCells} - 1\right)^{2}}{\left(\text{No}_{DataCells} - 2\right)\cdot\left(\text{No}_{DataCells} - 3\right)} \qquad \text{Kurtosis} = -1.266$$

Normal Probability Plot

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

$$r_j := j + 1 \qquad \text{rank}_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{\text{srt} = \text{srt}_j}\right)\cdot r}}{\Sigma\overrightarrow{\text{srt} = \text{srt}_j}}$$

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

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

Upper and Lower Confidence Values

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

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

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 985.346$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 1.045 \cdot 10^{3}$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$\text{Distribution} = \begin{array}{|c|} \hline 0 \\ \hline 1 \\ \hline 1 \\ \hline 8 \\ \hline 10 \\ \hline 6 \\ \hline 3 \\ \hline 8 \\ \hline 12 \\ \hline 0 \\ \hline 0 \\ \hline 0 \\ \hline \end{array}$$

The mid points of the Bins are calculated

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

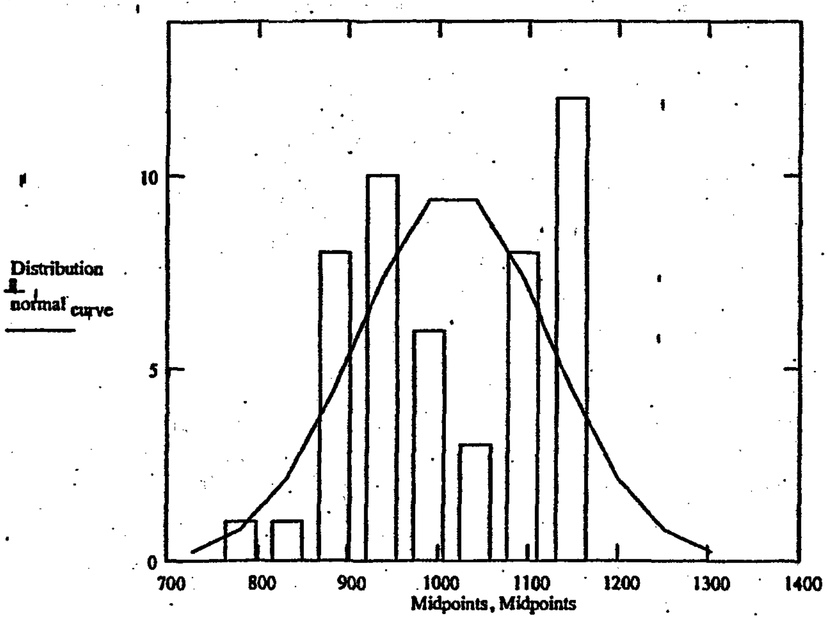
$$\text{normal}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_1, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

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

$$\text{normal}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$$

Results For 17A - The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values.

Data Distribution



$\mu_{actual} = 1.015 \cdot 10^3$

$\sigma_{actual} = 104.378$

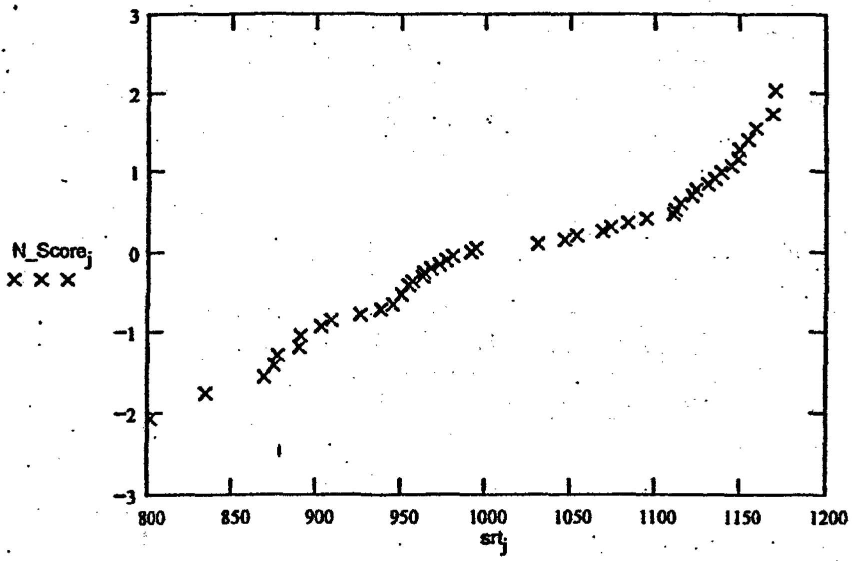
$\text{Standard}_{error} = 14.911$

Skewness = −0.073

Kurtosis = −1.266

$\text{Lower}_{95\%Con} = 985.346$ $\text{Upper}_{95\%Con} = 1.045 \cdot 10^3$

Normal Probability Plot



The data is not normally distributed. Previous calculations have split this data set into the top 3 row and the bottom four rows. In order to be consistent with past calculations this data will be split in two groups and analyzed. The entire data set will also be evaluated.

The two groups are named as follows: $StopCELL := 21$

$low_{points} := LOWROWS(Cells, No_{DataCells}, StopCELL)$, $high_{points} := TOPROWS(Cells, 49, StopCELL)$

Mean and Standard Deviation

$\mu low_{actual} := mean(low_{points})$ $\sigma low_{actual} := Stdev(low_{points})$

$\mu high_{actual} := mean(high_{points})$ $\sigma high_{actual} := Stdev(high_{points})$

Standard Error

$$Standardlow_{error} := \frac{\sigma low_{actual}}{\sqrt{length(low_{points})}} \qquad Standardhigh_{error} := \frac{\sigma high_{actual}}{\sqrt{length(high_{points})}}$$

Skewness

$Nolow_{DataCells} := length(low_{points})$

$$Skewness_{low} := \frac{(Nolow_{DataCells}) \cdot \Sigma\overrightarrow{(low_{points} - \mu low_{actual})^3}}{(Nolow_{DataCells} - 1) \cdot (Nolow_{DataCells} - 2) \cdot (\sigma low_{actual})^3}$$

$Nohigh_{DataCells} := length(high_{points})$

$$Skewness_{high} := \frac{(Nohigh_{DataCells}) \cdot \Sigma\overrightarrow{(high_{points} - \mu high_{actual})^3}}{(Nohigh_{DataCells} - 1) \cdot (Nohigh_{DataCells} - 2) \cdot (\sigma high_{actual})^3}$$

Kurtosis

$$Kurtosis_{low} := \frac{Nolow_{DataCells}\cdot\left(Nolow_{DataCells}+1\right)\cdot\overrightarrow{\Sigma\left(low_{points}-\mu low_{actual}\right)}^{4}}{\left(Nolow_{DataCells}-1\right)\cdot\left(Nolow_{DataCells}-2\right)\cdot\left(Nolow_{DataCells}-3\right)\cdot\left(\sigma low_{actual}\right)^{4}} \cdots + -\frac{3\cdot\left(Nolow_{DataCells}-1\right)^{2}}{\left(Nolow_{DataCells}-2\right)\cdot\left(Nolow_{DataCells}-3\right)}$$

$$Kurtosis_{high} := \frac{Nohigh_{DataCells}\cdot\left(Nohigh_{DataCells}+1\right)\cdot\overrightarrow{\Sigma\left(high_{points}-\mu high_{actual}\right)}^{4}}{\left(Nohigh_{DataCells}-1\right)\cdot\left(Nohigh_{DataCells}-2\right)\cdot\left(Nohigh_{DataCells}-3\right)\cdot\left(\sigma high_{actual}\right)^{4}} \cdots + -\frac{3\cdot\left(Nohigh_{DataCells}-1\right)^{2}}{\left(Nohigh_{DataCells}-2\right)\cdot\left(Nohigh_{DataCells}-3\right)}$$

Normal Probability Plot - Low points

$l := 0 .. last\left(low_{points}\right) \quad srt_{low} := sort\left(low_{points}\right)$

$L_l := l + 1$

$$rank_{low_l} := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt_{low}=srt_{low_l}}\right)\cdot L}}{\overrightarrow{\Sigma srt_{low}=srt_{low_l}}} \qquad p_{low_l} := \frac{rank_{low_l}}{rows\left(low_{points}\right)+1}$$

$x := 1 \qquad N\_Score_{low_l} := root\left[cnorm(x)-\left(p_{low_l}\right), x\right]$

Normal Probability Plot - High points

$h := 0 .. last\left(high_{points}\right) \qquad srt_{high} := sort\left(high_{points}\right)$

$H_h := h + 1$

$$rank_{high_h} := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt_{high}=srt_{high_h}}\right)\cdot H}}{\overrightarrow{\Sigma srt_{high}=srt_{high_h}}} \qquad p_{high_h} := \frac{rank_{high_h}}{rows\left(high_{points}\right)+1}$$

$x := 1 \qquad N\_Score_{high_h} := root\left[cnorm(x)-\left(p_{high_h}\right), x\right]$

Upper and Lower Confidence Values

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

$$Lowerhigh_{95\%Con} := \mu high_{actual} - T\alpha \cdot \frac{\sigma high_{actual}}{\sqrt{Nohigh_{DataCells}}}$$

$$Upperhigh_{95\%Con} := \mu high_{actual} + T\alpha \cdot \frac{\sigma high_{actual}}{\sqrt{Nohigh_{DataCells}}}$$

$$Lowerlow_{95\%Con} := \mu low_{actual} - T\alpha \cdot \frac{\sigma low_{actual}}{\sqrt{Nolow_{DataCells}}}$$

$$Upperlow_{95\%Con} := \mu low_{actual} + T\alpha \cdot \frac{\sigma low_{actual}}{\sqrt{Nolow_{DataCells}}}$$

Graphical Representation of Low Points

$$Bins_{low} := Make_{bins}\left(\mu low_{actual}, \sigma low_{actual}\right)$$

$$Distribution_{low} := hist\left(Bins_{low}, low_{points}\right)$$

$$Distribution_{low} = \begin{pmatrix} 0 \\ 1 \\ 1 \\ 3 \\ 4 \\ 2 \\ 9 \\ 5 \\ 1 \\ 2 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

$k := 0 .. 11$

$$Midpoints_{low_k} := \frac{\left(Bins_{low_k} + Bins_{low_{k+1}}\right)}{2}$$

$$normallow_{curve_0} := pnorm\left(Bins_{low_1}, \mu low_{actual}, \sigma low_{actual}\right)$$

$$normallow_{curve_k} := pnorm\left(Bins_{low_{k+1}}, \mu low_{actual}, \sigma low_{actual}\right) - pnorm\left(Bins_{low_k}, \mu low_{actual}, \sigma low_{actual}\right)$$

$$normallow_{curve} := Nolow_{DataCells} \cdot normallow_{curve}$$

Graphical Representation of High Points

$$\text{Bins}_{\text{high}} := \text{Make}_{\text{bins}}\left(\mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$$

$$\text{Distribution}_{\text{high}} := \text{hist}\left(\text{Bins}_{\text{high}}, \text{high}_{\text{points}}\right)$$

$$\text{Distribution}_{\text{high}} = \begin{pmatrix} 0 \\ 1 \\ 1 \\ 2 \\ 1 \\ 5 \\ 4 \\ 4 \\ 3 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

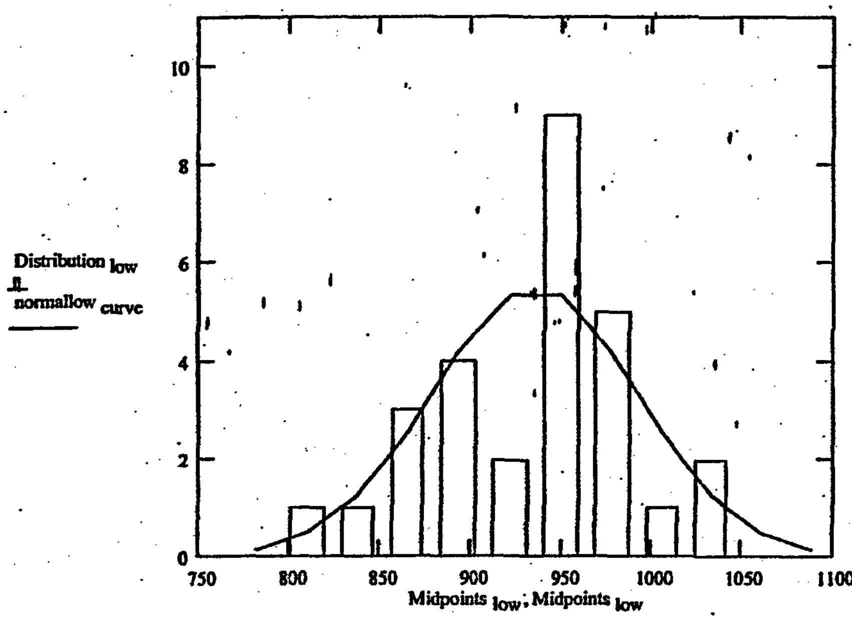
$$k := 0 .. 11 \qquad \text{Midpoints}_{\text{high}_k} := \frac{\left(\text{Bins}_{\text{high}_k} + \text{Bins}_{\text{high}_{k+1}}\right)}{2}$$

$$\text{normalhigh}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_{\text{high}_1}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$$

$$\text{normalhigh}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{\text{high}_{k+1}}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_{\text{high}_k}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$$

$$\text{normalhigh}_{\text{curve}} := \text{Nohigh}_{\text{DataCells}} \cdot \text{normalhigh}_{\text{curve}}$$

Results For 17A Thinner Points



$\mu low_{actual} = 935.429$

$\sigma low_{actual} = 55.725$

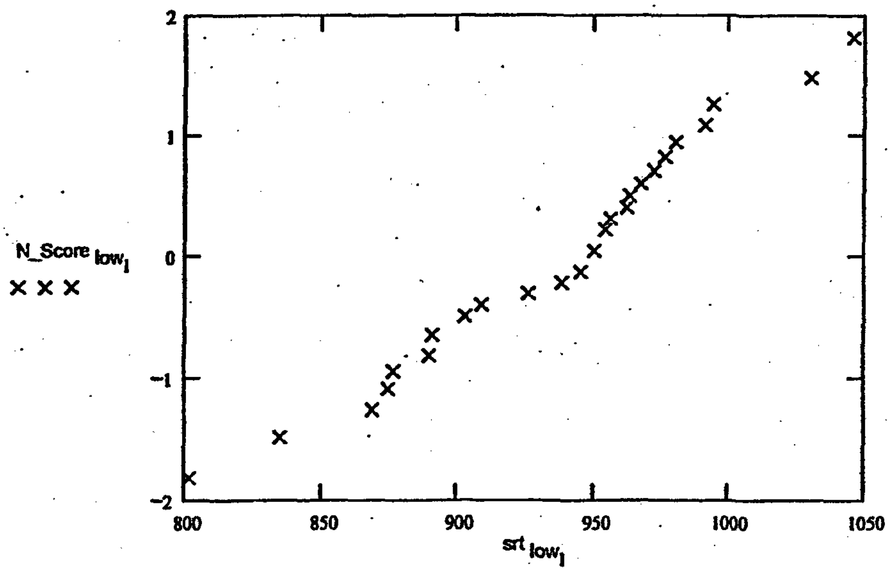
$Kurtosis_{low} = 0.179$

$Skewness_{low} = -0.358$

$Standardlow_{error} = 10.531$

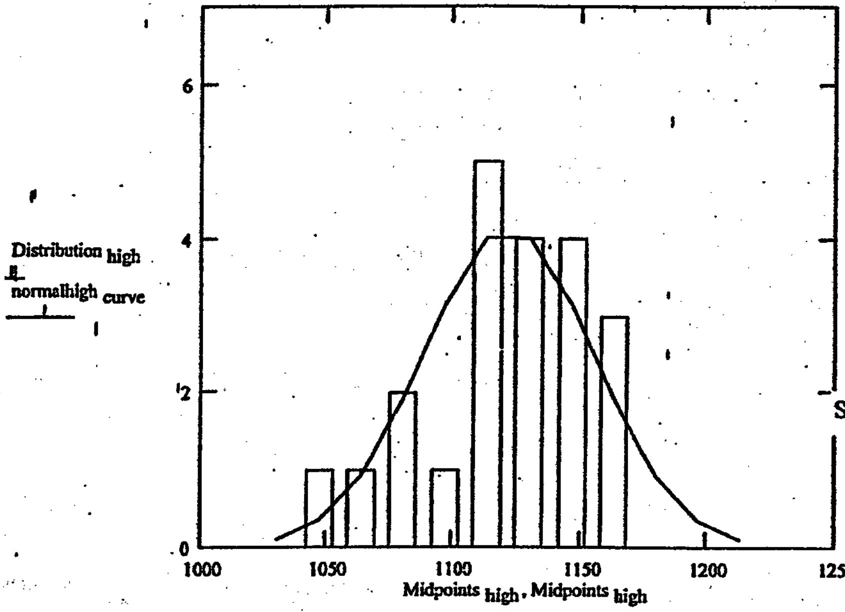
$Nolow_{DataCells} = 28$

$Lowerlow_{95\%Con} = 914.254$ $Upperlow_{95\%Con} = 956.603$



The above plots indicates that the thinner area is more normally distributed than the entire population.

Results For 17A Thicker Points



$\mu high_{actual} = 1.122 \cdot 10^3$

$\sigma high_{actual} = 33.194$

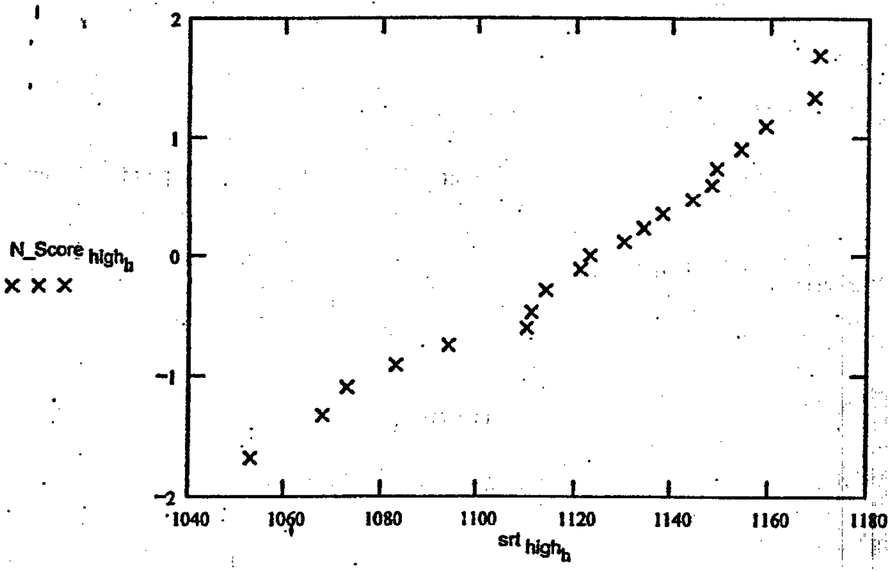
$Skewness_{high} = -0.495$

$Kurtosis_{high} = -0.497$

$Standardhigh_{error} = 7.243$

$Nohigh_{DataCells} = 21$

$Lower_{95\%Con} = 985.346$ $Upper_{95\%Con} = 1.045 \cdot 10^3$



The above plots indicates that the thicker areas are normally distributed.

Data from 1992 to 2006 is retrieved. $d := 0$

For Dec 31 1992

$page := READPRN(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Dec. 1992 Data\textbackslash sandbed\textbackslash DATA ONLY\textbackslash SB17A.txt"})$

$Points_{49} := showcells(page, 7, 0)$ $Dates_d := Day_{year}(12, 31, 1992)$

Data

$$Points_{49} = \begin{bmatrix} 1.159 & 1.153 & 1.158 & 1.138 & 1.127 & 1.169 & 1.167 \\ 1.121 & 1.155 & 1.121 & 1.143 & 1.125 & 1.151 & 1.12 \\ 1.071 & 1.095 & 1.112 & 1.115 & 1.097 & 1.07 & 1.053 \\ 1.02 & 0.995 & 0.977 & 1.012 & 1.048 & 1.029 & 0.951 \\ 0.976 & 0.919 & 0.881 & 0.935 & 0.871 & 0.936 & 0.964 \\ 0.866 & 0.961 & 0.892 & 0.822 & 0.804 & 0.946 & 0.991 \\ 0.934 & 0.97 & 0.923 & 0.925 & 0.871 & 0.952 & 0.986 \end{bmatrix}$$

$nnn := convert(Points_{49}, 7)$ $No_{DataCells} := length(nnn)$ $nnn := Zero_{one}(nnn, No_{DataCells}, 43)$

$Point_{40_d} := nnn_{39}$ $Point_{40} = 804$

The two groups are named as follows: $StopCELL := 21$ $No_{Cells} := length(Cells)$

$low_{points} := LOWROWS(nnn, No_{Cells}, StopCELL)$ $high_{points} := TOPROWS(nnn, No_{Cells}, StopCELL)$

$No_{lowCells} := length(low_{points})$ $No_{highCells} := length(high_{points})$

$Cells := deletezero_{cells}(nnn, No_{Cells})$

$low_{points} := deletezero_{cells}(low_{points}, No_{lowCells})$

$high_{points} := deletezero_{cells}(high_{points}, No_{highCells})$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$\mu high_{measured_d} := mean(high_{points})$ $\mu low_{measured_d} := mean(low_{points})$

$\sigma high_{measured_d} := Stdev(high_{points})$ $\sigma low_{measured_d} := Stdev(low_{points})$

$Standardhigh_{error_d} := \dfrac{\sigma high_{measured_d}}{\sqrt{length(high_{points})}}$ $Standardlow_{error_d} := \dfrac{\sigma low_{measured_d}}{\sqrt{length(low_{points})}}$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\DATA ONLY\SB17A.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(9, 26, 1994)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.163 & 1.146 & 1.158 & 1.141 & 1.136 & 1.168 & 1.172 \\ 1.122 & 1.155 & 1.122 & 1.144 & 1.128 & 1.157 & 1.133 \\ 1.121 & 1.088 & 1.108 & 1.116 & 1.102 & 1.071 & 1.055 \\ 0.977 & 0.993 & 0.981 & 0.989 & 1.046 & 1.001 & 0.956 \\ 0.962 & 0.914 & 0.869 & 0.942 & 0.877 & 0.938 & 0.962 \\ 0.861 & 0.963 & 0.894 & 0.82 & 0.809 & 0.947 & 0.984 \\ 0.927 & 0.97 & 0.866 & 0.895 & 0.893 & 0.956 & 0.953 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{40_d} := \text{nnn}_{39}$

The two groups are named as follows: $\text{StopCELL} := 21$ $\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$ $\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$ $\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$ $\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$ $\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$\text{Standardhigh}_{\text{error}_d} := \dfrac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$ $\text{Standardlow}_{\text{error}_d} := \dfrac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\DATA ONLY\SB17A.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 23, 1996)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.162 & 0.973 & 0.672 & 1.143 & 1.163 & 1.171 & 1.172 \\ 1.158 & 1.161 & 1.172 & 1.155 & 1.135 & 1.172 & 1.144 \\ 1.084 & 1.102 & 1.174 & 1.189 & 1.187 & 1.172 & 1.093 \\ 1.056 & 1.019 & 1.015 & 1.028 & 1.112 & 1.019 & 1.03 \\ 0.985 & 0.961 & 1.109 & 0.997 & 0.929 & 0.938 & 1.029 \\ 0.868 & 1.023 & 1.051 & 0.924 & 0.983 & 0.972 & 1.007 \\ 0.931 & 1.006 & 1.005 & 0.963 & 0.912 & 0.985 & 1.056 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{Point}_{40_d} := \text{nnn}_{39}$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{Cells}}, 3)$

The two groups are named as follows:

Point 3 was eliminated from the 1996 data

$\text{StopCELL} := 21$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$

$\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$

$\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Oct 2006 Data\Sandbed\SB17A.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 23, 2006)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.11 & 1.149 & 1.154 & 1.138 & 1.13 & 1.17 & 1.169 \\ 1.121 & 1.159 & 1.114 & 1.144 & 1.134 & 1.148 & 1.123 \\ 1.068 & 1.073 & 1.111 & 1.114 & 1.094 & 1.083 & 1.053 \\ 0.976 & 0.991 & 0.98 & 1.03 & 1.046 & 0.994 & 0.95 \\ 0.962 & 0.926 & 0.909 & 0.95 & 0.869 & 0.938 & 0.967 \\ 0.903 & 0.956 & 0.891 & 0.835 & 0.802 & 0.95 & 0.963 \\ 0.954 & 0.972 & 0.877 & 0.89 & 0.875 & 0.891 & 0.945 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}\,40_d := \text{nnn}_{39}$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{high}_{\text{points}} := \text{TOPROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{No}_{\text{lowCells}} := \text{length}\left(\text{low}_{\text{points}}\right)$

$\text{No}_{\text{highCells}} := \text{length}\left(\text{high}_{\text{points}}\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{Cells}}\right)$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}}\right)$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{high}_{\text{points}}, \text{No}_{\text{highCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}\left(\text{high}_{\text{points}}\right)$

$\mu\text{low}_{\text{measured}_d} := \text{mean}\left(\text{low}_{\text{points}}\right)$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}\left(\text{high}_{\text{points}}\right)$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}\left(\text{low}_{\text{points}}\right)$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{high}_{\text{points}}\right)}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{low}_{\text{points}}\right)}}$$

Below are the results

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^3 \\ 1.995 \cdot 10^3 \\ 1.997 \cdot 10^3 \\ 2.007 \cdot 10^3 \end{bmatrix} \qquad \text{Point}_{40} = \begin{bmatrix} 804 \\ 809 \\ 983 \\ 802 \end{bmatrix}$$

$$\text{Standard}_{\text{error}} = \begin{bmatrix} 14.971 \\ 15.472 \\ 12.949 \\ 14.911 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.022 \cdot 10^3 \\ 1.017 \cdot 10^3 \\ 1.058 \cdot 10^3 \\ 1.015 \cdot 10^3 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 104.798 \\ 108.306 \\ 90.646 \\ 104.378 \end{bmatrix}$$

$$\mu\text{high}_{\text{measured}} = \begin{bmatrix} 1.125 \cdot 10^3 \\ 1.129 \cdot 10^3 \\ 1.144 \cdot 10^3 \\ 1.122 \cdot 10^3 \end{bmatrix} \quad \sigma\text{high}_{\text{measured}} = \begin{bmatrix} 33.118 \\ 31.283 \\ 49.851 \\ 33.194 \end{bmatrix} \qquad \text{Standardhigh}_{\text{error}} = \begin{bmatrix} 7.227 \\ 6.827 \\ 11.147 \\ 7.243 \end{bmatrix}$$

$$\mu\text{low}_{\text{measured}} = \begin{bmatrix} 941.593 \\ 933.75 \\ 996.893 \\ 935.429 \end{bmatrix} \qquad \sigma\text{low}_{\text{measured}} = \begin{bmatrix} 61.37 \\ 56.659 \\ 56.487 \\ 55.725 \end{bmatrix} \qquad \text{Standardlow}_{\text{error}} = \begin{bmatrix} 11.811 \\ 10.708 \\ 10.675 \\ 10.531 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}\left(\mu_{\text{measured}}\right)$ $\text{Total}_{\text{means}} = 4$

$$SST := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2$$

$$SST_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{mean}\left(\mu\text{low}_{\text{measured}}\right)\right)^2$$

$$SST_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{mean}\left(\mu\text{high}_{\text{measured}}\right)\right)^2$$

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

$$SSE_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu\text{low}_{\text{measured}}\right)_i\right)^2$$

$$SSE_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu\text{high}_{\text{measured}}\right)_i\right)^2$$

$$SSR := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2$$

$$SSR_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu\text{low}_{\text{measured}}\right)_i - \text{mean}\left(\mu\text{low}_{\text{measured}}\right)\right)^2$$

$$SSR_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu\text{high}_{\text{measured}}\right)_i - \text{mean}\left(\mu\text{high}_{\text{measured}}\right)\right)^2$$

$\mathrm{DegreeFree}_{ss} := \mathrm{Total}_{means} - 2$ $\mathrm{DegreeFree}_{reg} := 1$ $\mathrm{DegreeFree}_{st} := \mathrm{Total}_{means} - 1$

$\mathrm{MSE} := \dfrac{\mathrm{SSE}}{\mathrm{DegreeFree}_{ss}}$ $\mathrm{MSE}_{low} := \dfrac{\mathrm{SSE}_{low}}{\mathrm{DegreeFree}_{ss}}$ $\mathrm{MSE}_{high} := \dfrac{\mathrm{SSE}_{high}}{\mathrm{DegreeFree}_{ss}}$

$\mathrm{Standard}_{error} := \sqrt{\mathrm{MSE}}$ $\mathrm{Standard}_{lowerror} := \sqrt{\mathrm{MSE}_{low}}$ $\mathrm{Standard}_{higherror} := \sqrt{\mathrm{MSE}_{high}}$

$\mathrm{MSR} := \dfrac{\mathrm{SSR}}{\mathrm{DegreeFree}_{reg}}$ $\mathrm{MSR}_{low} := \dfrac{\mathrm{SSR}_{low}}{\mathrm{DegreeFree}_{reg}}$ $\mathrm{MSR}_{high} := \dfrac{\mathrm{SSR}_{high}}{\mathrm{DegreeFree}_{reg}}$

$\mathrm{MST} := \dfrac{\mathrm{SST}}{\mathrm{DegreeFree}_{st}}$ $\mathrm{MST}_{low} := \dfrac{\mathrm{SST}_{low}}{\mathrm{DegreeFree}_{st}}$ $\mathrm{MST}_{high} := \dfrac{\mathrm{SST}_{high}}{\mathrm{DegreeFree}_{st}}$

Test the means with all points

F Test for Corrosion

$\alpha := .05$ $F_{actaul\_Reg} := \dfrac{\mathrm{MSR}}{\mathrm{MSE}}$

$F_{critical\_reg} := \mathrm{qF}\left(1 - \alpha, \mathrm{DegreeFree}_{reg}, \mathrm{DegreeFree}_{ss}\right)$

$F_{ratio\_reg} := \dfrac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 5.616 \cdot 10^{-3}$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Test the low points

F Test for Corrosion

$$F_{actaul\_Reg.low} := \frac{MSR_{low}}{MSE_{low}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.low} := \frac{F_{actaul\_Reg.low}}{F_{critical\_reg}}$$

$$F_{ratio\_reg.low} = 2.917 \cdot 10^{-3}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Test the high points

F Test for Corrosion

$$F_{actaul\_Reg.high} := \frac{MSR_{high}}{MSE_{high}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.high} := \frac{F_{actaul\_Reg.high}}{F_{critical\_reg}}$$

$$F_{ratio\_reg.high} = 0.013$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

The following will plot the results for the overall mean, the mean of thinner points, and the mean of thicker points

$i := 0 .. \text{Total}_{\text{means}} - 1$

$\mu\text{grand}_{\text{measured}_i} := \text{mean}(\mu_{\text{measured}})$ $\sigma\text{grand}_{\text{measured}} := \text{Stdev}(\mu_{\text{measured}})$

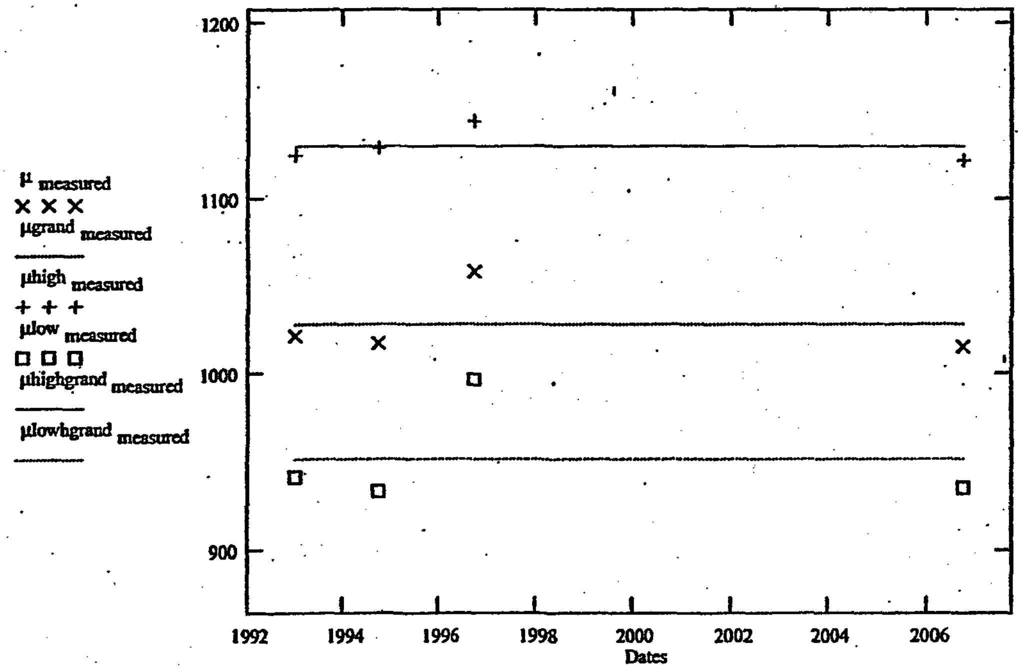
$$\text{GrandStandard}_{\text{error}} := \frac{\sigma\text{grand}_{\text{measured}}}{\sqrt{\text{Total}_{\text{means}}}}$$

$\sigma\text{grand}_{\text{lowmeasured}} := \text{Stdev}(\mu\text{low}_{\text{measured}})$ $\mu\text{lowhgrand}_{\text{measured}_i} := \text{mean}(\mu\text{low}_{\text{measured}})$

$$\text{GrandStandard}_{\text{lowerror}} := \frac{\sigma\text{grand}_{\text{lowmeasured}}}{\sqrt{\text{Total}_{\text{means}}}}$$

$\sigma\text{grand}_{\text{highmeasured}} := \text{Stdev}(\mu\text{high}_{\text{measured}})$ $\mu\text{highgrand}_{\text{measured}_i} := \text{mean}(\mu\text{high}_{\text{measured}})$

$$\text{GrandStandard}_{\text{higherror}} := \frac{\sigma\text{grand}_{\text{highmeasured}}}{\sqrt{\text{Total}_{\text{means}}}}$$



$\mu\text{grand}_{\text{measured}_0} = 1.028 \cdot 10^3$ $\text{GrandStandard}_{\text{error}} = 10.111$

$\text{mean}(\mu\text{low}_{\text{measured}}) = 951.916$ $\text{GrandStandard}_{\text{lowerror}} = 15.087$

$\text{mean}(\mu\text{high}_{\text{measured}}) = 1.13 \cdot 10^3$ $\text{GrandStandard}_{\text{higherror}} = 4.948$

The F Test indicates that the regression model does not hold for any of the data sets. However, the slopes and 95% Confidence curves are generated for all three cases.

$m_s := \mathrm{slope}(\mathrm{Dates}, \mu_{\mathrm{measured}})$ $y_b := \mathrm{intercept}(\mathrm{Dates}, \mu_{\mathrm{measured}})$

$m_{\mathrm{lows}} := \mathrm{slope}(\mathrm{Dates}, \mu\mathrm{low}_{\mathrm{measured}})$ $y_{\mathrm{lowb}} := \mathrm{intercept}(\mathrm{Dates}, \mu\mathrm{low}_{\mathrm{measured}})$

$m_{\mathrm{highs}} := \mathrm{slope}(\mathrm{Dates}, \mu\mathrm{high}_{\mathrm{measured}})$ $y_{\mathrm{highb}} := \mathrm{intercept}(\mathrm{Dates}, \mu\mathrm{high}_{\mathrm{measured}})$

$\alpha'_t := 0.05$ $k := 23$ $f := 0 .. k - 1$

$\mathrm{year}_{\mathrm{predict}_f} := 1985 + f \cdot 2$

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

$\mathrm{Thick}_{\mathrm{lowpredict}} := m_{\mathrm{lows}} \cdot \mathrm{year}_{\mathrm{predict}} + y_{\mathrm{lowb}}$

$\mathrm{Thick}_{\mathrm{highpredict}} := m_{\mathrm{highs}} \cdot \mathrm{year}_{\mathrm{predict}} + y_{\mathrm{highb}}$

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

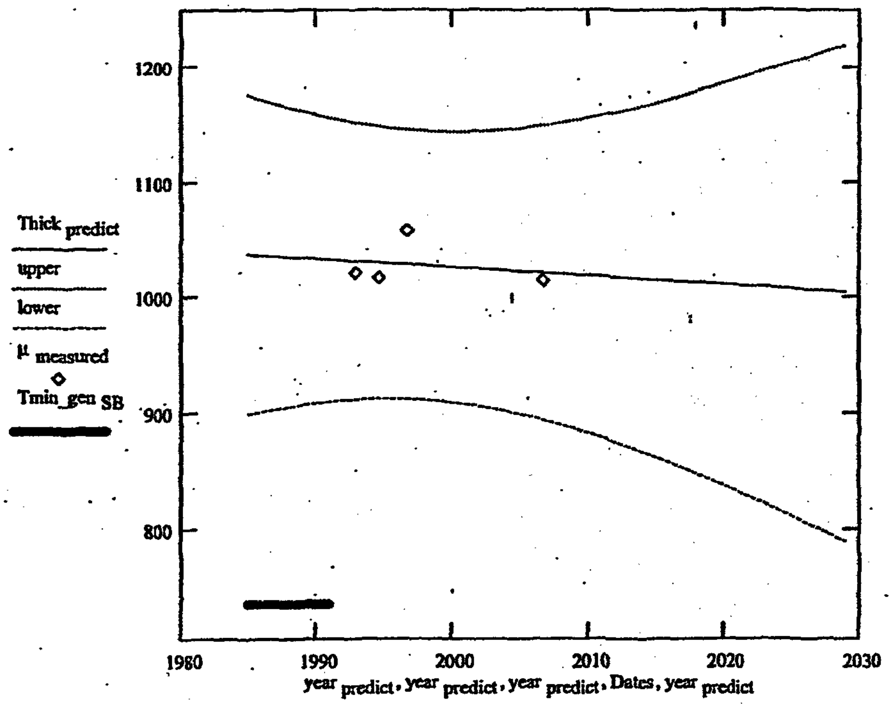
$\mathrm{sum} := \sum_i \left(\mathrm{Dates}_d - \mathrm{mean}(\mathrm{Dates})\right)^2$

For the entire grid

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

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

The minimum required thickness at this elevation is $\text{Tmin\_gen}_{\text{SB}_i} := 736$ (Ref. 3.25)

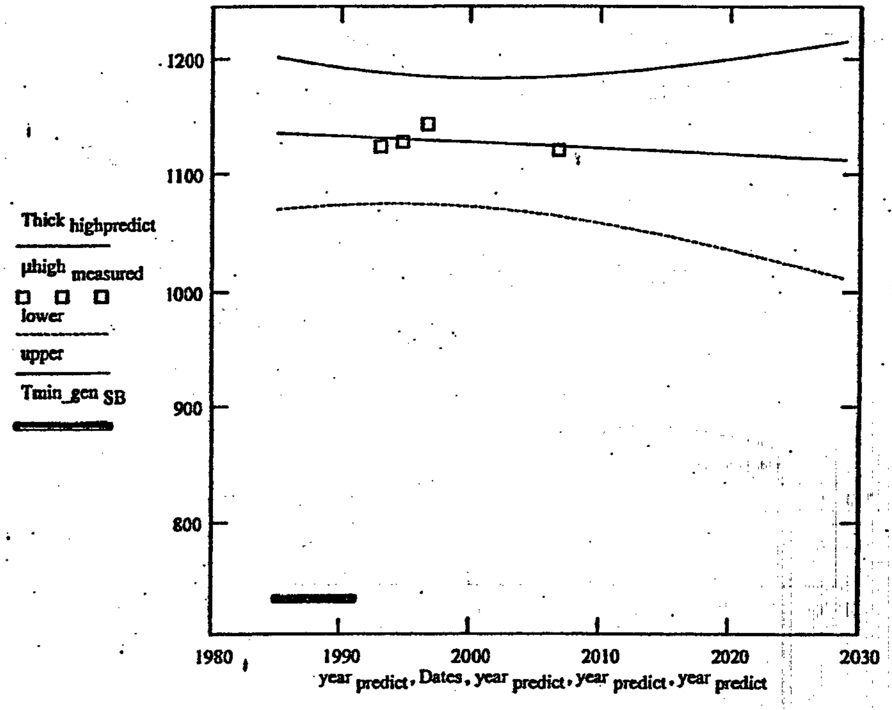


$m_s = -0.731$

For the points which are thicker

$$upper_f := Thick_{highpredict_f} \cdots$$
$$+ qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Standard_{higherror} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Thick_{actualmean}\right)^2}{sum}}$$

$$lower_f := Thick_{highpredict_f} \cdots$$
$$+ -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Standard_{higherror} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Thick_{actualmean}\right)^2}{sum}}\right]$$



$m_{highs} = -0.522$

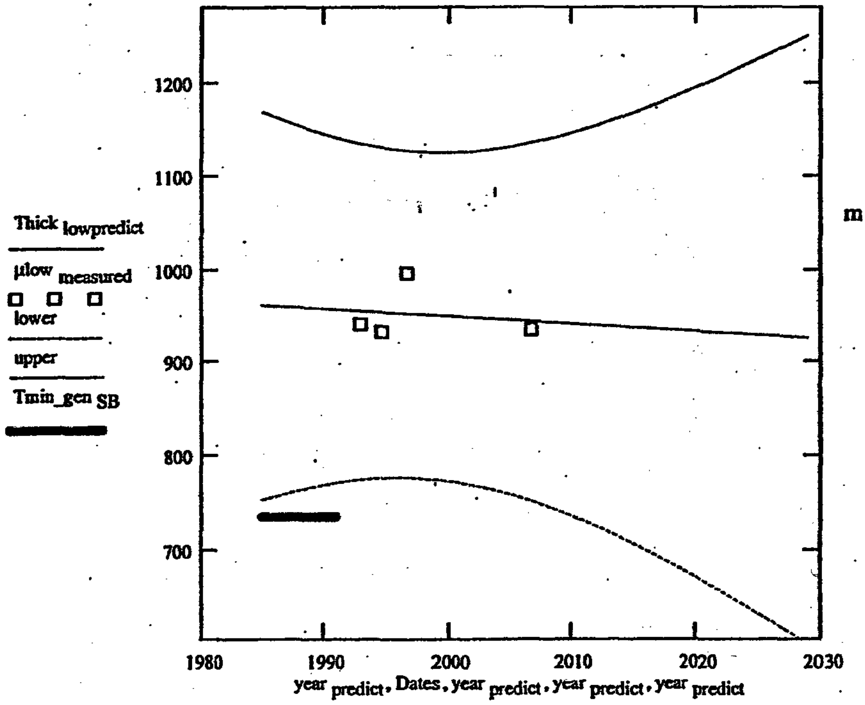
For the points which are thinner

$$upper_f := Thick_{lowpredict_f} \cdots$$

$$+ \; qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Standard_{lowerror} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Thick_{actualmean}\right)^2}{sum}}$$

$$lower_f := Thick_{lowpredict_f} \cdots$$

$$+ \; -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Standard_{lowerror} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Thick_{actualmean}\right)^2}{sum}}\right]$$



$m_{lows} = -0.796$

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\mathrm{Rate}_{\mathrm{min\_observed}} := 6.9$$

$$\mathrm{Postulated}_{\mathrm{meanthickness}} := \mu_{\mathrm{measured}_3} - \mathrm{Rate}_{\mathrm{min\_observed}} \cdot (2029 - 2006)$$

$\mathrm{Postulated}_{\mathrm{meanthickness}} = 856.627$ which is greater than $\mathrm{Tmin\_gen}_{\mathrm{SB}_3} = 736$

The following addresses the readings at the lowest single point

$$\mathrm{SST}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{Point}_{40_i} - \mathrm{mean}\left(\mathrm{Point}_{40}\right)\right)^2 \qquad \mathrm{SST}_{\mathrm{point}} = 2.379 \cdot 10^4$$

$$\mathrm{SSE}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{Point}_{40_i} - \mathrm{yhat}\left(\mathrm{Dates}, \mathrm{Point}_{40}\right)_i\right)^2 \qquad \mathrm{SSE}_{\mathrm{point}} = 2.334 \cdot 10^4$$

$$\mathrm{SSR}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{yhat}\left(\mathrm{Dates}, \mathrm{Point}_{40}\right)_i - \mathrm{mean}\left(\mathrm{Point}_{40}\right)\right)^2 \qquad \mathrm{SSR}_{\mathrm{point}} = 445.558$$

$$\mathrm{MSE}_{\mathrm{point}} := \frac{\mathrm{SSE}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{ss}}} \qquad \mathrm{MSR}_{\mathrm{point}} := \frac{\mathrm{SSR}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{reg}}} \qquad \mathrm{MST}_{\mathrm{point}} := \frac{\mathrm{SST}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{st}}}$$

$$\mathrm{StPoint}_{\mathrm{err}} := \sqrt{\mathrm{MSE}_{\mathrm{point}}} \qquad \mathrm{StPoint}_{\mathrm{err}} = 108.036$$

$$\mathrm{MSE}_{\mathrm{point}} = 1.167 \cdot 10^4 \qquad \mathrm{MSR}_{\mathrm{point}} = 445.558 \qquad \mathrm{MST}_{\mathrm{point}} = 7.93 \cdot 10^3$$

F Test for Corrosion

$$F_{\mathrm{actaul\_Reg}} := \frac{\mathrm{MSR}_{\mathrm{point}}}{\mathrm{MSE}_{\mathrm{point}}}$$

$$F_{\mathrm{ratio\_reg}} := \frac{F_{\mathrm{actaul\_Reg}}}{F_{\mathrm{critical\_reg}}}$$

$$F_{\mathrm{ratio\_reg}} = 2.062 \cdot 10^{-3}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \text{slope}(\text{Dates}, \text{Point}_{40})$ $m_{point} = -1.983$ $y_{point} := \text{intercept}(\text{Dates}, \text{Point}_{40})$ $y_{point} = 4.811 \cdot 10^3$

The 95% Confidence curves are calculated

$\text{Point}_{curve} := m_{point} \cdot \text{year}_{predict} + y_{point}$

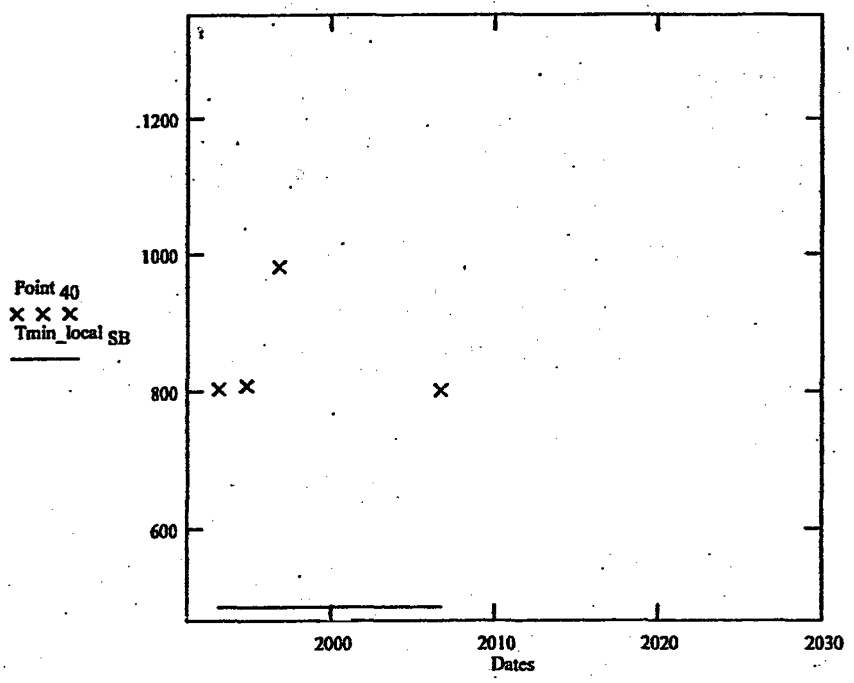
$\text{Point}_{actualmean} := \text{mean}(\text{Dates})$ $\text{sum}' := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

$$\text{uppoint}_f := \text{Point}_{curve_f} \cdots + qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{predict_f} - \text{Point}_{actualmean}\right)^2}{\text{sum}}}$$

$$\text{lopoint}_f := \text{Point}_{curve_f} \cdots + -\left[qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{predict_f} - \text{Point}_{actualmean}\right)^2}{\text{sum}}}\right]$$

Local Tmin for this elevation in the Drywell $\text{Tmin\_local}_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 40 Projected to Plant End Of Life



$m_{point} = -1.983$

$\text{lopoint}_{22} = -176.503$ $\text{year}_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate of 1.7mils per year (Appendix 22).

$$\mathrm{Rate}_{\mathrm{min\_observed}} := 6.9$$

$$\mathrm{Postulated}_{\mathrm{thickness}} := \mathrm{Point}\,{40}_{3} - \mathrm{Rate}_{\mathrm{min\_observed}} \cdot (2029 - 2006)$$

$\mathrm{Postulated}_{\mathrm{thickness}} = 643.3$ which is greater than $\mathrm{Tmin\_local}_{\mathrm{SB}_3} = 490$

e section below calculates what the postulated corrosion rate necessary for the thinnest individual point to ach the local required thickness by 2029.

$\mathrm{minpoint} = 0.802$ $\mathrm{year}_{\mathrm{predict}_{22}} = 2.029 \cdot 10^{3}$ $\mathrm{Tmin\_local}_{\mathrm{SB}_{22}} = 490$

$$\mathrm{required}_{\mathrm{rate.}} := \frac{\left(1000 \cdot \mathrm{minpoint} - \mathrm{Tmin\_local}_{\mathrm{SB}_{22}}\right)}{(2005 - 2029)}$$

$\mathrm{required}_{\mathrm{rate.}} = -13$ mils per year

Appendix 8 - Sand Bed Elevation Bay 17D

October 2006 Data

The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB17D.txt")

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

$$\text{Points}_{49} = \begin{bmatrix} 0.849 & 0.828 & 0.861 & 0.894 & 0.93 & 0.888 & 0.702 \\ 0.806 & 0.802 & 0.717 & 0.806 & 0.736 & 0.756 & 0.648 \\ 0.998 & 0.823 & 0.752 & 0.733 & 0.822 & 0.73 & 0.667 \\ 1.072 & 1.074 & 0.742 & 0.812 & 0.812 & 0.803 & 0.791 \\ 0.814 & 0.841 & 0.85 & 0.816 & 0.852 & 0.856 & 0.869 \\ 0.792 & 0.829 & 0.888 & 0.846 & 0.888 & 0.855 & 0.8 \\ 0.824 & 0.897 & 0.837 & 0.887 & 0.891 & 0.935 & 0.886 \end{bmatrix}$$

$$\text{Cells} := \text{convert}\left(\text{Points}_{49}, 7\right) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

The thinnest point at this location is point 14 which is shown below

$$\text{minpoint} := \min\left(\text{Points}_{49}\right) \qquad \text{minpoint} = 0.648$$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$$\text{Cells} := \text{Zero}_{\text{one}}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 15\right) \qquad \text{Cells} := \text{Zero}_{\text{one}}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 16\right)$$

$$\text{Cells} := \text{Zero}_{\text{one}}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 22\right) \qquad \text{Cells} := \text{Zero}_{\text{one}}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 23\right)$$

$$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 818.6667$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 66.335$

Standard Error

minpoint = 0.648

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

$\text{Standard}_{error} = 9.476$

Skewness

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

$\text{Skewness} = -0.576$

Kurtosis

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

$\text{Kurtosis} = -0.19$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

$$\alpha := .05 \qquad T\alpha := \text{qt}\left[\left(1 - \frac{\alpha}{2}\right), \text{No}_{\text{DataCells}}\right] \quad T\alpha = 2.014$$

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 798.75$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 838.583$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

Distribution =

1
1
2
5
1
11
9
5
8
2
0
0

The mid points of the Bins are calculated

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

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

$$\text{normal}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_1, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

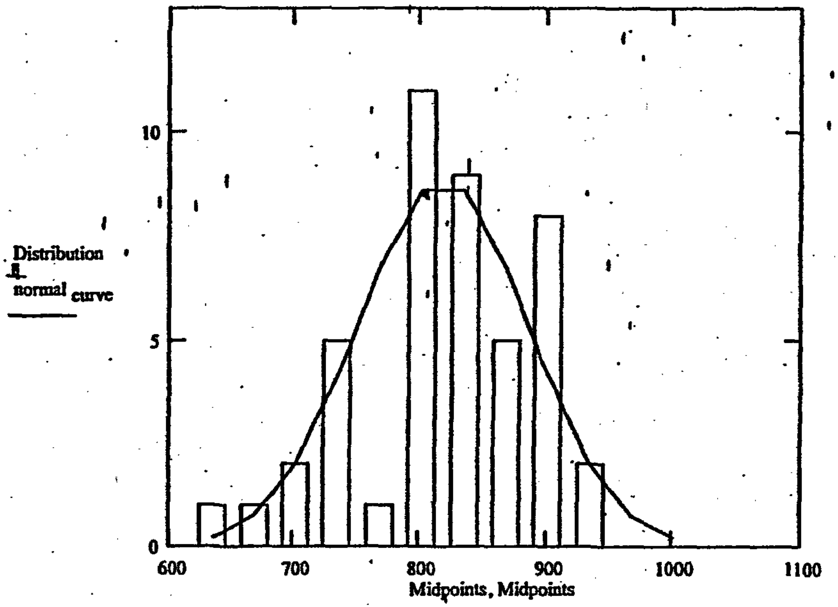
$$\text{normal}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{k+1}, \mu_{\text{actual}}, \sigma_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_k, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

$$\text{normal}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$$

Results For Elevation Sandbed Elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 818.667$

$\sigma_{actual} = 66.335$

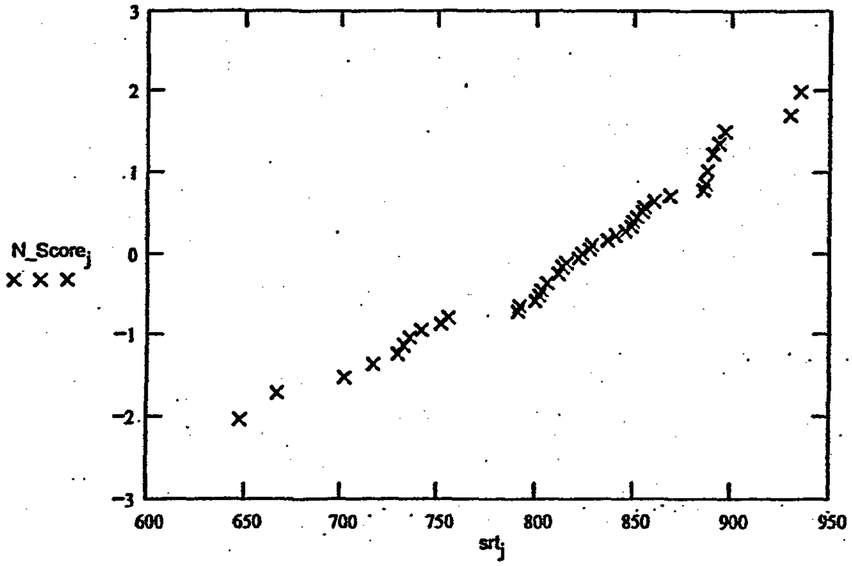
$\text{Standard}_{error} = 9.476$

$\text{Skewness} = -0.576$

$\text{Kurtosis} = -0.19$

$\text{Lower}_{95\%Con} = 798.75$ $\text{Upper}_{95\%Con} = 838.583$

Normal Probability Plot



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

Sandbed Location 17D Trend

$d := 0$

Data from the 1992, 1994 and 1996 is retrieved.

For 1992

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB17D.txt")

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.839 & 0.802 & 0.853 & 0.905 & 0.955 & 0.877 & 0.71 \\ 0.804 & 0.802 & 0.71 & 0.806 & 0.737 & 0.762 & 0.648 \\ 1.029 & 0.814 & 0.752 & 0.802 & 0.819 & 0.737 & 0.668 \\ 1.069 & 1.069 & 0.748 & 0.803 & 0.784 & 0.806 & 0.785 \\ 0.809 & 0.845 & 0.845 & 0.816 & 0.846 & 0.845 & 0.84 \\ 0.79 & 0.833 & 0.892 & 0.846 & 0.878 & 0.855 & 0.792 \\ 0.832 & 0.896 & 0.835 & 0.882 & 0.886 & 0.936 & 0.862 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}\left(\mathrm{Points}_{49}, 7\right)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

$\mathrm{point}_{13_d} := \mathrm{nnn}_{13}$

$\mathrm{point}_{13} = 648$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 15\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 16\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 22\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 23\right)$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$

$\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$

$$\mathrm{Standard}_{\mathrm{error}_d} := \frac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB17D.txt")

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(9, 14, 1994)$

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.797 & 0.815 & 0.853 & 0.887 & 0.925 & 0.878 & 0.696 \\ 0.807 & 0.806 & 0.698 & 0.802 & 0.729 & 0.734 & 0.646 \\ 1.008 & 0.243 & 0.749 & 0.741 & 0.816 & 0.735 & 0.662 \\ 1.068 & 1.066 & 0.739 & 0.812 & 0.772 & 0.793 & 0.785 \\ 0.804 & 0.836 & 0.838 & 0.794 & 0.853 & 0.828 & 0.842 \\ 0.79 & 0.825 & 0.885 & 0.847 & 0.872 & 0.853 & 0.795 \\ 0.827 & 0.899 & 0.826 & 0.863 & 0.922 & 0.934 & 0.835 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}\left(\mathrm{Points}_{49}, 7\right)$ $\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

$\mathrm{point}_{13_d} := \mathrm{nnn}_{13}$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 15\right)$ $\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 16\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 22\right)$ $\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 23\right)$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$ $\mathrm{Standard}_{\mathrm{error}_d} := \dfrac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$

For 1996

$d := d + 1$

$page := READPRN(\text{"U:\\MSOFFICE\\Drywell Program data\\Sept.1996 Data\\sandbed\\Data Only\\SB17D.txt"})$

$Dates_d := Day_{year}(9, 16, 1996)$

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

Data

$$Points_{49} = \begin{bmatrix} 0.88 & 0.895 & 0.896 & 0.909 & 0.88 & 0.845 & 0.746 \\ 0.893 & 0.812 & 0.736 & 0.837 & 0.863 & 0.783 & 0.693 \\ 0.775 & 1.038 & 0.767 & 0.808 & 0.774 & 0.813 & 0.807 \\ 0.803 & 1.121 & 1.001 & 0.772 & 0.835 & 0.877 & 0.794 \\ 0.786 & 0.787 & 0.839 & 0.88 & 0.849 & 0.892 & 0.867 \\ 0.827 & 0.808 & 0.843 & 0.904 & 0.898 & 0.892 & 0.912 \\ 0.883 & 0.859 & 0.864 & 0.82 & 0.892 & 0.962 & 0.979 \end{bmatrix}$$

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

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

$point_{13_d} := nnn_{13}$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$nnn := Zero_{one}(nnn, No_{DataCells}, 15)$

$nnn := Zero_{one}(nnn, No_{DataCells}, 16)$

$nnn := Zero_{one}(nnn, No_{DataCells}, 22)$

$nnn := Zero_{one}(nnn, No_{DataCells}, 23)$

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

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB17D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.849 & 0.828 & 0.861 & 0.894 & 0.93 & 0.888 & 0.702 \\ 0.806 & 0.802 & 0.717 & 0.806 & 0.736 & 0.756 & 0.648 \\ 0.998 & 0.823 & 0.752 & 0.733 & 0.822 & 0.73 & 0.667 \\ 1.072 & 1.074 & 0.742 & 0.812 & 0.812 & 0.803 & 0.791 \\ 0.814 & 0.841 & 0.85 & 0.816 & 0.852 & 0.856 & 0.869 \\ 0.792 & 0.829 & 0.888 & 0.846 & 0.888 & 0.855 & 0.8 \\ 0.824 & 0.897 & 0.837 & 0.887 & 0.891 & 0.935 & 0.886 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{point}_{13_d} := \text{nnn}_{13}$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 15\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 16\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 22\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 23\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993\cdot10^{3} \\ 1.995\cdot10^{3} \\ 1.997\cdot10^{3} \\ 2.007\cdot10^{3} \end{bmatrix} \qquad \text{point}_{13} = \begin{bmatrix} 648 \\ 646 \\ 693 \\ 648 \end{bmatrix}$$

$$\mu_{\text{measured}} := \begin{bmatrix} 817.2222 \\ 809.8889 \\ 847.9778 \\ 818.6667 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 9.214 \\ 9.448 \\ 8.983 \\ 9.476 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 64.496 \\ 66.133 \\ 62.884 \\ 66.335 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}\left(\mu_{\text{measured}}\right) \qquad \text{Total}_{\text{means}} = 4$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2 \qquad \text{SST} = 847.181$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i\right)^2 \qquad \text{SSE} = 847.126$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2 \qquad \text{SSR} = 0.055$$

$$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{MSE} = 423.563 \qquad \text{MSR} = 0.055 \qquad \text{MST} = 282.394$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 20.581$$

F Test for Corrosion

$\alpha := 0.05$ $\qquad F_{actaul\_Reg} := \frac{MSR}{MSE}$

$$F_{critical\_reg} := qF(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss})$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 6.985 \cdot 10^{-6}$$

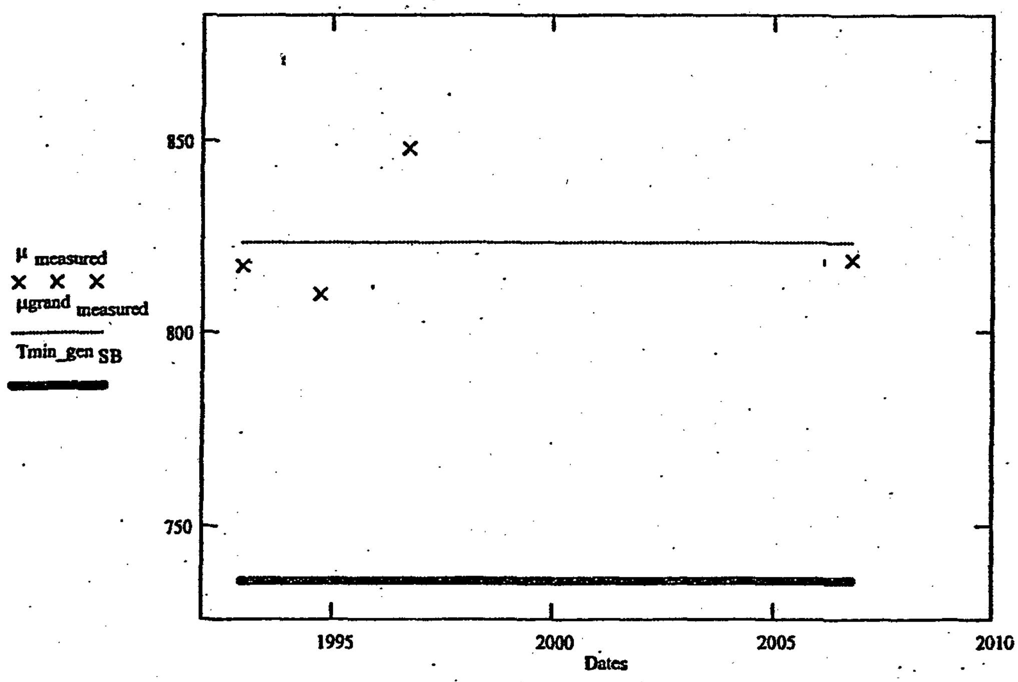
Therefore no conclusion can be made as to whether the data best fits the regression model The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\qquad \mu grand_{measured_i} := mean(\mu_{measured})$

$\sigma grand_{measured} := Stdev(\mu_{measured})$ $\qquad GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 823.439$ $\qquad GrandStandard_{error} = 8.402$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}\left(\text{Dates}, \mu_{\text{measured}}\right) \quad m_s = 0.022 \qquad y_b := \text{intercept}\left(\text{Dates}, \mu_{\text{measured}}\right) \; y_b = 779.89$

The 95% Confidence curves are calculated

$\alpha_t := 0.05 \quad k := 2029 - 1985 \qquad f := 0 .. k - 1$

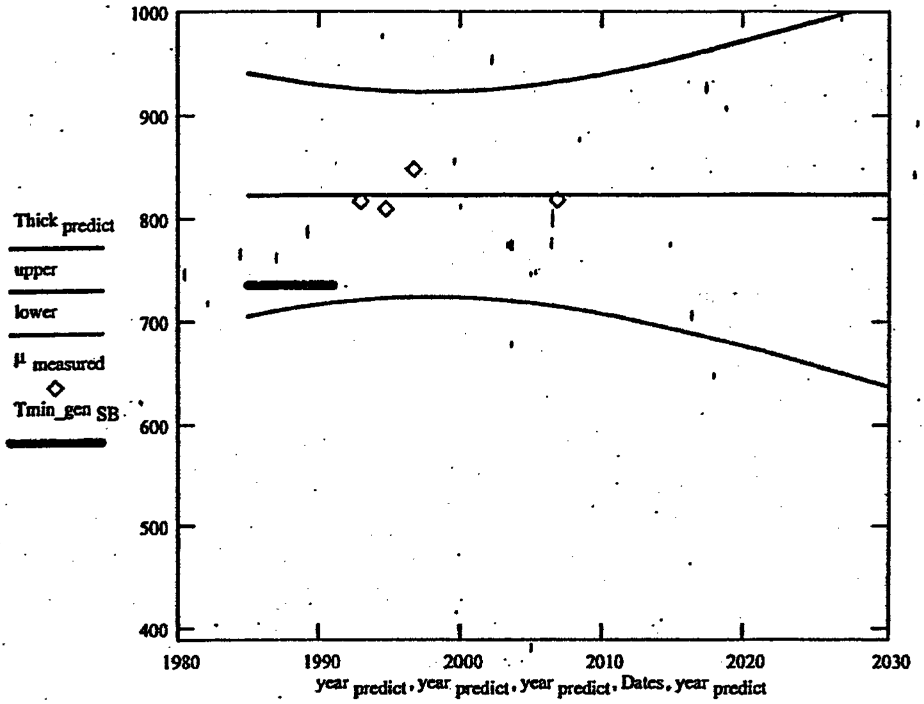
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2 \quad \text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates}) \qquad \text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = 0.022$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2016 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 749.667$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

he following addresses the readings at the lowest single point

The F-Ratio is calculated for the point as follows

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(point_{13_i} - mean\left(point_{13}\right)\right)^2 \qquad SST_{point} = 1.567 \cdot 10^3$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(point_{13_i} - yhat\left(Dates, point_{13}\right)_i\right)^2 \qquad SSE_{point} = 1.551 \cdot 10^3$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, point_{13}\right)_i - mean\left(point_{13}\right)\right)^2 \qquad SSR_{point} = 15.491$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$Stpoint_{err} := \sqrt{MSE_{point}} \qquad Stpoint_{err} = 27.85$$

$$MSE_{point} = 775.629 \qquad MSR_{point} = 15.491 \qquad MST_{point} = 522.25$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 1.079 \cdot 10^{-3}$$

Therefore no conclusion can be made as to whether the data best fits the regression model The figure below provides a trend of the data and the grandmean

$m_{point} := slope(Dates, point_{13})$ $m_{point} = -0.367$ $y_{point} := intercept(Dates, point_{13})$ $y_{point} = 1.391\cdot10^{3}$

The 95% Confidence curves are calculated

$point_{curve} := m_{point}\cdot year_{predict} + y_{point}$

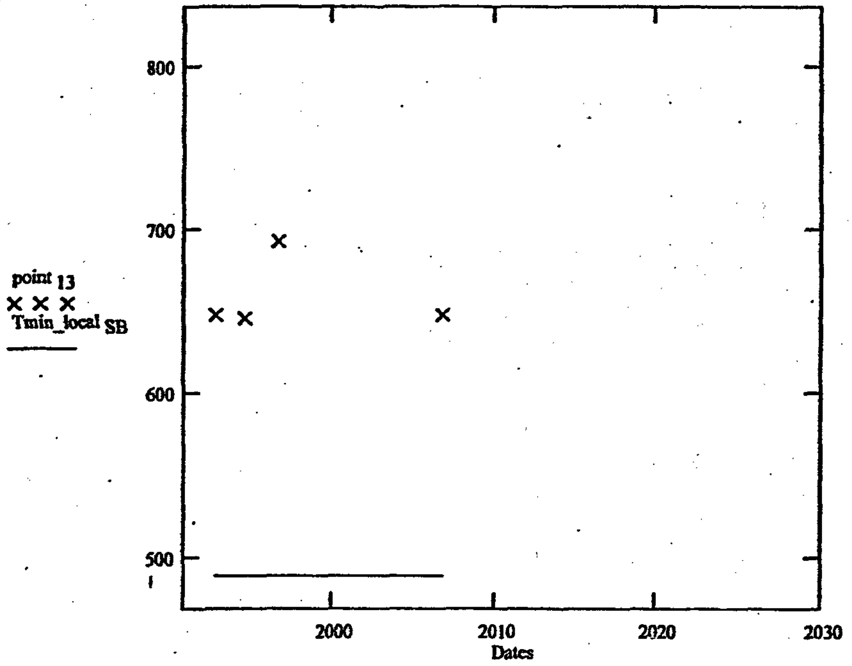
$point_{actualmean} := mean(Dates)$ $sum := \sum_{i}\left(Dates_{d} - mean(Dates)\right)^{2}$

$$uppoint_{f} := point_{curve_{f}} + qt\left(1 - \frac{\alpha_{t}}{2}, Total_{means} - 2\right)\cdot Stpoint_{err}\cdot\sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_{f}} - point_{actualmean}\right)^{2}}{sum}}$$

$$lopoint_{f} := point_{curve_{f}} + -\left[qt\left(1 - \frac{\alpha_{t}}{2}, Total_{means} - 2\right)\cdot Stpoint_{err}\cdot\sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_{f}} - point_{actualmean}\right)^{2}}{sum}}\right]$$

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_{f}} := 490$ (Ref. 3.25)

Curve Fit For Point 13 Projected to Plant End Of Life



$m_{point} = -0.367$

$lopoint_{22} = 400.182$ $year_{predict_{22}} = 2.029\cdot10^{3}$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{point}_{13_3} - \text{Rate}_{\text{min\_observed}} \cdot (2016 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 579$ which is greater than $\text{Tmin\_local}_{SB_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 0.648$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{SB_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{SB_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -6.583$ mils per year

Appendix 9 - Sandbed 17-19
October 2006 Data

The data shown below was collected on 10/18/06

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB17-19.txt")

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

$$\text{Points}_{49} = \begin{bmatrix} 0.969 & 0.962 & 0.945 & 0.931 & 0.965 & 0.96 & 0.928 \\ 0.972 & 0.977 & 0.959 & 0.991 & 0.967 & 0.955 & 0.937 \\ 0.968 & 0.974 & 1.004 & 0.987 & 0.982 & 0.996 & 0.924 \\ 1.022 & 0.959 & 0.963 & 0.974 & 0.993 & 0.985 & 0.952 \\ 0.96 & 0.962 & 0.951 & 0.95 & 0.943 & 0.982 & 0.901 \\ 1.001 & 0.994 & 0.952 & 0.929 & 0.917 & 0.962 & 1.001 \\ 0.995 & 1.019 & 1.012 & 0.995 & 1.009 & 0.946 & 1 \end{bmatrix}$$

$\text{Cells} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

The thinnest point at this location is point 35 and shown below

$\text{minpoint} := \min\left(\text{Points}_{49}\right)$ $\text{minpoint} = 0.901$

$$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$$

$$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

Mean and Standard Deviation

$\mu_{actual} := \mathrm{mean}(Cells)$ $\mu_{actual} = 969.02$ $\sigma_{actual} := \mathrm{Stdev}(Cells)$ $\sigma_{actual} = 27.654$

Standard Error

$$Standard_{error} := \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}}$$

$Standard_{error} = 3.951$

Skewness

$$Skewness := \frac{(No_{DataCells}) \cdot \overrightarrow{\Sigma(Cells - \mu_{actual})^3}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (\sigma_{actual})^3}$$

$Skewness = -0.182$

Kurtosis

$$Kurtosis := \frac{No_{DataCells} \cdot (No_{DataCells} + 1) \cdot \overrightarrow{\Sigma(Cells - \mu_{actual})^4}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (No_{DataCells} - 3) \cdot (\sigma_{actual})^4} + -\frac{3 \cdot (No_{DataCells} - 1)^2}{(No_{DataCells} - 2) \cdot (No_{DataCells} - 3)}$$

$Kurtosis = -0.365$

Normal Probability Plot

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

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

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

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

Upper and Lower Confidence Values

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

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

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 961.077$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 976.963$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

Distribution =

	0
0	0
1	1
2	2
3	4
4	8
5	12
6	6
7	8
8	5
9	3
10	0
11	0

The mid points of the Bins are calculated

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

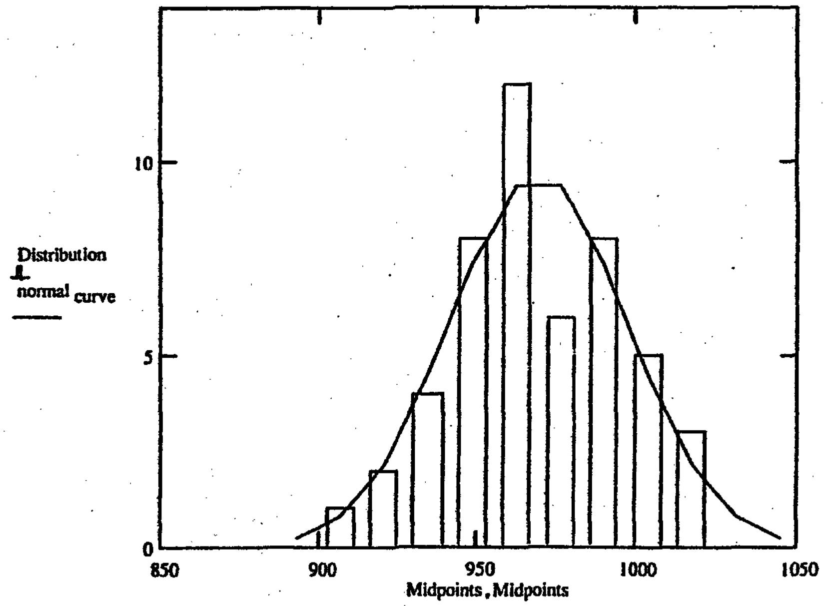
$$\text{normal}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_1, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

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

$$\text{normal}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$$

Results For Bay 17-19
The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values.

Data Distribution



$\mu_{actual} = 969.02$

$\sigma_{actual} = 27.654$

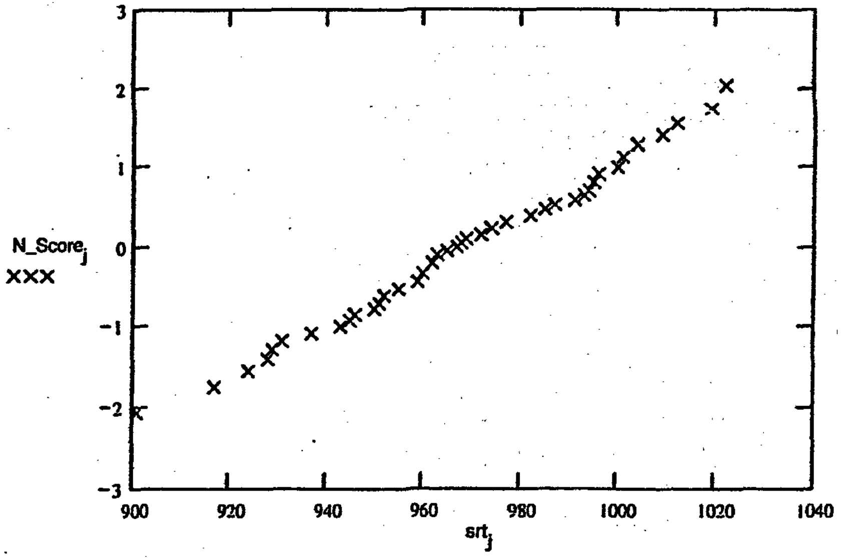
$\text{Standard}_{error} = 3.951$

Skewness = −0.182

Kurtosis = −0.365

$\text{Lower}_{95\%Con} = 961.077$ $\text{Upper}_{95\%Con} = 976.963$

Normal Probability Plot



This data (2006) is normally distributed. However, past calculations (ref. 3.22) have split this area out as a separate groups and performed analysis on both groups. In order to be consistent with past calculations this data will be split in two groups and analyzed. As well as the entire data set.

The two groups are named as follows: $StopCELL := 21$

$low_{points} := LOWROWS\left(Cells, No_{DataCells}, StopCELL\right)$ $high_{points} := TOPROWS(Cells, 49, StopCELL)$

Mean and Standard Deviation

$\mu low_{actual} := mean\left(low_{points}\right)$ $\sigma low_{actual} := Stdev\left(low_{points}\right)$

$\mu high_{actual} := mean\left(high_{points}\right)$ $\sigma high_{actual} := Stdev\left(high_{points}\right)$

Standard Error

$$Standardlow_{error} := \frac{\sigma low_{actual}}{\sqrt{length\left(low_{points}\right)}} \qquad Standardhigh_{error} := \frac{\sigma high_{actual}}{\sqrt{length\left(high_{points}\right)}}$$

Skewness

$Nolow_{DataCells} := length\left(low_{points}\right)$

$$Skewness_{low} := \frac{\left(Nolow_{DataCells}\right)\cdot\sum\overrightarrow{\left(low_{points} - \mu low_{actual}\right)^3}}{\left(Nolow_{DataCells} - 1\right)\cdot\left(Nolow_{DataCells} - 2\right)\cdot\left(\sigma low_{actual}\right)^3}$$

$Nohigh_{DataCells} := length\left(high_{points}\right)$

$$Skewness_{high} := \frac{\left(Nohigh_{DataCells}\right)\cdot\sum\overrightarrow{\left(high_{points} - \mu high_{actual}\right)^3}}{\left(Nohigh_{DataCells} - 1\right)\cdot\left(Nohigh_{DataCells} - 2\right)\cdot\left(\sigma high_{actual}\right)^3}$$

Kurtosis

$$\text{Kurtosis}_{low} := \frac{Nolow_{DataCells}\cdot\left(Nolow_{DataCells}+1\right)\cdot\overrightarrow{\Sigma\left(low_{points}-\mu low_{actual}\right)^{4}}}{\left(Nolow_{DataCells}-1\right)\cdot\left(Nolow_{DataCells}-2\right)\cdot\left(Nolow_{DataCells}-3\right)\cdot\left(\sigma low_{actual}\right)^{4}} \cdots + -\frac{3\cdot\left(Nolow_{DataCells}-1\right)^{2}}{\left(Nolow_{DataCells}-2\right)\cdot\left(Nolow_{DataCells}-3\right)}$$

$$\text{Kurtosis}_{high} := \frac{Nohigh_{DataCells}\cdot\left(Nohigh_{DataCells}+1\right)\cdot\overrightarrow{\Sigma\left(high_{points}-\mu high_{actual}\right)^{4}}}{\left(Nohigh_{DataCells}-1\right)\cdot\left(Nohigh_{DataCells}-2\right)\cdot\left(Nohigh_{DataCells}-3\right)\cdot\left(\sigma high_{actual}\right)^{4}} \cdots + -\frac{3\cdot\left(Nohigh_{DataCells}-1\right)^{2}}{\left(Nohigh_{DataCells}-2\right)\cdot\left(Nohigh_{DataCells}-3\right)}$$

Normal Probability Plot - Low points

$l := 0..\,\text{last}\left(low_{points}\right)$ $\quad srt_{low} := \text{sort}\left(low_{points}\right)$

$L_l := l + 1$

$$rank_{low_l} := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt_{low}=srt_{low_l}}\right)\cdot L}}{\Sigma\overrightarrow{srt_{low}=srt_{low_l}}} \qquad p_{low_l} := \frac{rank_{low_l}}{\text{rows}\left(low_{points}\right)+1}$$

$x := 1$ $\quad N\_Score_{low_l} := \text{root}\left[\text{cnorm}(x)-\left(p_{low_l}\right), x\right]$

Normal Probability Plot - High points

$h := 0..\,\text{last}\left(high_{points}\right)$ $\quad srt_{high} := \text{sort}\left(high_{points}\right)$

$H_h := h + 1$

$$rank_{high_h} := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt_{high}=srt_{high_h}}\right)\cdot H}}{\Sigma\overrightarrow{srt_{high}=srt_{high_h}}} \qquad p_{high_h} := \frac{rank_{high_h}}{\text{rows}\left(high_{points}\right)+1}$$

$x := 1$ $\quad N\_Score_{high_h} := \text{root}\left[\text{cnorm}(x)-\left(p_{high_h}\right), x\right]$

Upper and Lower Confidence Values

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

$$\text{Lowerhigh}_{95\%\text{Con}} := \mu\text{high}_{\text{actual}} - T\alpha \cdot \frac{\sigma\text{high}_{\text{actual}}}{\sqrt{\text{Nohigh}_{\text{DataCells}}}}$$

$$\text{Upperhigh}_{95\%\text{Con}} := \mu\text{high}_{\text{actual}} + T\alpha \cdot \frac{\sigma\text{high}_{\text{actual}}}{\sqrt{\text{Nohigh}_{\text{DataCells}}}}$$

$$\text{Lowerlow}_{95\%\text{Con}} := \mu\text{low}_{\text{actual}} - T\alpha \cdot \frac{\sigma\text{low}_{\text{actual}}}{\sqrt{\text{Nolow}_{\text{DataCells}}}}$$

$$\text{Upperlow}_{95\%\text{Con}} := \mu\text{low}_{\text{actual}} + T\alpha \cdot \frac{\sigma\text{low}_{\text{actual}}}{\sqrt{\text{Nolow}_{\text{DataCells}}}}$$

Graphical Representation of Low Points

$\text{Bins}_{\text{low}} := \text{Make}_{\text{bins}}\left(\mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$

$\text{Distribution}_{\text{low}} := \text{hist}\left(\text{Bins}_{\text{low}}, \text{low}_{\text{points}}\right)$

The mid points of the Bins are calculated

$\text{Distribution}_{\text{low}} =$

	0
0	0
1	1
2	1
3	1
4	6
5	5
6	3
7	7
8	3
9	1
10	0
11	0

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

$$\text{normallow}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_{\text{low}_1}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$$

$$\text{normallow}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{\text{low}_{k+1}}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_{\text{low}_k}, \mu\text{low}_{\text{actual}}, \sigma\text{low}_{\text{actual}}\right)$$

$$\text{normallow}_{\text{curve}} := \text{Nolow}_{\text{DataCells}} \cdot \text{normallow}_{\text{curve}}$$

Graphical Representation of High Points

$\text{Bins}_{\text{high}} := \text{Make}_{\text{bins}}\left(\mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$

$\text{Distribution}_{\text{high}} := \text{hist}\left(\text{Bins}_{\text{high}}, \text{high}_{\text{points}}\right)$

$\text{Distribution}_{\text{high}} =$

	0
0	0
1	0
2	3
3	1
4	1
5	4
6	6
7	2
8	3
9	1
10	0
11	0

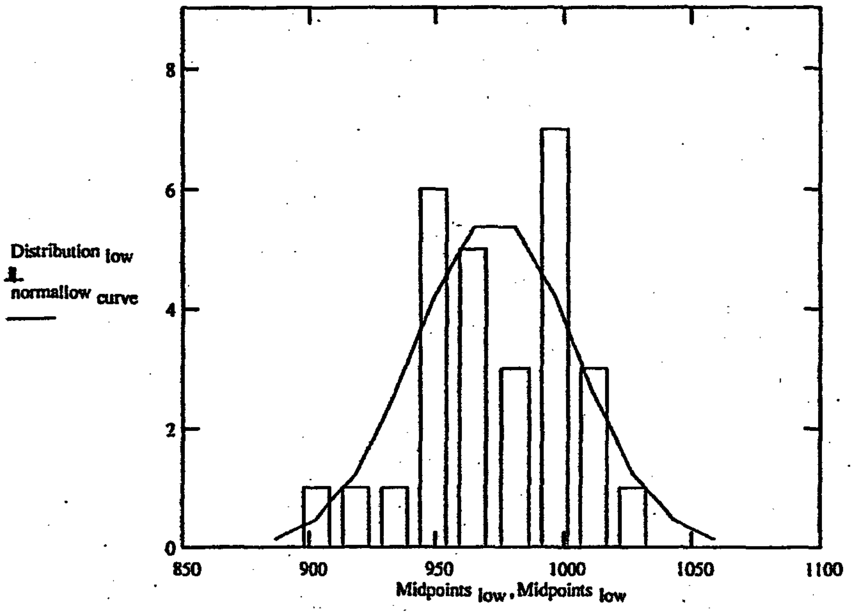
$k := 0..11$ $\text{Midpoints}_{\text{high}_k} := \dfrac{\left(\text{Bins}_{\text{high}_k} + \text{Bins}_{\text{high}_{k+1}}\right)}{2}$

$\text{normalhigh}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_{\text{high}_1}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$

$\text{normalhigh}_{\text{curve}_k} := \text{pnorm}\left(\text{Bins}_{\text{high}_{k+1}}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right) - \text{pnorm}\left(\text{Bins}_{\text{high}_k}, \mu\text{high}_{\text{actual}}, \sigma\text{high}_{\text{actual}}\right)$

$\text{normalhigh}_{\text{curve}} := \text{Nohigh}_{\text{DataCells}} \cdot \text{normalhigh}_{\text{curve}}$

Results For Sandbed Bay 17/19 thinner points



$\mu low_{actual} = 972.464$

$\sigma low_{actual} = 31.118$

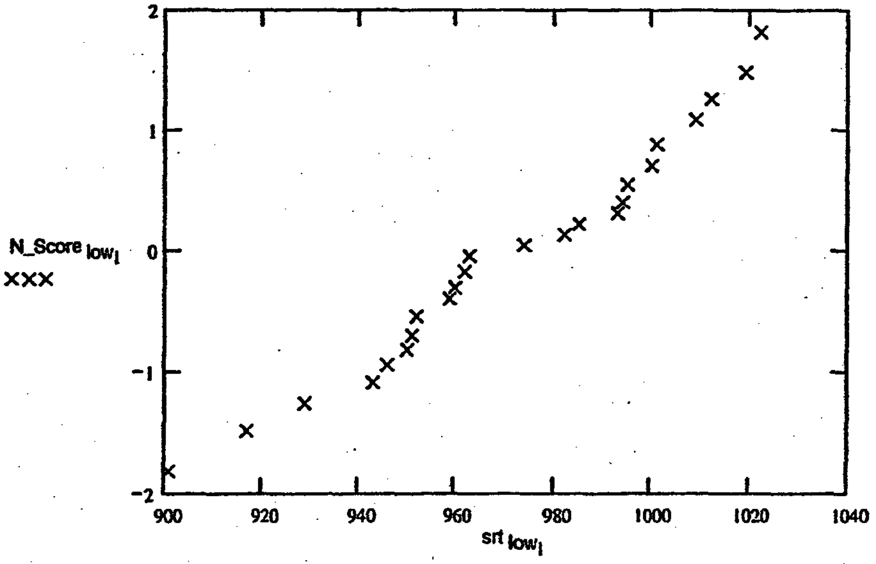
$Kurtosis_{low} = -0.451$

$Skewness_{low} = -0.348$

$Standardlow_{error} = 5.881$

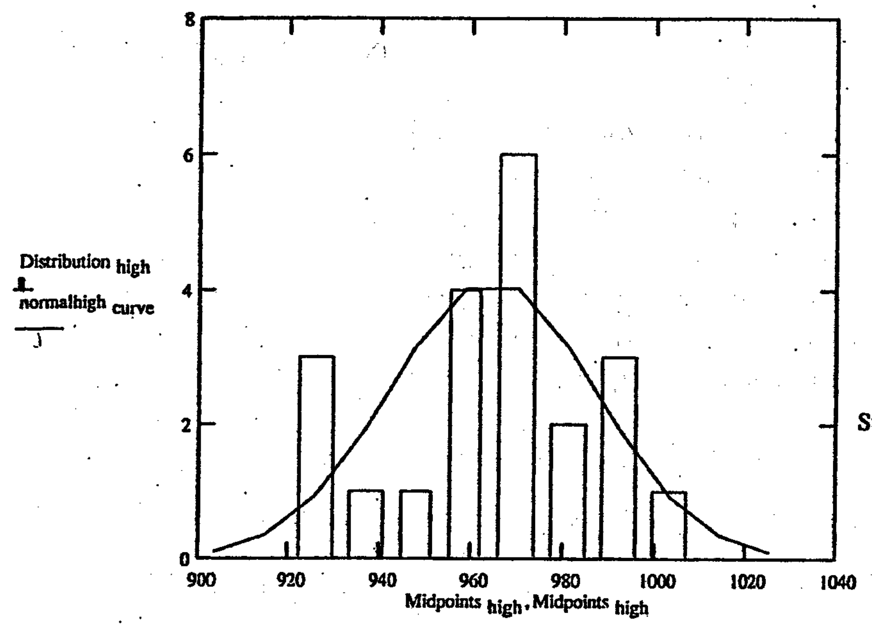
$Nolow_{DataCells} = 28$

$Lowerlow_{95\%Con} = 960.64$ $Upperlow_{95\%Con} = 984.288$



The above plots indicates that the thinner area is more normally distributed than the entire population.

Results For Sandbed Bay 17/19 thinner points



$\mu high_{actual} = 964.429$

$\sigma high_{actual} = 22.121$

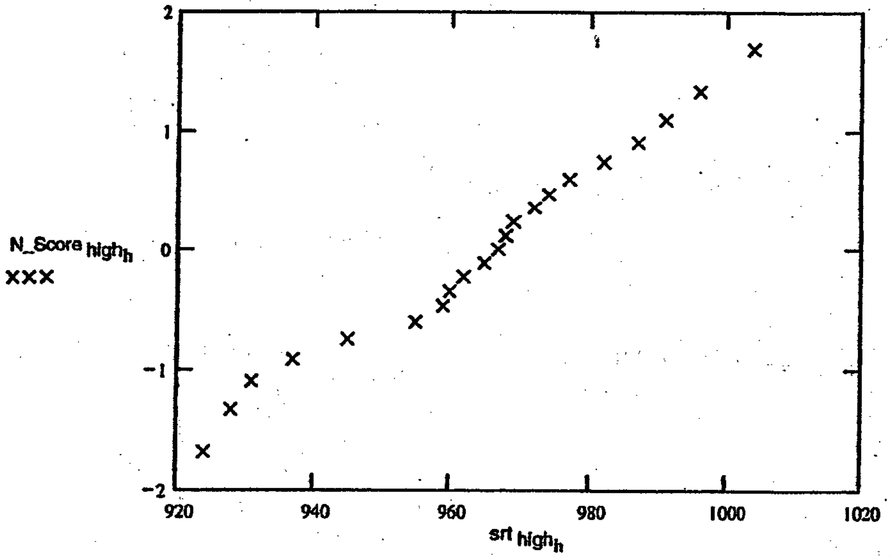
$Skewness_{high} = {}^{-}0.246$

$Kurtosis_{high} = {}^{-}0.481$

$Standardhigh_{error} = 4.827$

$Nohigh_{DataCells} = 21$

$Lower_{95\%Con} = 961.077$ $Upper_{95\%Con} = 976.963$



The above plots indicates that the thicker areas are normally distributed.

Data from 1992 to 2006 is retrieved. $d := 0$

For Dec 31 1992

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\DATA ONLY\SB17-19.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(12, 31, 1992)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.958 & 1.007 & 0.954 & 0.934 & 0.959 & 0.957 & 0.964 \\ 0.982 & 0.977 & 0.968 & 0.992 & 0.96 & 1.001 & 0.969 \\ 0.978 & 0.975 & 1.004 & 0.985 & 0.984 & 1.03 & 0.959 \\ 1.01 & 0.958 & 0.957 & 0.979 & 0.991 & 0.985 & 0.956 \\ 0.968 & 0.963 & 0.992 & 0.947 & 0.979 & 0.997 & 0.914 \\ 1.045 & 1.012 & 0.968 & 0.974 & 0.958 & 0.97 & 0.994 \\ 1.034 & 1.038 & 1.039 & 1.005 & 1.056 & 0.99 & 1.004 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{35_d} := \text{nnn}_{34}$ $\text{Point}_{35} = 914$

The two groups are named as follows: $\text{StopCELL} := 21$ $\text{No}_{\text{Cells}} := \text{length}(\text{Cells})$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$ $\text{high}_{\text{points}} := \text{TOPROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{No}_{\text{lowCells}} := \text{length}\left(\text{low}_{\text{points}}\right)$ $\text{No}_{\text{highCells}} := \text{length}\left(\text{high}_{\text{points}}\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{Cells}}\right)$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}}\right)$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{high}_{\text{points}}, \text{No}_{\text{highCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$\mu\text{high}_{\text{measured}_d} := \text{mean}\left(\text{high}_{\text{points}}\right)$ $\mu\text{low}_{\text{measured}_d} := \text{mean}\left(\text{low}_{\text{points}}\right)$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}\left(\text{high}_{\text{points}}\right)$ $\sigma\text{low}_{\text{measured}_d} := \text{Stdev}\left(\text{low}_{\text{points}}\right)$

$\text{Standardhigh}_{\text{error}_d} := \dfrac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{high}_{\text{points}}\right)}}$ $\text{Standardlow}_{\text{error}_d} := \dfrac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{low}_{\text{points}}\right)}}$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\DATA ONLY\SB17-19.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(9, 26, 1994)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.921 & 0.957 & 0.955 & 0.967 & 0.96 & 0.952 & 0.922 \\ 0.955 & 0.97 & 0.955 & 1.001 & 0.945 & 0.957 & 0.97 \\ 0.982 & 0.977 & 0.991 & 0.993 & 0.969 & 0.995 & 0.933 \\ 1.039 & 0.965 & 0.973 & 0.979 & 0.997 & 0.985 & 0.953 \\ 0.959 & 1.002 & 0.953 & 0.942 & 0.943 & 0.975 & 0.906 \\ 0.998 & 0.995 & 0.967 & 0.938 & 0.834 & 0.96 & 0.98 \\ 1.027 & 1.008 & 1.011 & 0.992 & 1.038 & 0.993 & 0.983 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{35_d} := \text{nnn}_{34}$

The two groups are named as follows: $\text{StopCELL} := 21$ $\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$ $\text{high}_{\text{points}} := \text{TOPROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{No}_{\text{lowCells}} := \text{length}\left(\text{low}_{\text{points}}\right)$ $\text{No}_{\text{highCells}} := \text{length}\left(\text{high}_{\text{points}}\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{Cells}}\right)$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}}\right)$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{high}_{\text{points}}, \text{No}_{\text{highCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$\mu\text{high}_{\text{measured}_d} := \text{mean}\left(\text{high}_{\text{points}}\right)$ $\mu\text{low}_{\text{measured}_d} := \text{mean}\left(\text{low}_{\text{points}}\right)$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}\left(\text{high}_{\text{points}}\right)$ $\sigma\text{low}_{\text{measured}_d} := \text{Stdev}\left(\text{low}_{\text{points}}\right)$

$\text{Standardhigh}_{\text{error}_d} := \dfrac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{high}_{\text{points}}\right)}}$ $\text{Standardlow}_{\text{error}_d} := \dfrac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{low}_{\text{points}}\right)}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\DATA ONLY\SB17-19.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 23, 1996)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.945 & 0.945 & 0.948 & 0.953 & 0.944 & 0.962 & 0.924 \\ 1.001 & 0.979 & 0.955 & 0.99 & 0.961 & 0.959 & 0.939 \\ 0.99 & 0.972 & 1 & 1.012 & 1.016 & 0.994 & 0.926 \\ 1.015 & 0.954 & 0.959 & 0.983 & 0.991 & 0.983 & 0.974 \\ 0.991 & 0.966 & 0.954 & 0.949 & 0.997 & 1.024 & 0.935 \\ 1.053 & 1.037 & 0.953 & 1.01 & 0.957 & 0.983 & 1.008 \\ 1.028 & 1.043 & 1.003 & 0.989 & 1.033 & 0.943 & 1.009 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{Point}_{35_d} := \text{nnn}_{34}$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{high}_{\text{points}} := \text{TOPROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{No}_{\text{lowCells}} := \text{length}\left(\text{low}_{\text{points}}\right)$

$\text{No}_{\text{highCells}} := \text{length}\left(\text{high}_{\text{points}}\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{Cells}}\right)$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}}\right)$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{high}_{\text{points}}, \text{No}_{\text{highCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}\left(\text{high}_{\text{points}}\right)$

$\mu\text{low}_{\text{measured}_d} := \text{mean}\left(\text{low}_{\text{points}}\right)$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}\left(\text{high}_{\text{points}}\right)$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}\left(\text{low}_{\text{points}}\right)$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{high}_{\text{points}}\right)}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{low}_{\text{points}}\right)}}$$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB17-19.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 23, 2006)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.969 & 0.962 & 0.945 & 0.931 & 0.965 & 0.96 & 0.928 \\ 0.972 & 0.977 & 0.959 & 0.991 & 0.967 & 0.955 & 0.937 \\ 0.968 & 0.974 & 1.004 & 0.987 & 0.982 & 0.996 & 0.924 \\ 1.022 & 0.959 & 0.963 & 0.974 & 0.993 & 0.985 & 0.952 \\ 0.96 & 0.962 & 0.951 & 0.95 & 0.943 & 0.982 & 0.901 \\ 1.001 & 0.994 & 0.952 & 0.929 & 0.917 & 0.962 & 1.001 \\ 0.995 & 1.019 & 1.012 & 0.995 & 1.009 & 0.946 & 1 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{35_d} := \text{nnn}_{34}$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$

$\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$

$\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$$

Below are the results

$$\text{Dates} = \begin{bmatrix} 1.993\cdot 10^{3} \\ 1.995\cdot 10^{3} \\ 1.997\cdot 10^{3} \\ 2.007\cdot 10^{3} \end{bmatrix}$$

$$\text{Standard}_{\text{error}} = \begin{bmatrix} 4.203 \\ 4.94 \\ 4.645 \\ 3.951 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 983.265 \\ 969.837 \\ 980.388 \\ 969.02 \end{bmatrix} \quad \text{Point}_{35} = \begin{bmatrix} 914 \\ 906 \\ 935 \\ 901 \end{bmatrix} \quad \sigma_{\text{measured}} = \begin{bmatrix} 29.423 \\ 34.58 \\ 32.516 \\ 27.654 \end{bmatrix}$$

$$\mu\text{high}_{\text{measured}} = \begin{bmatrix} 976.048 \\ 963.19 \\ 967.381 \\ 964.429 \end{bmatrix} \quad \sigma\text{high}_{\text{measured}} = \begin{bmatrix} 22.083 \\ 22.272 \\ 27.623 \\ 22.121 \end{bmatrix} \quad \text{Standardhigh}_{\text{error}} = \begin{bmatrix} 4.819 \\ 4.86 \\ 6.028 \\ 4.827 \end{bmatrix}$$

$$\mu\text{low}_{\text{measured}} = \begin{bmatrix} 988.679 \\ 974.821 \\ 990.143 \\ 972.464 \end{bmatrix} \quad \sigma\text{low}_{\text{measured}} = \begin{bmatrix} 33.27 \\ 41.21 \\ 32.926 \\ 31.118 \end{bmatrix} \quad \text{Standardlow}_{\text{error}} = \begin{bmatrix} 6.287 \\ 7.788 \\ 6.222 \\ 5.881 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}})$ $\text{Total}_{\text{means}} = 4$

$$SST := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2$$

$$SST_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{mean}(\mu\text{low}_{\text{measured}})\right)^2$$

$$SST_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{mean}(\mu\text{high}_{\text{measured}})\right)^2$$

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

$$SSE_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu\text{low}_{\text{measured}})_i\right)^2$$

$$SSE_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu\text{high}_{\text{measured}})_i\right)^2$$

$$SSR := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2$$

$$SSR_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu\text{low}_{\text{measured}})_i - \text{mean}(\mu\text{low}_{\text{measured}})\right)^2$$

$$SSR_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu\text{high}_{\text{measured}})_i - \text{mean}(\mu\text{high}_{\text{measured}})\right)^2$$

$DegreeFree_{ss} := Total_{means} - 2$ $DegreeFree_{reg} := 1$ $DegreeFree_{st} := Total_{means} - 1$

$MSE := \frac{SSE}{DegreeFree_{ss}}$ $MSE_{low} := \frac{SSE_{low}}{DegreeFree_{ss}}$ $MSE_{high} := \frac{SSE_{high}}{DegreeFree_{ss}}$

$Standard_{error} := \sqrt{MSE}$ $Standard_{lowerror} := \sqrt{MSE_{low}}$ $Standard_{higherror} := \sqrt{MSE_{high}}$

$MSR := \frac{SSR}{DegreeFree_{reg}}$ $MSR_{low} := \frac{SSR_{low}}{DegreeFree_{reg}}$ $MSR_{high} := \frac{SSR_{high}}{DegreeFree_{reg}}$

$MST := \frac{SST}{DegreeFree_{st}}$ $MST_{low} := \frac{SST_{low}}{DegreeFree_{st}}$ $MST_{high} := \frac{SST_{high}}{DegreeFree_{st}}$

Test the means with all points

F Test for Corrosion

$\alpha := 0.05$ $F_{actaul\_Reg} := \frac{MSR}{MSE}$

$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 0.068$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Test the low points

F Test for Corrosion

$$F_{actaul\_Reg.low} := \frac{MSR_{low}}{MSE_{low}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.low} := \frac{F_{actaul\_Reg.low}}{F_{critical\_reg}}$$

$$F_{ratio\_reg.low} = 0.066$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

Test the high points

F Test for Corrosion

$$F_{actaul\_Reg.high} := \frac{MSR_{high}}{MSE_{high}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.high} := \frac{F_{actaul\_Reg.high}}{F_{critical\_reg}}$$

$$F_{ratio\_reg.high} = 0.039$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean.

The following will plot the results for the overall mean, the mean of thinner points, and the mean of thicker points

$i := 0 .. \text{Total}_{\text{means}} - 1$

$\mu\text{grand}_{\text{measured}_i} := \text{mean}(\mu_{\text{measured}})$ $\sigma\text{grand}_{\text{measured}} := \text{Stdev}(\mu_{\text{measured}})$

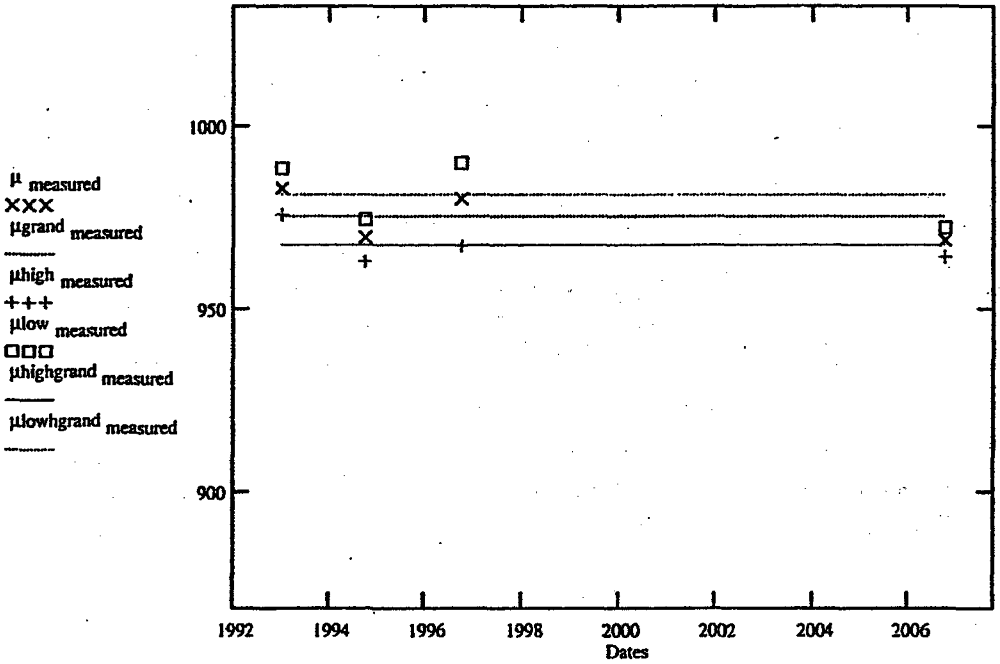
$$\text{GrandStandard}_{\text{error}} := \frac{\sigma\text{grand}_{\text{measured}}}{\sqrt{\text{Total}_{\text{means}}}}$$

$\sigma\text{grand}_{\text{lowmeasured}} := \text{Stdev}(\mu\text{low}_{\text{measured}})$ $\mu\text{lowhgrand}_{\text{measured}_i} := \text{mean}(\mu\text{low}_{\text{measured}})$

$$\text{GrandStandard}_{\text{lowerror}} := \frac{\sigma\text{grand}_{\text{lowmeasured}}}{\sqrt{\text{Total}_{\text{means}}}}$$

$\sigma\text{grand}_{\text{highmeasured}} := \text{Stdev}(\mu\text{high}_{\text{measured}})$ $\mu\text{highgrand}_{\text{measured}_i} := \text{mean}(\mu\text{high}_{\text{measured}})$

$$\text{GrandStandard}_{\text{higherror}} := \frac{\sigma\text{grand}_{\text{highmeasured}}}{\sqrt{\text{Total}_{\text{means}}}}$$



$\mu\text{grand}_{\text{measured}_0} = 975.628$ $\text{GrandStandard}_{\text{error}} = 3.631$

$\text{mean}(\mu\text{low}_{\text{measured}}) = 981.527$ $\text{GrandStandard}_{\text{lowerror}} = 4.587$

$\text{mean}(\mu\text{high}_{\text{measured}}) = 967.762$ $\text{GrandStandard}_{\text{higherror}} = 2.898$

The F Test indicates that the regression model does not hold for any of the data sets. However, the slopes and 95% Confidence curves are generated for all three cases.

$m_s := \mathrm{slope}(\mathrm{Dates}, \mu_{measured})$ $y_b := \mathrm{intercept}(\mathrm{Dates}, \mu_{measured})$

$m_{lows} := \mathrm{slope}(\mathrm{Dates}, \mu low_{measured})$ $y_{lowb} := \mathrm{intercept}(\mathrm{Dates}, \mu low_{measured})$

$m_{highs} := \mathrm{slope}(\mathrm{Dates}, \mu high_{measured})$ $y_{highb} := \mathrm{intercept}(\mathrm{Dates}, \mu high_{measured})$

$\alpha_t := 0.05$ $k := 23$ $f := 0..k-1$

$year_{predict_f} := 1985 + f \cdot 2$

$Thick_{predict} := m_s \cdot year_{predict} + y_b$

$Thick_{lowpredict} := m_{lows} \cdot year_{predict} + y_{lowb}$

$Thick_{highpredict} := m_{highs} \cdot year_{predict} + y_{highb}$

$Thick_{actualmean} := \mathrm{mean}(\mathrm{Dates})$

$sum := \sum_i (\mathrm{Dates}_d - \mathrm{mean}(\mathrm{Dates}))^2$

For the entire grid

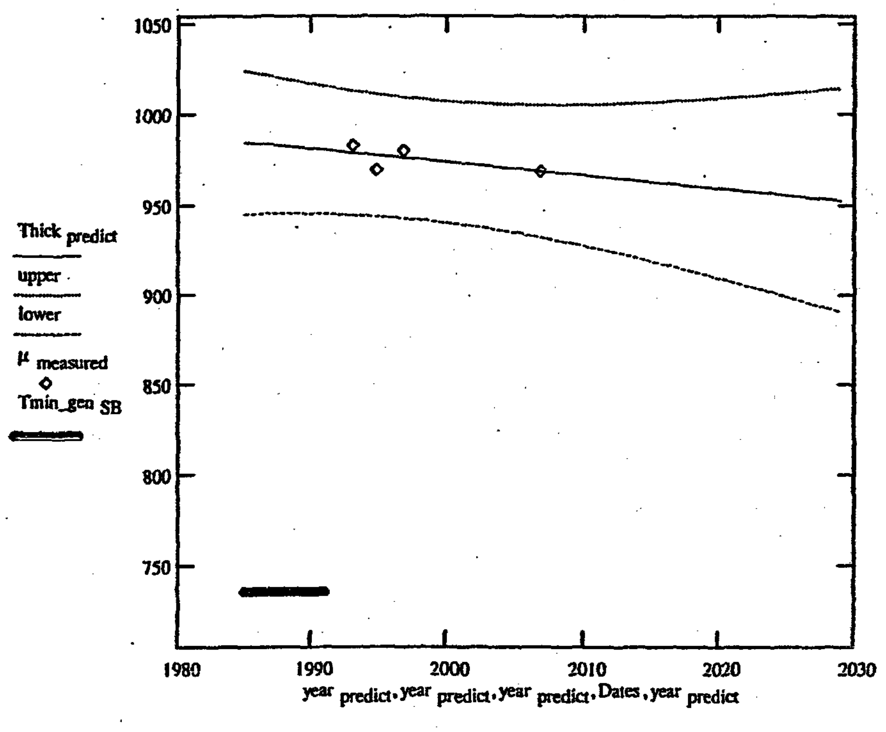
$$\text{upper}_f := \text{Thick}_{\text{predict}_f} \cdots$$

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

$$\text{lower}_f := \text{Thick}_{\text{predict}_f} \cdots$$

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

The minimum required thickness at this elevation is $\text{Tmin\_gen}_{\text{SB}_1} := 736$ (Ref. 3.25)



$m_s = -0.733$

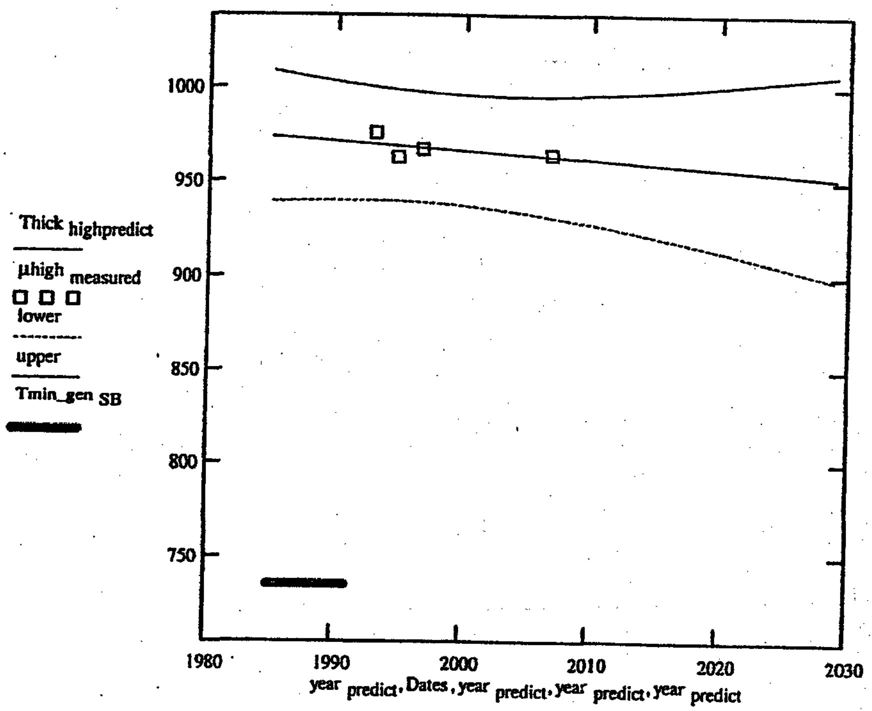
ie points which are thicker

$$\mathrm{upper}_f := \mathrm{Thick}_{\mathrm{highpredict}_f} \cdots$$

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

$$\mathrm{lower}_f := \mathrm{Thick}_{\mathrm{highpredict}_f} \cdots$$

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



$m_{\mathrm{highs}} = -0.487$

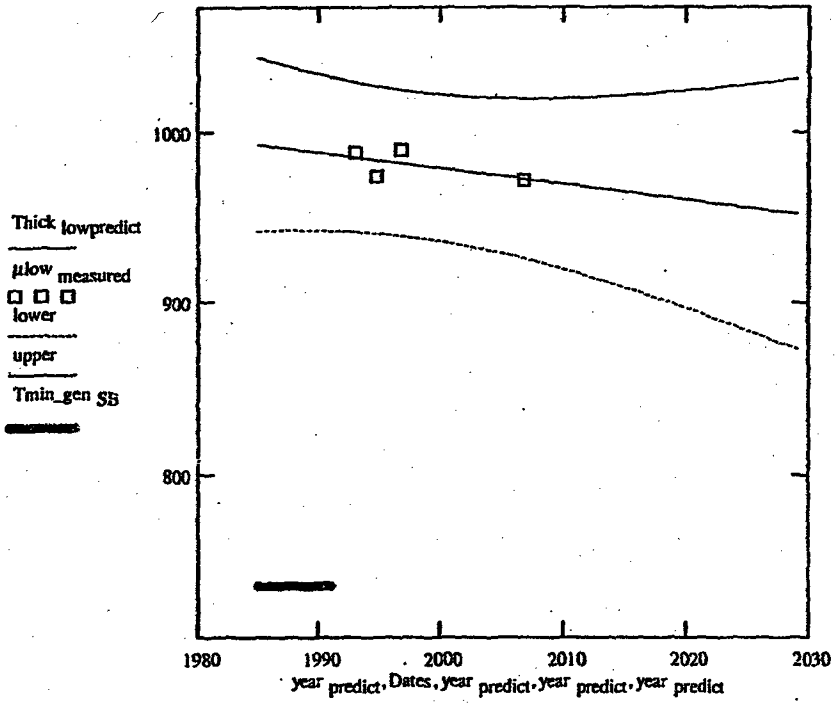
the points which are thinner

$$upper_f := Thick_{lowpredict_f} \cdots$$

$$+ qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Standard_{lowerror} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Thick_{actualmean}\right)^2}{sum}}$$

$$lower_f := Thick_{lowpredict_f} \cdots$$

$$+ -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot Standard_{lowerror} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Thick_{actualmean}\right)^2}{sum}}\right]$$



$m_{lows} = -0.917$

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a inimum observable rate observed in appendix 22.

$$Rate_{min\_observed} := 6.9$$

$$Postulated_{meanthickness} := \mu_{measured_3} - Rate_{min\_observed} \cdot (2029 - 2006)$$

$Postulated_{meanthickness} = 810.32$ which is greater than $Tmin\_gen_{SB_3} = 736$

e following addresses the readings at the lowest single point

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point35_i - mean(Point35)\right)^2 \qquad SST_{point} = 674$$

$$E_{point} := \sum_{i=0}^{last(Dates)} \left(Point35_i - yhat(Dates, Point35)_i\right)^2 \qquad SSE_{point} = 559.156$$

$$R_{point} := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, Point35)_i - mean(Point35)\right)^2 \qquad SSR_{point} = 114.844$$

$$SE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 16.721$$

$$MSE_{point} = 279.578 \qquad MSR_{point} = 114.844 \qquad MST_{point} = 224.667$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.022$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \mathrm{slope}(\mathrm{Dates}, \mathrm{Point}_{35})$ $m_{point} = -1.007$ $y_{point} := \mathrm{intercept}(\mathrm{Dates}, \mathrm{Point}_{35})$ $y_{point} = 2.925 \cdot 10^{3}$

The 95% Confidence curves are calculated

$\mathrm{Point}_{curve} := m_{point} \cdot \mathrm{year}_{predict} + y_{point}$

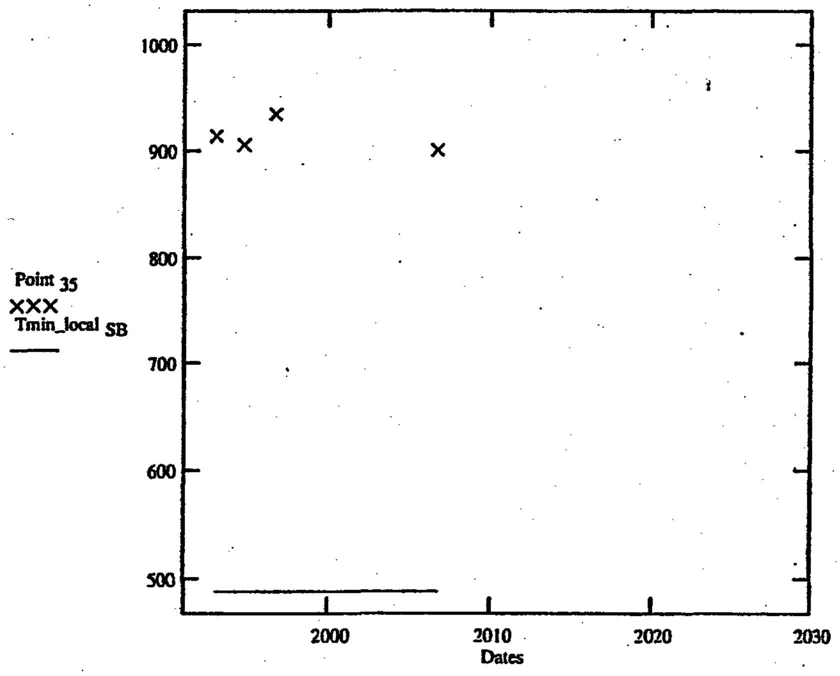
$\mathrm{Point}_{actualmean} := \mathrm{mean}(\mathrm{Dates})$ $\mathrm{sum} := \sum_{i} \left(\mathrm{Dates}_{d} - \mathrm{mean}(\mathrm{Dates})\right)^{2}$

$$\mathrm{uppoint}_{f} := \mathrm{Point}_{curve_{f}} \cdots + \mathrm{qt}\left(1 - \frac{\alpha_{t}}{2}, \mathrm{Total}_{means} - 2\right) \cdot \mathrm{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{predict_{f}} - \mathrm{Point}_{actualmean}\right)^{2}}{\mathrm{sum}}}$$

$$\mathrm{lopoint}_{f} := \mathrm{Point}_{curve_{f}} \cdots + -\left[\mathrm{qt}\left(1 - \frac{\alpha_{t}}{2}, \mathrm{Total}_{means} - 2\right) \cdot \mathrm{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{predict_{f}} - \mathrm{Point}_{actualmean}\right)^{2}}{\mathrm{sum}}}\right]$$

Local Tmin for this elevation in the Drywell $\mathrm{Tmin\_local}_{SB_{f}} := 490$ (Ref. 3.25)

Curve Fit For Point 35 Projected to Plant End Of Life



$m_{point} = -1.007$

$\mathrm{lopoint}_{22} = 733.369$ $\mathrm{year}_{predict_{22}} = 2.029 \cdot 10^{3}$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$Rate_{min\_observed} := 6.9$$

$$Postulated_{thickness} := Point\,35_0 - Rate_{min\_observed} \cdot (2029 - 2006)$$

$Postulated_{thickness} = 755.3$ which is greater than $Tmin\_local_{SB_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$minpoint = 0.901$ $year_{predict_{22}} = 2.029 \cdot 10^3$ $Tmin\_local_{SB_{22}} = 490$

$$required_{rate.} := \frac{\left(1000 \cdot minpoint - Tmin\_local_{SB_{22}}\right)}{(2005 - 2029)}$$

$required_{rate.} = -17.125$ mils per year

Appendix 10 - Sand Bed Elevation Bay 19A

October 2006 Data

The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB19A.txt")

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

$$\text{Points}_{49} = \begin{bmatrix} 0.692 & 0.788 & 0.743 & 0.648 & 0.699 & 0.702 & 0.735 \\ 0.807 & 0.774 & 0.845 & 0.736 & 0.747 & 0.724 & 0.773 \\ 0.813 & 0.812 & 0.892 & 0.885 & 0.861 & 0.792 & 0.806 \\ 0.916 & 0.883 & 0.805 & 1.179 & 0.808 & 0.777 & 0.766 \\ 0.873 & 0.904 & 0.842 & 1.16 & 0.801 & 0.752 & 0.878 \\ 0.844 & 0.768 & 0.834 & 0.858 & 0.851 & 0.834 & 0.867 \\ 0.865 & 0.803 & 0.793 & 0.844 & 0.878 & 0.817 & 0.808 \end{bmatrix}$$

$\text{Cells} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

The thinnest point at this location is point 4 which shown below

$\text{minpoint} := \min(\text{Points}_{49})$ $\text{minpoint} = 0.648$

For this location point 24, 25, 31, and 32 are over a plug (refer 3.22)

$\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 24)$ $\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 25)$

$\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 31)$ $\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 32)$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{Cells}, \text{No}_{\text{DataCells}})$

Mean and Standard Deviation

$\mu_{actual} := mean(Cells)$ $\mu_{actual} = 806.5778$ $\sigma_{actual} := Stdev(Cells)$ $\sigma_{actual} = 62.384$

Standard Error

minpoint = 0.648

$$Standard_{error} := \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}}$$

$Standard_{error} = 8.912$

Skewness

$$Skewness := \frac{(No_{DataCells}) \cdot \overrightarrow{\Sigma(Cells - \mu_{actual})^3}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (\sigma_{actual})^3}$$

$Skewness = -0.377$

Kurtosis

$$Kurtosis := \frac{No_{DataCells} \cdot (No_{DataCells} + 1) \cdot \overrightarrow{\Sigma(Cells - \mu_{actual})^4}}{(No_{DataCells} - 1) \cdot (No_{DataCells} - 2) \cdot (No_{DataCells} - 3) \cdot (\sigma_{actual})^4} + -\frac{3 \cdot (No_{DataCells} - 1)^2}{(No_{DataCells} - 2) \cdot (No_{DataCells} - 3)}$$

$Kurtosis = -0.572$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

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

$\alpha := .05 \qquad T\alpha := qt\left[\left(1-\frac{\alpha}{2}\right), No_{DataCells}\right] \qquad T\alpha = 2.014$

$Lower_{95\%Con} := \mu_{actual} - T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 787.847$

$Upper_{95\%Con} := \mu_{actual} + T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 825.308$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

$Distribution := hist(Bins, Cells)$

$$Distribution = \begin{pmatrix} 1 \\ 0 \\ 3 \\ 4 \\ 6 \\ 7 \\ 8 \\ 8 \\ 6 \\ 2 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

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

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

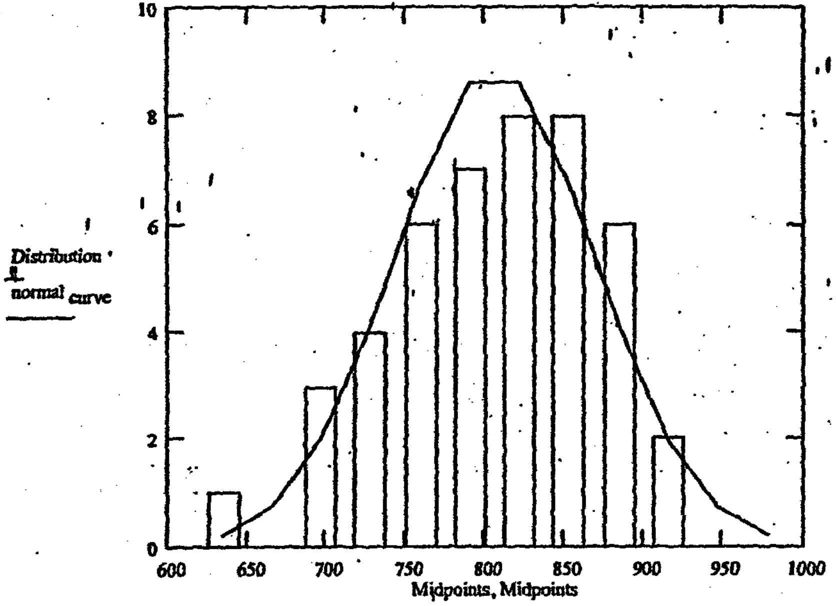
$normal_{curve_k} := pnorm(Bins_{k+1}, \mu_{actual}, \sigma_{actual}) - pnorm(Bins_k, \mu_{actual}, \sigma_{actual})$

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

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 806.578$

$\sigma_{actual} = 62.384$

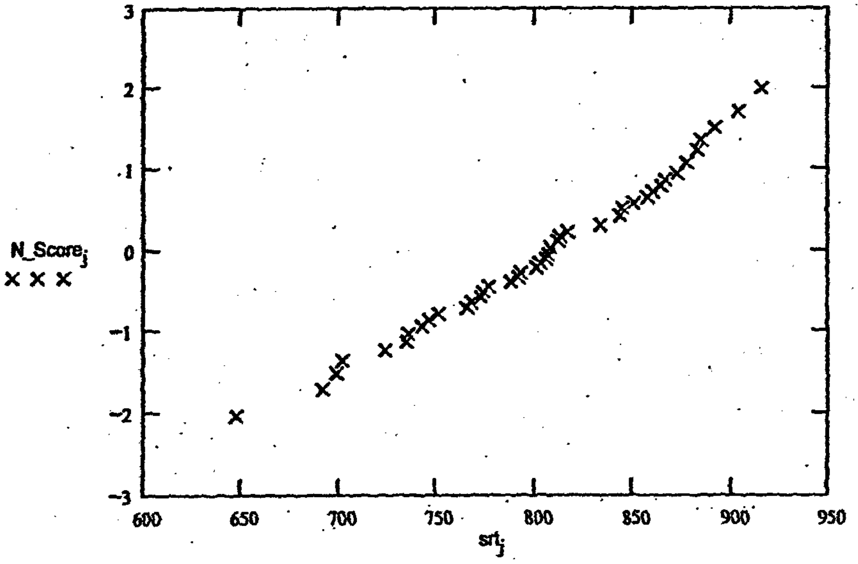
$Standard_{error} = 8.912$

$Skewness = -0.377$

$Kurtosis = -0.572$

$Lower_{95\%Con} = 787.847$ $Upper_{95\%Con} = 825.308$

Normal Probability Plot



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

Sandbed Location 19A Trend

$d := 0$

For 1992 $\qquad Dates_d := Day_{year}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB19A.txt")

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

Data

$$Points_{49} = \begin{bmatrix} 0.681 & 0.781 & 0.749 & 0.659 & 0.729 & 0.694 & 0.731 \\ 0.81 & 0.778 & 0.82 & 0.759 & 0.747 & 0.723 & 0.773 \\ 0.776 & 0.8 & 0.888 & 0.755 & 0.771 & 0.809 & 0.806 \\ 0.886 & 0.888 & 0.803 & 1.077 & 0.794 & 0.772 & 0.762 \\ 0.872 & 0.864 & 0.273 & 1.16 & 0.796 & 0.751 & 0.859 \\ 0.859 & 0.766 & 0.844 & 0.848 & 0.859 & 0.894 & 0.85 \\ 0.864 & 0.802 & 0.803 & 0.844 & 0.882 & 0.818 & 0.792 \end{bmatrix}$$

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

$Point_{4_d} := nnn_3 \qquad Point_4 = 659$

For this location point 24, 25, 31, and 32 are over a plug (refer 3.22)

$nnn := Zero_{one}\left(nnn, No_{DataCells}, 24\right) \qquad nnn := Zero_{one}\left(nnn, No_{DataCells}, 25\right)$

$nnn := Zero_{one}\left(nnn, No_{DataCells}, 31\right) \qquad nnn := Zero_{one}\left(nnn, No_{DataCells}, 32\right)$

$Cells := deletezero_{cells}\left(nnn, No_{DataCells}\right)$

$\mu_{measured_d} := mean(Cells) \qquad \sigma_{measured_d} := Stdev(Cells) \qquad Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 1994

$$d := d + 1$$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB19A.txt")

$$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(9, 14, 1994)$$

$$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.679 & 0.808 & 0.748 & 0.65 & 0.722 & 0.696 & 0.727 \\ 0.778 & 0.767 & 0.82 & 0.739 & 0.743 & 0.723 & 0.766 \\ 0.77 & 0.794 & 0.885 & 0.756 & 0.796 & 0.833 & 0.785 \\ 0.889 & 0.9 & 0.266 & 1.143 & 0.795 & 0.771 & 0.759 \\ 0.868 & 0.862 & 0.253 & 1.161 & 0.793 & 0.763 & 0.861 \\ 0.945 & 0.767 & 0.814 & 0.87 & 0.852 & 0.88 & 0.857 \\ 0.888 & 0.799 & 0.808 & 0.847 & 0.88 & 0.854 & 0.975 \end{bmatrix}$$

$$\mathrm{nnn} := \mathrm{convert}\left(\mathrm{Points}_{49}, 7\right) \qquad \mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$$

$$\mathrm{Point}_{4_d} := \mathrm{nnn}_3$$

For this location point 24, 25, 31, and 32 are over a plug (refer 3.22)

$$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 24\right) \qquad \mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 25\right)$$

$$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 31\right) \qquad \mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 32\right)$$

$$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$$

$$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells}) \qquad \sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells}) \qquad \mathrm{Standard}_{\mathrm{error}_d} := \frac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$$

For 1996

$$d := d + 1$$

$$\text{page} := \text{READPRN}(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Sept.1996 Data\textbackslash sandbed\textbackslash Data Only\textbackslash SB19A.txt"})$$

$$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$$

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.657 & 0.781 & 0.734 & 0.68 & 0.722 & 0.719 & 0.745 \\ 0.779 & 0.83 & 0.875 & 0.779 & 0.762 & 0.755 & 0.769 \\ 0.821 & 0.788 & 0.906 & 0.786 & 0.793 & 0.815 & 0.805 \\ 0.892 & 0.889 & 0.898 & 1.159 & 0.789 & 0.713 & 0.833 \\ 0.876 & 0.906 & 0.833 & 1.159 & 0.795 & 0.762 & 0.864 \\ 0.944 & 0.779 & 0.84 & 0.857 & 0.865 & 0.809 & 0.85 \\ 0.924 & 0.83 & 0.889 & 0.866 & 0.925 & 0.872 & 0.801 \end{bmatrix}$$

$$\text{nnn} := \text{convert}(\text{Points}_{49}, 7) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$$

$$\text{Point}_{4_d} := \text{nnn}_3$$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 24) \qquad \text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 25)$$

$$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 31) \qquad \text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 32)$$

$$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$$

$$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB19A.txt")

$Dates_d := Day_{year}(10, 16, 2006)$

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

Data

$$Points_{49} = \begin{bmatrix} 0.692 & 0.788 & 0.743 & 0.648 & 0.699 & 0.702 & 0.735 \\ 0.807 & 0.774 & 0.845 & 0.736 & 0.747 & 0.724 & 0.773 \\ 0.813 & 0.812 & 0.892 & 0.885 & 0.861 & 0.792 & 0.806 \\ 0.916 & 0.883 & 0.805 & 1.179 & 0.808 & 0.777 & 0.766 \\ 0.873 & 0.904 & 0.842 & 1.16 & 0.801 & 0.752 & 0.878 \\ 0.844 & 0.768 & 0.834 & 0.858 & 0.851 & 0.834 & 0.867 \\ 0.865 & 0.803 & 0.793 & 0.844 & 0.878 & 0.817 & 0.808 \end{bmatrix}$$

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

$Point\,4_d := nnn_3$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$nnn := Zero_{one}(nnn, No_{DataCells}, 24)$

$nnn := Zero_{one}(nnn, No_{DataCells}, 25)$

$nnn := Zero_{one}(nnn, No_{DataCells}, 31)$

$nnn := Zero_{one}(nnn, No_{DataCells}, 32)$

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

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\mathrm{Dates} = \begin{bmatrix} 1.993\cdot 10^3 \\ 1.995\cdot 10^3 \\ 1.997\cdot 10^3 \\ 2.007\cdot 10^3 \end{bmatrix} \qquad \mathrm{Point}_4 = \begin{bmatrix} 659 \\ 650 \\ 680 \\ 648 \end{bmatrix} \qquad \sigma_{\mathrm{measured}} = \begin{bmatrix} 58.564 \\ 69.319 \\ 67.305 \\ 62.384 \end{bmatrix}$$

$$\mu_{\mathrm{measured}} = \begin{bmatrix} 800.1778 \\ 806.2667 \\ 814.9111 \\ 806.5778 \end{bmatrix} \qquad \mathrm{Standard}_{\mathrm{error}} = \begin{bmatrix} 8.366 \\ 9.903 \\ 9.615 \\ 8.912 \end{bmatrix}$$

$$\mathrm{Total}_{\mathrm{means}} := \mathrm{rows}\left(\mu_{\mathrm{measured}}\right) \qquad \mathrm{Total}_{\mathrm{means}} = 4$$

$$\mathrm{SST} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{mean}\left(\mu_{\mathrm{measured}}\right)\right)^2 \qquad \mathrm{SST} = 109.843$$

$$\mathrm{SSE} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{yhat}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)_i\right)^2 \qquad \mathrm{SSE} = 105.245$$

$$\mathrm{SSR} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{yhat}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)_i - \mathrm{mean}\left(\mu_{\mathrm{measured}}\right)\right)^2 \qquad \mathrm{SSR} = 4.598$$

$$\mathrm{DegreeFree}_{ss} := \mathrm{Total}_{\mathrm{means}} - 2 \qquad \mathrm{DegreeFree}_{reg} := 1 \qquad \mathrm{DegreeFree}_{st} := \mathrm{Total}_{\mathrm{means}} - 1$$

$$\mathrm{MSE} := \frac{\mathrm{SSE}}{\mathrm{DegreeFree}_{ss}} \qquad \mathrm{MSR} := \frac{\mathrm{SSR}}{\mathrm{DegreeFree}_{reg}} \qquad \mathrm{MST} := \frac{\mathrm{SST}}{\mathrm{DegreeFree}_{st}}$$

$$\mathrm{MSE} = 52.623 \qquad \mathrm{MSR} = 4.598 \qquad \mathrm{MST} = 36.614$$

$$\mathrm{StGrand}_{err} := \sqrt{\mathrm{MSE}} \qquad \mathrm{StGrand}_{err} = 7.254$$

F Test for Corrosion

$$\alpha := 0.05 \qquad F_{\mathrm{actaul\_Reg}} := \frac{\mathrm{MSR}}{\mathrm{MSE}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 4.72\cdot10^{-3}$$

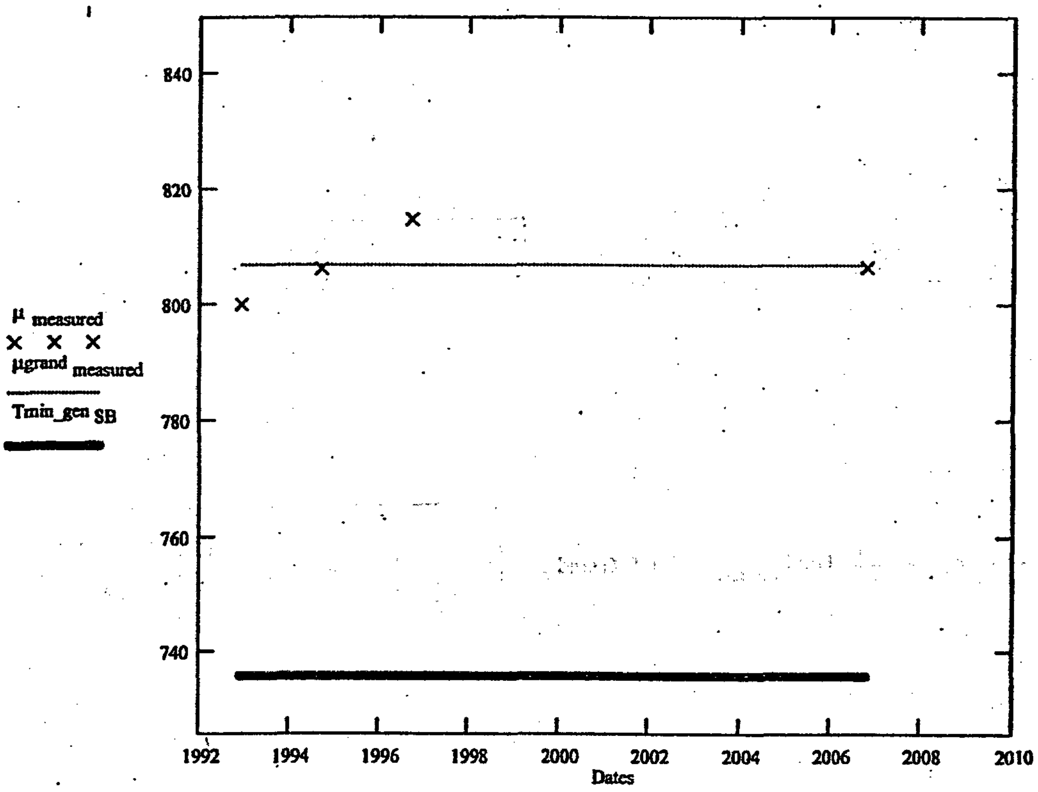
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure low provides a trend of the data and the grandmean

$i := 0 .. \text{Total}_{\text{means}} - 1$ $\mu\text{grand}_{\text{measured}_i} := \text{mean}(\mu_{\text{measured}})$

$\sigma\text{grand}_{\text{measured}} := \text{Stdev}(\mu_{\text{measured}})$ $\text{GrandStandard}_{\text{error}_0} := \dfrac{\sigma\text{grand}_{\text{measured}}}{\sqrt{\text{Total}_{\text{means}}}}$

The minimum required thickness at this elevation is $\text{Tmin\_gen}_{\text{SB}_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu\text{grand}_{\text{measured}_0} = 806.983$ $\text{GrandStandard}_{\text{error}} = 3.025$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \mathrm{slope}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)$ $m_s = 0.2$ $y_b := \mathrm{intercept}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)$ $y_b = -407.976$

The 95% Confidence curves are calculated

$\alpha_t := 0.05$ $k := 2029 - 1985$ $f := 0 .. k - 1$

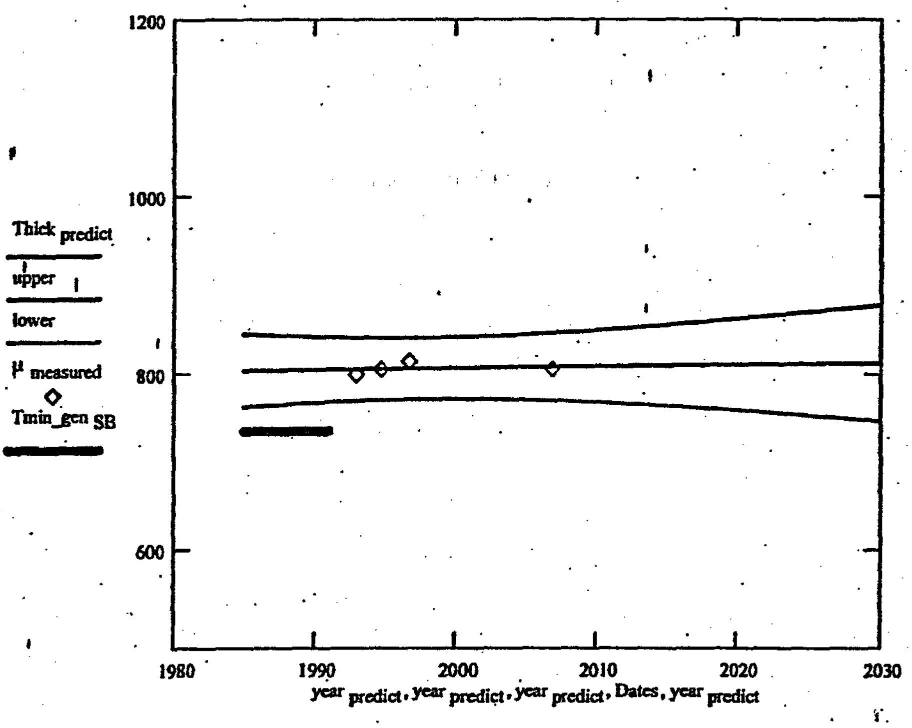
$\mathrm{year}_{\mathrm{predict}_f} := 1985 + f \cdot 2$ $\mathrm{Thick}_{\mathrm{predict}} := m_s \cdot \mathrm{year}_{\mathrm{predict}} + y_b$

$\mathrm{Thick}_{\mathrm{actualmean}} := \mathrm{mean}(\mathrm{Dates})$ $\mathrm{sum} := \sum_i \left(\mathrm{Dates}_d - \mathrm{mean}(\mathrm{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$\dot{m}_s = 0.2$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if it corrode at a minimum observable rate of LATER mils per year.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thicknessin2008}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2008 - 2006)$$

$\text{Postulated}_{\text{thicknessin2008}} = 792.778$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2016 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 737.578$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

The F-Ratio is calculated for the point as follows

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{4_i} - mean\left(Point_4\right)\right)^2 \qquad SST_{point} = 642.75$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{4_i} - yhat\left(Dates, Point_4\right)_i\right)^2 \qquad SSE_{point} = 566.21$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, Point_4\right)_i - mean\left(Point_4\right)\right)^2 \qquad SSR_{point} = 76.54$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 283.105 \qquad MSR_{point} = 76.54 \qquad MST_{point} = 214.25$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 16.826$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.015$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \mathrm{slope}(Dates, Point_4)$ $m_{point} = -0.815$ $y_{point} := \mathrm{intercept}(Dates, Point_4)$ $y_{point} = 2.287 \cdot 10^3$

The 95% Confidence curves are calculated

$Point_{curve} := m_{point} \cdot year_{predict} + y_{point}$

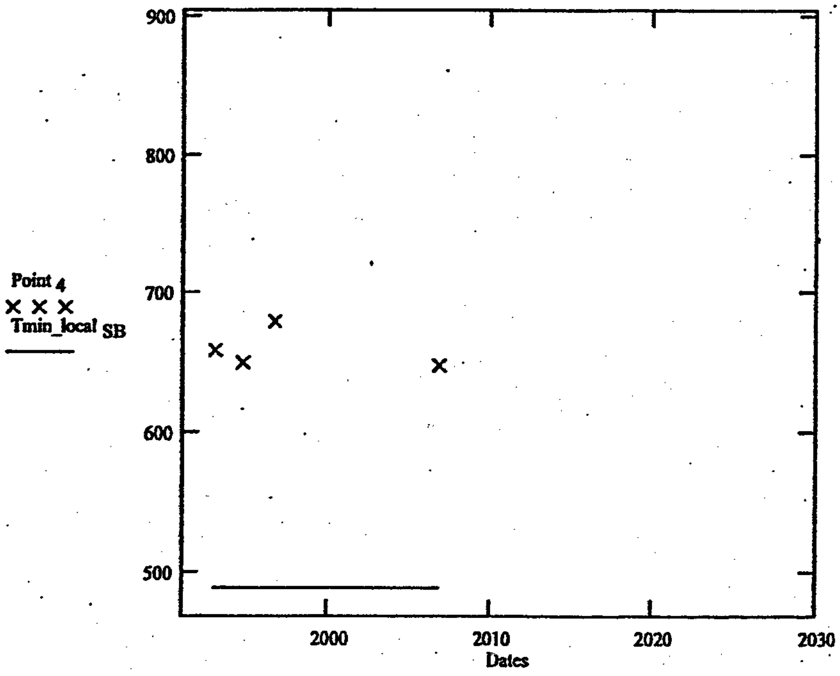
$Point_{actualmean} := \mathrm{mean}(Dates)$ $sum := \sum_i (Dates_d - \mathrm{mean}(Dates))^2$

$$uppoint_f := Point_{curve_f} + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(year_{predict_f} - Point_{actualmean})^2}{sum}}$$

$$lopoint_f := Point_{curve_f} + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(year_{predict_f} - Point_{actualmean})^2}{sum}}\right]$$

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 4 Projected to Plant End Of Life



$m_{point} = -0.815$

$lopoint_{22} = 484.514$ $year_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thicknessin2008}} := \text{Point}_{4_3} - \text{Rate}_{\text{min\_observed}} \cdot (2016 - 2006)$$

$\text{Postulated}_{\text{thicknessin2008}} = 579$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 0.648$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -6.583$ mils per year

Appendix 11 - Sand Bed Elevation Bay 19B

October 2006 Data

The data shown below was collected on 10/18/06

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB19B.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$$\text{Points}_{49} = \begin{bmatrix} 0.865 & 0.862 & 0.872 & 0.932 & 0.947 & 0.992 & 0.802 \\ 0.842 & 0.883 & 0.78 & 0.84 & 0.915 & 0.778 & 0.866 \\ 0.861 & 0.906 & 0.838 & 0.898 & 0.974 & 0.93 & 0.834 \\ 0.869 & 0.883 & 0.807 & 0.801 & 0.766 & 0.834 & 0.774 \\ 0.811 & 0.77 & 0.785 & 0.788 & 0.799 & 0.731 & 0.778 \\ 0.828 & 0.787 & 0.885 & 0.891 & 0.934 & 0.834 & 0.738 \\ 0.872 & 0.822 & 0.904 & 0.828 & 0.843 & 0.875 & 0.871 \end{bmatrix}$$

$\text{Cells} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$

The thinnest point at this location is point 34 which is shown below

$\text{minpoint} := \min\left(\text{Points}_{49}\right)$ $\text{minpoint} = 0.731$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 847.449$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 59.933$

Standard Error

$$\text{Standard}_{error} := \frac{\sigma_{actual}}{\sqrt{\text{No}_{DataCells}}}$$ $\text{Standard}_{error} = 8.562$

Skewness

$$\text{Skewness} := \frac{(\text{No}_{DataCells})\cdot\overrightarrow{\Sigma(\text{Cells} - \mu_{actual})^3}}{(\text{No}_{DataCells} - 1)\cdot(\text{No}_{DataCells} - 2)\cdot(\sigma_{actual})^3}$$ $\text{Skewness} = 0.26$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{DataCells}\cdot(\text{No}_{DataCells} + 1)\cdot\overrightarrow{\Sigma(\text{Cells} - \mu_{actual})^4}}{(\text{No}_{DataCells} - 1)\cdot(\text{No}_{DataCells} - 2)\cdot(\text{No}_{DataCells} - 3)\cdot(\sigma_{actual})^4} + -\frac{3\cdot(\text{No}_{DataCells} - 1)^2}{(\text{No}_{DataCells} - 2)\cdot(\text{No}_{DataCells} - 3)}$$ $\text{Kurtosis} = -0.325$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$No_{DataCells} := \mathrm{length}(Cells)$$

$$\alpha := .05 \qquad T\alpha := qt\left[\left(1-\frac{\alpha}{2}\right), No_{DataCells}\right] \qquad T\alpha = 2.01$$

$$Lower_{95\%Con} := \mu_{actual} - T\alpha\cdot\frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 830.243$$

$$Upper_{95\%Con} := \mu_{actual} + T\alpha\cdot\frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 864.655$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$Distribution = \begin{pmatrix}0\\0\\2\\8\\6\\10\\9\\7\\4\\1\\2\\0\end{pmatrix}$$

The mid points of the Bins are calculated

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

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

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

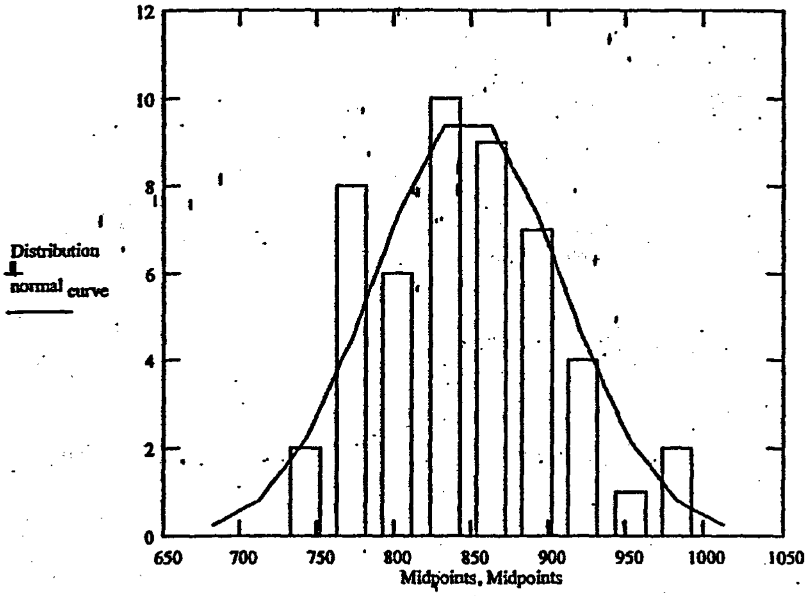
$$normal_{curve_k} := pnorm(Bins_{k+1}, \mu_{actual}, \sigma_{actual}) - pnorm(Bins_k, \mu_{actual}, \sigma_{actual})$$

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

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



μ_{actual} = 847.449

σ_{actual} = 59.933

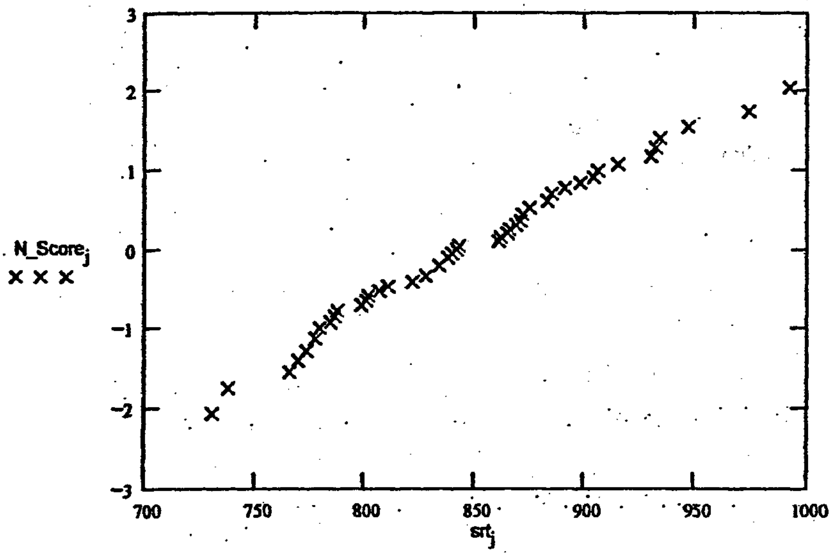
$Standard_{error}$ = 8.562

Skewness = 0.26

Kurtosis = -0.325

$Lower_{95\%Con}$ = 830.243 $Upper_{95\%Con}$ = 864.655

Normal Probability Plot



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

Sandbed Location 19B Trend

$d := 0$

For 1992

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB19B.txt")

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.868 & 0.834 & 0.829 & 0.925 & 0.914 & 0.998 & 0.823 \\ 0.832 & 0.819 & 0.778 & 0.838 & 0.905 & 0.796 & 0.824 \\ 0.865 & 0.867 & 0.821 & 0.879 & 0.915 & 0.85 & 0.876 \\ 0.892 & 0.821 & 0.809 & 0.834 & 0.761 & 0.765 & 0.748 \\ 0.795 & 0.766 & 0.814 & 0.783 & 0.827 & 0.743 & 0.685 \\ 0.825 & 0.839 & 0.887 & 0.889 & 0.933 & 0.828 & 0.732 \\ 0.872 & 0.803 & 0.92 & 0.82 & 0.845 & 0.943 & 0.906 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}\left(\mathrm{Points}_{49}, 7\right)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mathrm{Point}_{34_d} := \mathrm{Cells}_{33}$

$\mathrm{Point}_{34} = .743$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$

$\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$

$$\mathrm{Standard}_{\mathrm{error}_d} := \frac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB19B.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.864 & 0.831 & 0.831 & 0.918 & 0.897 & 0.868 & 0.796 \\ 0.829 & 0.816 & 0.775 & 0.834 & 0.857 & 0.77 & 0.827 \\ 0.866 & 0.866 & 0.819 & 0.85 & 0.914 & 0.847 & 0.801 \\ 0.811 & 0.815 & 0.75 & 0.845 & 0.752 & 0.769 & 0.754 \\ 0.782 & 0.764 & 0.783 & 0.778 & 0.807 & 0.716 & 0.689 \\ 0.825 & 0.785 & 0.883 & 0.888 & 0.931 & 0.818 & 0.745 \\ 0.863 & 0.817 & 0.93 & 0.821 & 0.853 & 0.893 & 0.843 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{34_d} := \text{Cells}_{33}$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB19B.txt")

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(9, 16, 1996)$

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.91 & 0.834 & 0.843 & 0.964 & 0.91 & 0.793 & 0.788 \\ 0.835 & 0.821 & 0.777 & 0.848 & 0.916 & 0.776 & 0.83 \\ 0.933 & 0.882 & 0.818 & 0.898 & 0.912 & 0.845 & 0.803 \\ 0.754 & 0.826 & 0.795 & 0.796 & 0.713 & 0.744 & 0.83 \\ 0.795 & 0.759 & 0.749 & 0.862 & 0.766 & 0.745 & 0.755 \\ 0.862 & 0.877 & 0.907 & 0.852 & 0.916 & 0.836 & 0.758 \\ 0.87 & 0.825 & 0.933 & 0.795 & 0.832 & 1.017 & 0.927 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}\left(\mathrm{Points}_{49}, 7\right)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mathrm{Point}_{34_d} := \mathrm{Cells}_{33}$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$ $\mathrm{Standard}_{\mathrm{error}_d} := \dfrac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$

For 2006

$d := d + 1$

$page := READPRN(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash OCT 2006 Data\textbackslash Sandbed\textbackslash SB19B.txt"})$

$Dates_d := Day_{year}(10, 16, 2006)$

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

Data

$$Points_{49} = \begin{bmatrix} 0.865 & 0.862 & 0.872 & 0.932 & 0.947 & 0.992 & 0.802 \\ 0.842 & 0.883 & 0.78 & 0.84 & 0.915 & 0.778 & 0.866 \\ 0.861 & 0.906 & 0.838 & 0.898 & 0.974 & 0.93 & 0.834 \\ 0.869 & 0.883 & 0.807 & 0.801 & 0.766 & 0.834 & 0.774 \\ 0.811 & 0.77 & 0.785 & 0.788 & 0.799 & 0.731 & 0.778 \\ 0.828 & 0.787 & 0.885 & 0.891 & 0.934 & 0.834 & 0.738 \\ 0.872 & 0.822 & 0.904 & 0.828 & 0.843 & 0.875 & 0.871 \end{bmatrix}$$

$nnn := convert\left(Points_{49}, 7\right)$

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

$Cells := deletezero_{cells}\left(nnn, No_{DataCells}\right)$

$Point_{34_d} := Cells_{33}$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993\cdot10^{3} \\ 1.995\cdot10^{3} \\ 1.997\cdot10^{3} \\ 2.007\cdot10^{3} \end{bmatrix} \qquad \text{Point}_{34} = \begin{bmatrix} 743 \\ 716 \\ 745 \\ 731 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 839.612 \\ 824.204 \\ 837.388 \\ 847.449 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 8.719 \\ 7.792 \\ 9.469 \\ 8.562 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 61.035 \\ 54.542 \\ 66.28 \\ 59.933 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}}) \qquad \text{Total}_{\text{means}} = 4$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SST} = 279.784$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 153.92$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 125.865$$

$$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{MSE} = 76.96 \qquad \text{MSR} = 125.865 \qquad \text{MST} = 93.261$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 8.773$$

F Test for Corrosion

$\alpha := 0.05$ $F_{actaul\_Reg} := \frac{MSR}{MSE}$

$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 0.088$

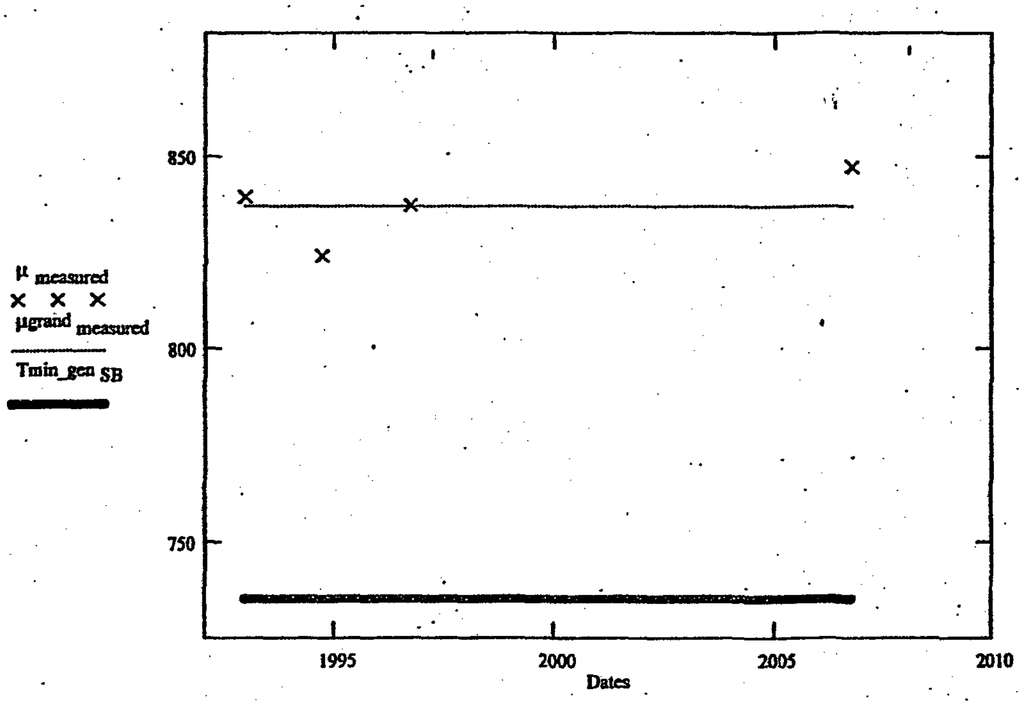
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$ $GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 837.163$ $GrandStandard_{error} = 4.829$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \mathrm{slope}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right) \quad m_s = 1.045 \qquad y_b := \mathrm{intercept}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right) \; y_b = -1.25 \cdot 10^3$

The 95% Confidence curves are calculated

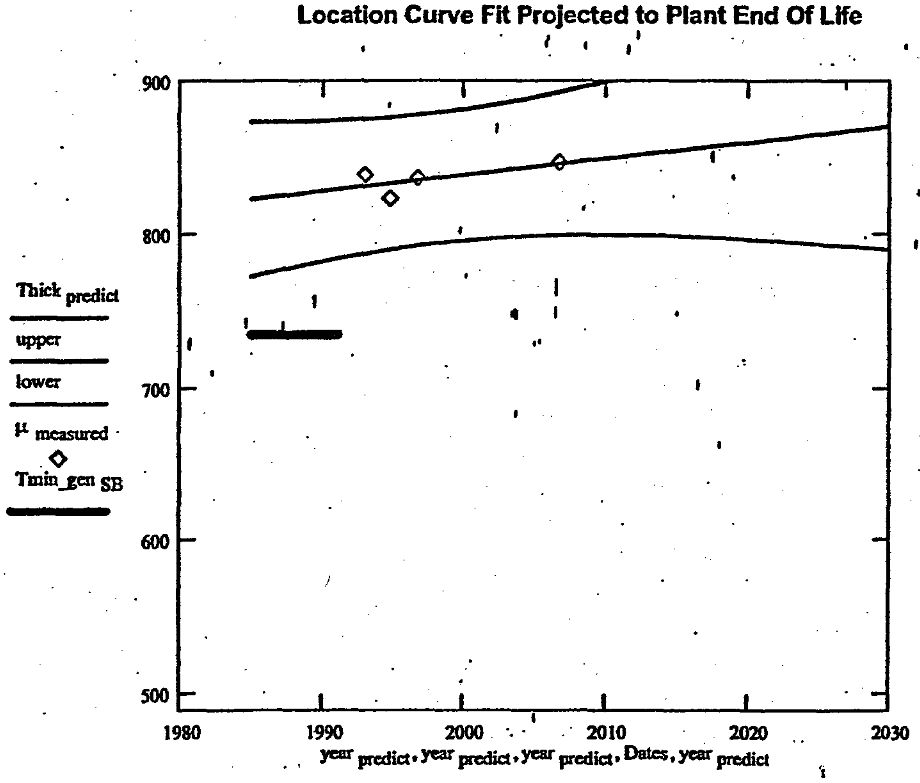
$\alpha_t := 0.05 \quad k := 2029 - 1985 \qquad f := 0..k - 1$

$\mathrm{year}_{\mathrm{predict}_f} := 1985 + f \cdot 2 \quad \mathrm{Thick}_{\mathrm{predict}} := m_s \cdot \mathrm{year}_{\mathrm{predict}} + y_b$

$\mathrm{Thick}_{\mathrm{actualmean}} := \mathrm{mean}(\mathrm{Dates}) \qquad \mathrm{sum} := \sum_i \left(\mathrm{Dates}_d - \mathrm{mean}(\mathrm{Dates})\right)^2$

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

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



$m_s = 1.045$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$Rate_{min\_observed} := 6.9$$

$$Postulated_{meanthickness} := \mu_{measured_3} - Rate_{min\_observed} \cdot (2022 - 2006)$$

$Postulated_{meanthickness} = 737.049$ which is greater than $Tmin\_gen_{SB_3} = 736$

The following addresses the readings at the lowest single point

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{34_i} - mean(Point_{34})\right)^2 \qquad SST_{point} = 534.75$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{34_i} - yhat(Dates, Point_{34})_i\right)^2 \qquad SSE_{point} = 528.414$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, Point_{34})_i - mean(Point_{34})\right)^2 \qquad SSR_{point} = 6.336$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 264.207 \qquad MSR_{point} = 6.336 \qquad MST_{point} = 178.25$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 16.254$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 1.295 \cdot 10^{-3}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \text{slope}(\text{Dates}, \text{Point}_{34})$ $m_{point} = -0.234$ $y_{point} := \text{intercept}(\text{Dates}, \text{Point}_{34})$ $y_{point} = 1.202 \cdot 10^3$

The 95% Confidence curves are calculated

$\text{Point}_{curve} := m_{point} \cdot \text{year}_{predict} + y_{point}$

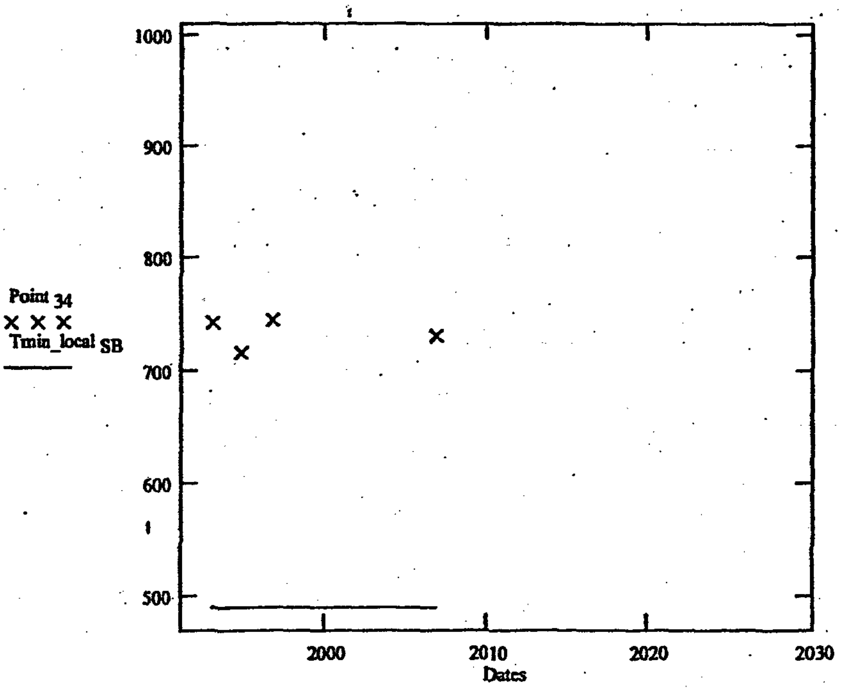
$\text{Point}_{actualmean} := \text{mean}(\text{Dates})$ $\text{sum} := \sum_i (\text{Dates}_d - \text{mean}(\text{Dates}))^2$

$$\text{uppoint}_f := \text{Point}_{curve_f} \cdots + qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year}_{predict_f} - \text{Point}_{actualmean})^2}{\text{sum}}}$$

$$\text{lopoint}_f := \text{Point}_{curve_f} \cdots + -\left[qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year}_{predict_f} - \text{Point}_{actualmean})^2}{\text{sum}}}\right]$$

Local Tmin for this elevation in the Drywell $\text{Tmin\_local}_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 34 Projected to Plant End Of Life



$m_{point} = -0.234$

$\text{lopoint}_{22} = 582.2$ $\text{year}_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point}_{34_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 572.3$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 0.731$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -10.042$ mils per year

Appendix 12 - Sand Bed Elevation Bay 19C

October 2006 Data

The data shown below was collected on 10/18/06

$$\text{page} := \text{READPRN}(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash OCT 2006 Data\textbackslash Sandbed\textbackslash SB19C.txt"})$$

$$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$$

$$\text{Points}_{49} = \begin{bmatrix} 0.809 & 0.768 & 0.862 & 1.059 & 0.968 & 0.961 & 0.92 \\ 0.679 & 0.745 & 0.695 & 0.814 & 0.766 & 0.865 & 0.845 \\ 0.816 & 0.775 & 0.87 & 0.871 & 0.863 & 0 & 0.896 \\ 0.791 & 0.66 & 0.715 & 0.793 & 1.151 & 1.164 & 0.918 \\ 0.851 & 0.781 & 0.733 & 0.762 & 0.862 & 0.787 & 0.796 \\ 0.866 & 0.83 & 0.88 & 0.757 & 0.867 & 0.75 & 0.753 \\ 0.801 & 0.794 & 0.852 & 0.841 & 0.901 & 0.906 & 0.84 \end{bmatrix}$$

$$\text{Cells} := \text{convert}(\text{Points}_{49}, 7) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

For this location no points were identified (reference 3.22).

For this location point 20, 26, 27, and 33 are over a plug (refer 3.22)

$$\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 20) \qquad \text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 26)$$

$$\text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 27) \qquad \text{Cells} := \text{Zero}_{\text{one}}(\text{Cells}, \text{No}_{\text{DataCells}}, 33)$$

$$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{Cells}, \text{No}_{\text{DataCells}})$$

Point 30 is the thinnest

$$\text{minpoint} := \min(\text{Cells}) \qquad \text{minpoint} = 660$$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 823.822$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 79.123$

Standard Error

$$\text{Standard}_{error} := \frac{\sigma_{actual}}{\sqrt{\text{No}_{DataCells}}}$$ $\text{Standard}_{error} = 11.303$

Skewness

$$\text{Skewness} := \frac{\left(\text{No}_{DataCells}\right)\cdot\overrightarrow{\Sigma\left(\text{Cells} - \mu_{actual}\right)^3}}{\left(\text{No}_{DataCells} - 1\right)\cdot\left(\text{No}_{DataCells} - 2\right)\cdot\left(\sigma_{actual}\right)^3}$$ $\text{Skewness} = 0.366$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{DataCells}\cdot\left(\text{No}_{DataCells} + 1\right)\cdot\overrightarrow{\Sigma\left(\text{Cells} - \mu_{actual}\right)^4}}{\left(\text{No}_{DataCells} - 1\right)\cdot\left(\text{No}_{DataCells} - 2\right)\cdot\left(\text{No}_{DataCells} - 3\right)\cdot\left(\sigma_{actual}\right)^4} + -\frac{3\cdot\left(\text{No}_{DataCells} - 1\right)^2}{\left(\text{No}_{DataCells} - 2\right)\cdot\left(\text{No}_{DataCells} - 3\right)}$$ $\text{Kurtosis} = 0.393$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

$r_j := j + 1$ $\quad$ $\text{rank}_j := \dfrac{\overrightarrow{\Sigma\left(\overrightarrow{srt = srt_j}\right)\cdot r}}{\overrightarrow{\Sigma srt = srt_j}}$

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

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

$x := 1$ $\quad$ $N\_Score_j := \text{root}\left[\text{cnorm}(x) - \left(p_j\right), x\right]$

Upper and Lower Confidence Values

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

$$No_{DataCells} := \mathrm{length}(Cells)$$

$$\alpha := .05 \qquad T\alpha := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right] \quad T\alpha = 2.014$$

$$Lower_{95\%Con} := \mu_{actual} - T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 800.066$$

$$Upper_{95\%Con} := \mu_{actual} + T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 847.578$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$Distribution = \begin{pmatrix} 0 \\ 1 \\ 2 \\ 2 \\ 9 \\ 9 \\ 8 \\ 8 \\ 3 \\ 2 \\ 0 \\ 1 \end{pmatrix}$$

The mid points of the Bins are calculated

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

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

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

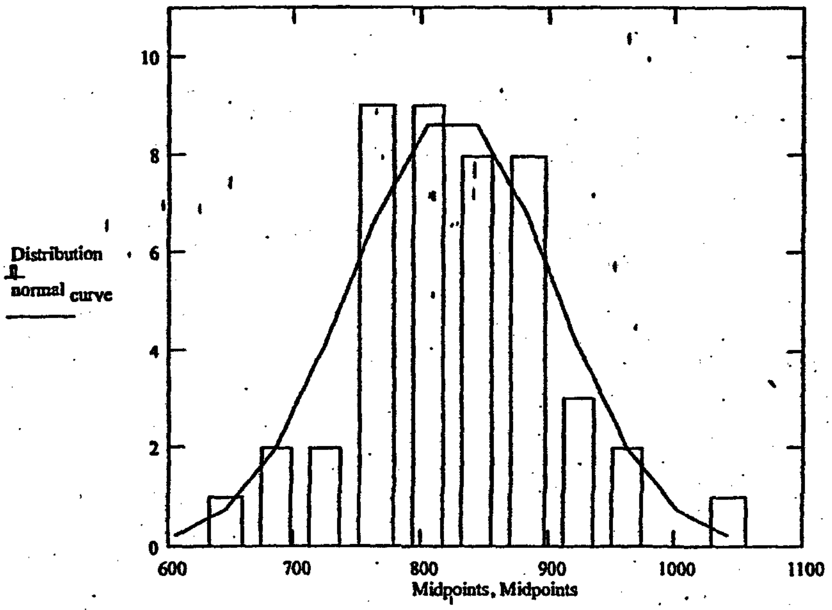
$$normal_{curve_k} := pnorm(Bins_{k+1}, \mu_{actual}, \sigma_{actual}) - pnorm(Bins_k, \mu_{actual}, \sigma_{actual})$$

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

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 823.822$

$\sigma_{actual} = 79.123$

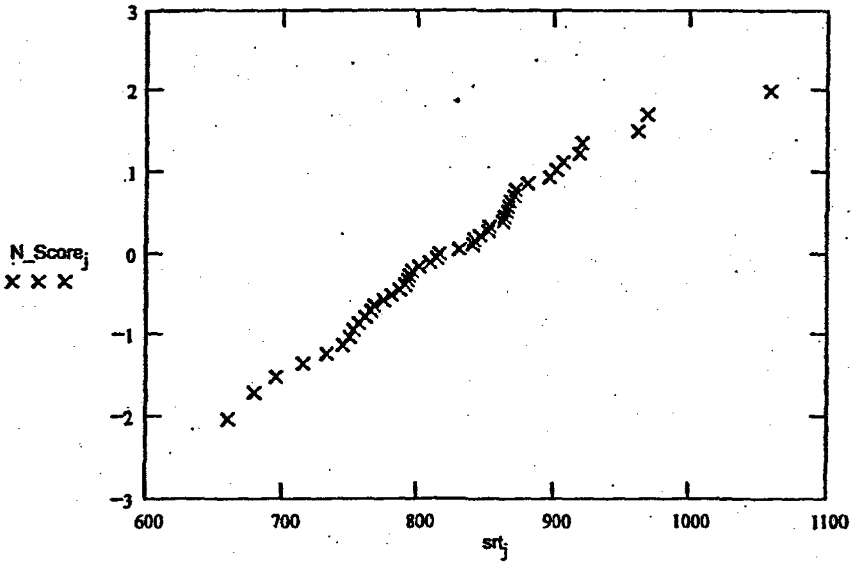
$\text{Standard}_{error} = 11.303$

Skewness = 0.366

Kurtosis = 0.393

$\text{Lower}_{95\%Con} = 800.066$ $\text{Upper}_{95\%Con} = 847.578$

Normal Probability Plot



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

Sandbed Location 19C Trend

$d := 0$

Data from the 1992, 1994 and 1996 is retrieved.

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

$\text{page} := \text{READPRN}(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Dec. 1992 Data\textbackslash sandbed\textbackslash Data Only\textbackslash SB19C.txt"})$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.822 & 0.757 & 0.792 & 0.994 & 0.922 & 0.979 & 0.931 \\ 0.683 & 0.716 & 0.693 & 0.797 & 0.753 & 0.887 & 0.838 \\ 0.815 & 0.744 & 0.879 & 0.859 & 0.856 & 0.222 & 0.888 \\ 0.785 & 0.65 & 0.713 & 0.766 & 1.147 & 1.152 & 0.907 \\ 0.839 & 0.782 & 0.732 & 0.762 & 0.859 & 0.791 & 0.838 \\ 0.867 & 0.833 & 0.88 & 0.756 & 0.852 & 0.736 & 0.752 \\ 0.835 & 0.861 & 0.889 & 0.842 & 0.896 & 0.884 & 0.809 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

For this location point 20, 26, 27, and 33 are over a plug (refer 3.22)

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 20\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 26\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 27\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 33\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{minpoint} := \min(\text{Cells})$ $\text{minpoint} = 650$

$\text{Point}_{21_d} := \text{Cells}_{\text{Point}_{21}} = 650$

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

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB19C.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.816 & 0.757 & 0.82 & 0.979 & 0.904 & 0.952 & 0.917 \\ 0.677 & 0.738 & 0.694 & 0.798 & 0.762 & 0.897 & 0.831 \\ 0.813 & 0.736 & 0.876 & 0.855 & 0.838 & 0.221 & 0.884 \\ 0.787 & 0.666 & 0.718 & 0.762 & 1.153 & 1.149 & 0.906 \\ 0.841 & 0.782 & 0.734 & 0.764 & 0.856 & 0.787 & 0.834 \\ 0.871 & 0.832 & 0.886 & 0.766 & 0.867 & 0.735 & 0.748 \\ 0.836 & 0.853 & 0.892 & 0.851 & 0.9 & 0.902 & 0.831 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\qquad$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

For this location point 20, 26, 27, and 33 are over a plug (refer 3.22)

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 20\right)$ $\qquad$ $\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 26\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 27\right)$ $\qquad$ $\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 33\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{21_d} := \text{Cells}_{21}$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\qquad$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\qquad$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB19C.txt")

$Dates_d := Day_{year}(9, 16, 1996)$

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

Data

$$Points_{49} = \begin{bmatrix} 0.949 & 0.836 & 0.892 & 1.11 & 1.017 & 0.998 & 0.935 \\ 0.85 & 0.701 & 0.752 & 0.781 & 0.755 & 0.944 & 0.866 \\ 0.857 & 0.8 & 0.889 & 0.861 & 0.907 & 0.918 & 0.945 \\ 0.876 & 0.771 & 0.75 & 0.862 & 1.141 & 0.895 & 0.916 \\ 0.744 & 0.802 & 0.772 & 0.758 & 0.87 & 0.867 & 0.845 \\ 0.886 & 0.851 & 0.876 & 0.791 & 0.871 & 0.728 & 0.742 \\ 0.854 & 0.854 & 0.905 & 0.839 & 0.926 & 0.856 & 0.834 \end{bmatrix}$$

$nnn := convert\left(Points_{49}, 7\right)$

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

For this location point 20, 26, 27, and 33 are over a plug (refer 3.22)

$nnn := Zero_{one}\left(nnn, No_{DataCells}, 20\right)$

$nnn := Zero_{one}\left(nnn, No_{DataCells}, 26\right)$

$nnn := Zero_{one}\left(nnn, No_{DataCells}, 27\right)$

$nnn := Zero_{one}\left(nnn, No_{DataCells}, 33\right)$

$Cells := deletezero_{cells}\left(nnn, No_{DataCells}\right)$

$Point_{21_d} := Cells_{21}$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB19C.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.809 & 0.768 & 0.862 & 1.059 & 0.968 & 0.961 & 0.92 \\ 0.679 & 0.745 & 0.695 & 0.814 & 0.766 & 0.865 & 0.845 \\ 0.816 & 0.775 & 0.87 & 0.871 & 0.863 & 0 & 0.896 \\ 0.791 & 0.66 & 0.715 & 0.793 & 1.151 & 1.164 & 0.918 \\ 0.851 & 0.781 & 0.733 & 0.762 & 0.862 & 0.787 & 0.796 \\ 0.866 & 0.83 & 0.88 & 0.757 & 0.867 & 0.75 & 0.753 \\ 0.801 & 0.794 & 0.852 & 0.841 & 0.901 & 0.906 & 0.84 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

For this location point 20, 26, 27, and 33 are over a plug (refer 3.22)

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 20)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 26)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 27)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 33)$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\text{Point}\,21_d := \text{Cells}_{21}$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993\cdot10^{3} \\ 1.995\cdot10^{3} \\ 1.997\cdot10^{3} \\ 2.007\cdot10^{3} \end{bmatrix} \qquad \text{Point}_{21} = \begin{bmatrix} 650 \\ 666 \\ 771 \\ 660 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 77.068 \\ 73.396 \\ 82.35 \\ 79.123 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 819.156 \\ 819.889 \\ 853.8 \\ 823.822 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 11.01 \\ 10.485 \\ 11.764 \\ 11.303 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}}) \qquad \text{Total}_{\text{means}} = 4$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SST} = 821.664$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 821.61$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 0.054$$

$$\text{DegreeFree}_{ss} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{st} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{ss}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{st}}$$

$$\text{MSE} = 410.805 \qquad \text{MSR} = 0.054 \qquad \text{MST} = 273.888$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 20.268$$

F Test for Corrosion

$$\alpha := 0.05 \qquad F_{\text{actaul\_Reg}} := \frac{\text{MSR}}{\text{MSE}} \qquad F_{\text{critical\_reg}} := \text{qF}(1 - \alpha, \text{DegreeFree}_{\text{reg}}, \text{DegreeFree}_{ss})$$

$$F_{\text{ratio\_reg}} := \frac{F_{\text{actaul\_Reg}}}{F_{\text{critical\_reg}}} \qquad F_{\text{ratio\_reg}} = 7.076\cdot10^{-6}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

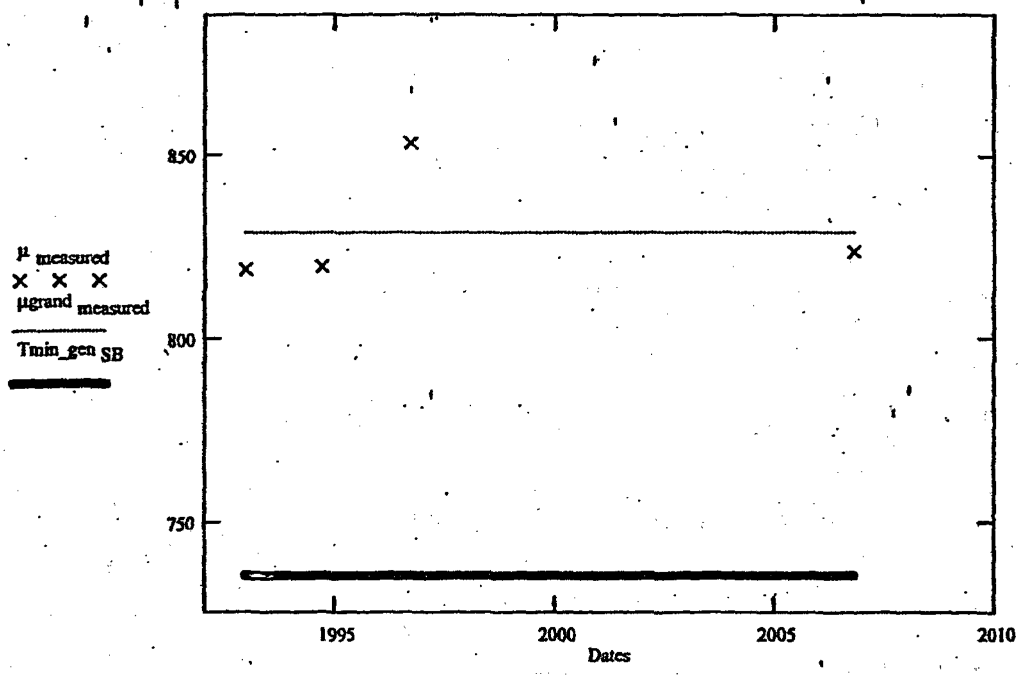
Therefore the curve fit of the means does not have a slope and the grandmean is an accurate measure of the thickness at this location

$i := 0 .. \text{Total}_{\text{means}} - 1$ $\mu\text{grand}_{\text{measured}_i} := \text{mean}\left(\mu_{\text{measured}}\right)$

$\sigma\text{grand}_{\text{measured}} := \text{Stdev}\left(\mu_{\text{measured}}\right)$ $\text{GrandStandard}_{\text{error}_0} := \dfrac{\sigma\text{grand}_{\text{measured}}}{\sqrt{\text{Total}_{\text{means}}}}$

The minimum required thickness at this elevation is $\text{Tmin\_gen}_{\text{SB}_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu\text{grand}_{\text{measured}_0} = 829.167$ $\text{GrandStandard}_{\text{error}} = 8.275$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \mathrm{slope}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right) \quad m_s = 0.022 \qquad y_b := \mathrm{intercept}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right) \quad y_b = 786.002$

The 95% Confidence curves are calculated

$\alpha_t := 0.05 \quad k := 2029 - 1985 \qquad f := 0..k-1$

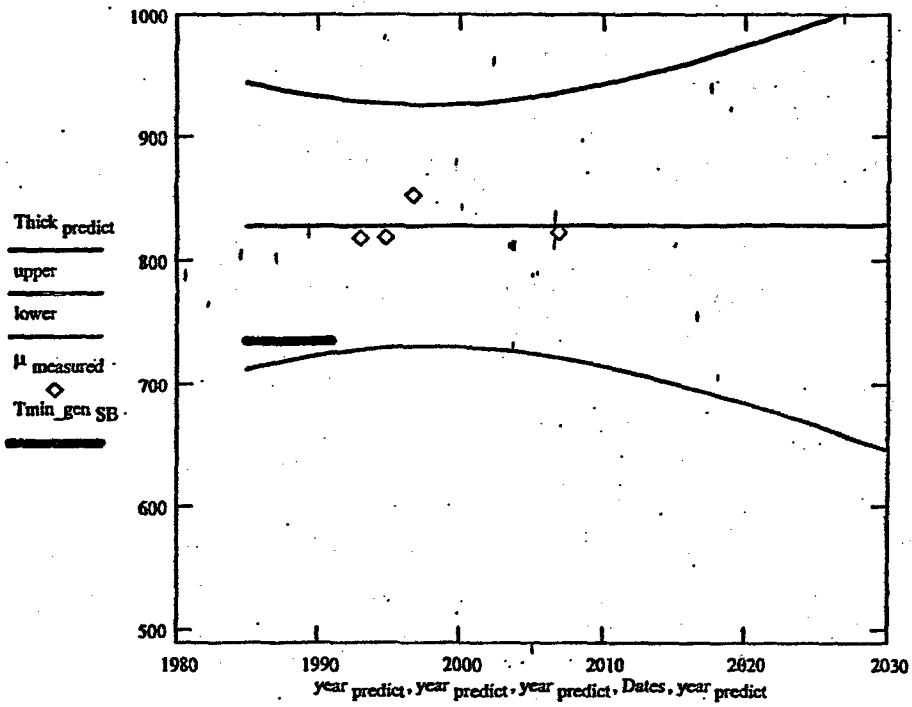
$\mathrm{year}_{\mathrm{predict}_f} := 1985 + f \cdot 2 \quad \mathrm{Thick}_{\mathrm{predict}} := m_s \cdot \mathrm{year}_{\mathrm{predict}} + y_b$

$\mathrm{Thick}_{\mathrm{actualmean}} := \mathrm{mean}(\mathrm{Dates}) \qquad \mathrm{sum} := \sum_i \left(\mathrm{Dates}_d - \mathrm{mean}(\mathrm{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = 0.022$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2018 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 741.022$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point21_i - mean(Point21)\right)^2 \qquad SST_{point} = 9.595 \cdot 10^3$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Point21_i - yhat(Dates, Point21)_i\right)^2 \qquad SSE_{point} = 9.525 \cdot 10^3$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, Point21)_i - mean(Point21)\right)^2 \qquad SSR_{point} = 69.399$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 4.763 \cdot 10^3 \qquad MSR_{point} = 69.399 \qquad MST_{point} = 3.198 \cdot 10^3$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 69.012$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 7.871 \cdot 10^{-4}$$

The conclusion can be made that the mean best fits the grandmean model. The grandmean ratio is greater than one. The figure below provides a trend of the data and the grandmean

$m_{point} := \text{slope}(Dates, Point_{21})$ $m_{point} = -0.776$ $y_{point} := \text{intercept}(Dates, Point_{21})$ $y_{point} = 2.237 \cdot 10^3$

The 95% Confidence curves are calculated

$Point_{curve} := m_{point} \cdot year_{predict} + y_{point}$

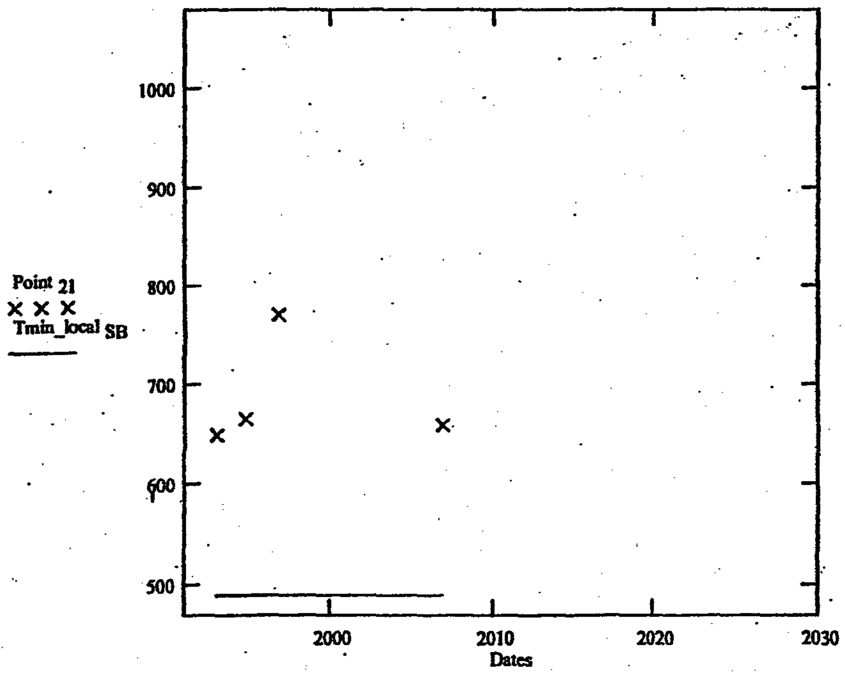
$Point_{actualmean} := \text{mean}(Dates)$ $sum := \sum_i \left(Dates_d - \text{mean}(Dates)\right)^2$

$$uppoint_f := Point_{curve_f} + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Point_{actualmean}\right)^2}{sum}}$$

$$lopoint_f := Point_{curve_f} + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Point_{actualmean}\right)^2}{sum}}\right]$$

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_f} := 490$ (Ref. 2.35)

Curve Fit For Point 21 Projected to Plant End Of Life



$m_{point} = -0.776$

$lopoint_{22} = 50.16$ $year_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point }21_3 - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 501.3$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 650$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(\text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -6.667$ mils per year

Appendix 13 - Sand Bed Elevation Bay 1D

October 2006 Data
The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB1D.txt")

$$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$$

$$\text{Points}_7 = [\ 0.881 \quad 1.156 \quad 1.104 \quad 1.124 \quad 1.134 \quad 1.093 \quad 1.122\ ]$$

$$\text{Cells} := \text{con7vert}\left(\text{Points}_7, 7, 1\right) \quad \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

$$\text{Cells} := \text{Zero}_{\text{one}}\left(\text{Cells}, \text{No}_{\text{DataCells}}, 1\right)$$

$$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$$

The thinnest point at this location is shown below

$$\text{minpoint} := \min\left(\text{Points}_7\right)$$

$$\text{minpoint} = 0.881$$

Mean and Standard Deviation

$\mu_{\text{actual}} := \text{mean}(\text{Cells})$ $\quad \mu_{\text{actual}} = 1.122 \cdot 10^3$ $\quad \sigma_{\text{actual}} := \text{Stdev}(\text{Cells})$ $\quad \sigma_{\text{actual}} = 22.221$

Standard Error

$$\text{Standard}_{\text{error}} := \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Standard}_{\text{error}} = 8.399$$

Skewness

$$\text{Skewness} := \frac{\left(\text{No}_{\text{DataCells}}\right) \cdot \overrightarrow{\Sigma\left(\text{Cells} - \mu_{\text{actual}}\right)^3}}{\left(\text{No}_{\text{DataCells}} - 1\right) \cdot \left(\text{No}_{\text{DataCells}} - 2\right) \cdot \left(\sigma_{\text{actual}}\right)^3} \qquad \text{Skewness} = 0.204$$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{\text{DataCells}} \cdot \left(\text{No}_{\text{DataCells}} + 1\right) \cdot \overrightarrow{\Sigma\left(\text{Cells} - \mu_{\text{actual}}\right)^4}}{\left(\text{No}_{\text{DataCells}} - 1\right) \cdot \left(\text{No}_{\text{DataCells}} - 2\right) \cdot \left(\text{No}_{\text{DataCells}} - 3\right) \cdot \left(\sigma_{\text{actual}}\right)^4} + -\frac{3 \cdot \left(\text{No}_{\text{DataCells}} - 1\right)^2}{\left(\text{No}_{\text{DataCells}} - 2\right) \cdot \left(\text{No}_{\text{DataCells}} - 3\right)} \qquad \text{Kurtosis} = -1.261$$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$No_{DataCells} := \text{length}(Cells)$$

$$\alpha := .05 \qquad T\alpha := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right] \quad T\alpha = 2.447$$

$$Lower_{95\%Con} := \mu_{actual} - T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 1.1 \cdot 10^{3}$$

$$Upper_{95\%Con} := \mu_{actual} + T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 1.144 \cdot 10^{3}$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$Distribution = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

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

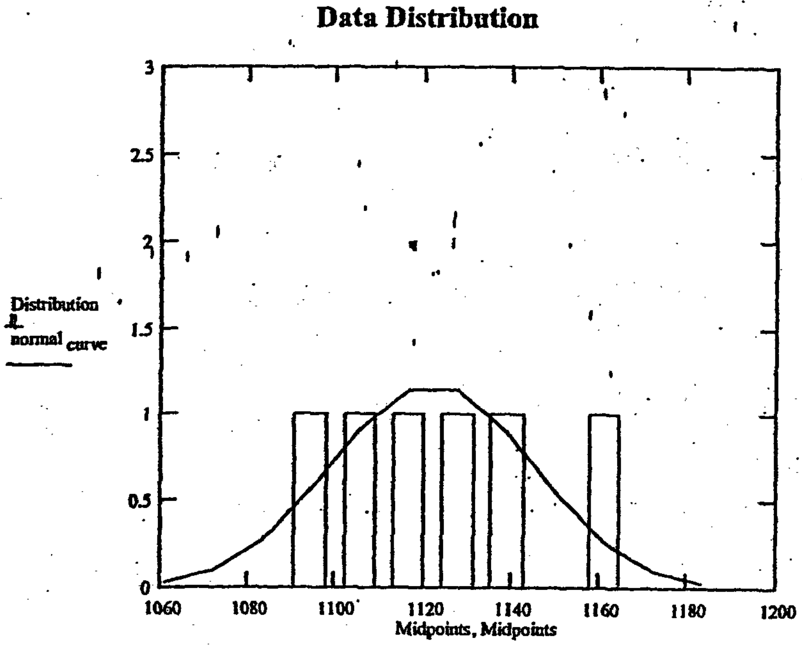
$$normal_{curve_0} := \text{pnorm}(Bins_{1}, \mu_{actual}, \sigma_{actual})$$

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

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

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.



$\mu_{actual} = 1.122 \cdot 10^3$

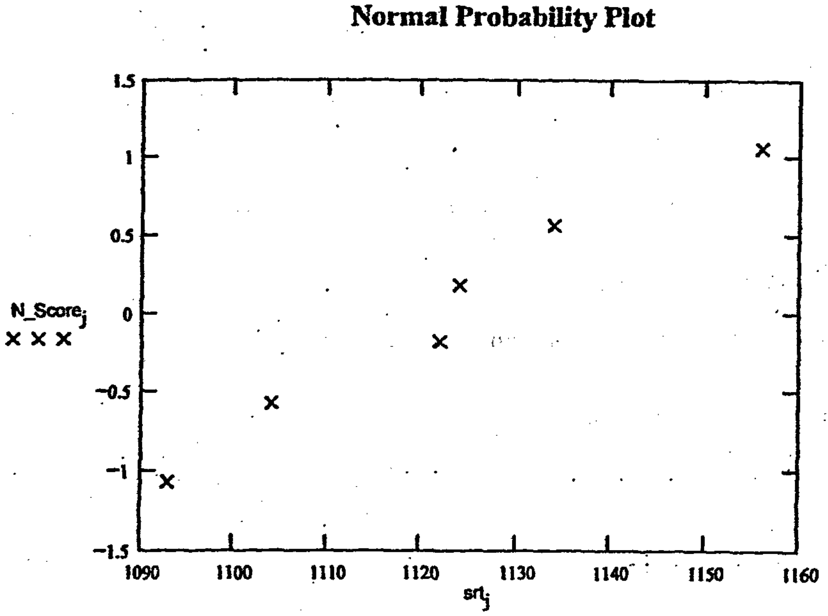
$\sigma_{actual} = 22.221$

$Standard_{error} = 8.399$

$Skewness = 0.204$

$Kurtosis = -1.261$

$Lower_{95\%Con} = 1.1 \cdot 10^3$ $Upper_{95\%Con} = 1.144 \cdot 10^3$



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

Sandbed Location 1D Trend

$d := 0$

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB1D.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\,0.889 \quad 1.138 \quad 1.112 \quad 1.114 \quad 1.132 \quad 1.103 \quad 1.126\,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{1_d} := \text{Points}_{7_0}$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 1\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_1 = 0.889$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB1D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 0.879 \quad 1.054 \quad 1.105 \quad 1.119 \quad 1.124 \quad 1.088 \quad 1.118\ ]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{1_d} := \text{Points}_{7_0}$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 1\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 1996

$d := d + 1$

$page := READPRN(\text{"U:\\MSOFFICE\\Drywell Program data\\Sept.1996 Data\\sandbed\\Data Only\\SB1D.txt"})$

$Dates_d := Day_{year}(9, 16, 1996)$

$Points_7 := show7cells(page, 1, 7, 0)$

Data

$Points_7 = [\; 0.881 \quad 1.103 \quad 1.178 \quad 1.146 \quad 1.194 \quad 1.134 \quad 0.881 \;]$

$nnn := con7vert\left(Points_7, 7, 1\right)$

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

$Point_{1_d} := Points_{7_0}$

$nnn := Zero_{one}\left(nnn, No_{DataCells}, 1\right)$

$nnn := Zero_{one}\left(nnn, No_{DataCells}, 7\right)$

$Cells := deletezero_{cells}\left(nnn, No_{DataCells}\right)$

$\mu_{measured_d} := mean(Cells) \quad \sigma_{measured_d} := Stdev(Cells) \quad Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 2006.

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB1D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = \begin{bmatrix} 0.881 & 1.156 & 1.104 & 1.124 & 1.134 & 1.093 & 1.122 \end{bmatrix}$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{1_d} := \text{Points}_{7_0}$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 1\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$$\text{Point}_1 = \begin{bmatrix} 0.889 \\ 0.879 \\ 0.881 \\ 0.881 \end{bmatrix}$$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\mathrm{Dates} = \begin{bmatrix} 1.993\cdot10^3 \\ 1.995\cdot10^3 \\ 1.997\cdot10^3 \\ 2.007\cdot10^3 \end{bmatrix} \qquad \mathrm{Point}_1 = \begin{bmatrix} 0.889 \\ 0.879 \\ 0.881 \\ 0.881 \end{bmatrix}$$

$$\mu_{\mathrm{measured}} = \begin{bmatrix} 1.12083\cdot10^3 \\ 1.10133\cdot10^3 \\ 1.151\cdot10^3 \\ 1.12217\cdot10^3 \end{bmatrix} \qquad \mathrm{Standard}_{\mathrm{error}} = \begin{bmatrix} 5.039 \\ 10.05 \\ 13.622 \\ 8.399 \end{bmatrix} \qquad \sigma_{\mathrm{measured}} = \begin{bmatrix} 13.333 \\ 26.591 \\ 36.042 \\ 22.221 \end{bmatrix}$$

$\mathrm{Total}_{\mathrm{means}} := \mathrm{rows}\left(\mu_{\mathrm{measured}}\right)$ $\qquad$ $\mathrm{Total}_{\mathrm{means}} = 4$

$$\mathrm{SST} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{mean}\left(\mu_{\mathrm{measured}}\right)\right)^2 \qquad \mathrm{SST} = 1.256\cdot10^3$$

$$\mathrm{SSE} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{yhat}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)_i\right)^2 \qquad \mathrm{SSE} = 1.242\cdot10^3$$

$$\mathrm{SSR} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{yhat}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)_i - \mathrm{mean}\left(\mu_{\mathrm{measured}}\right)\right)^2 \qquad \mathrm{SSR} = 13.63$$

$\mathrm{DegreeFree}_{\mathrm{ss}} := \mathrm{Total}_{\mathrm{means}} - 2$ $\qquad$ $\mathrm{DegreeFree}_{\mathrm{reg}} := 1$ $\qquad$ $\mathrm{DegreeFree}_{\mathrm{st}} := \mathrm{Total}_{\mathrm{means}} - 1$

$$\mathrm{MSE} := \frac{\mathrm{SSE}}{\mathrm{DegreeFree}_{\mathrm{ss}}} \qquad \mathrm{MSR} := \frac{\mathrm{SSR}}{\mathrm{DegreeFree}_{\mathrm{reg}}} \qquad \mathrm{MST} := \frac{\mathrm{SST}}{\mathrm{DegreeFree}_{\mathrm{st}}}$$

$\mathrm{MSE} = 621.213$ $\qquad$ $\mathrm{MSR} = 13.63$ $\qquad$ $\mathrm{MST} = 418.685$

$\mathrm{StGrand}_{\mathrm{err}} := \sqrt{\mathrm{MSE}}$ $\qquad$ $\mathrm{StGrand}_{\mathrm{err}} = 24.924$

F Test for Corrosion

$\alpha := 0.05$

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

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 1.185 \cdot 10^{-3}$$

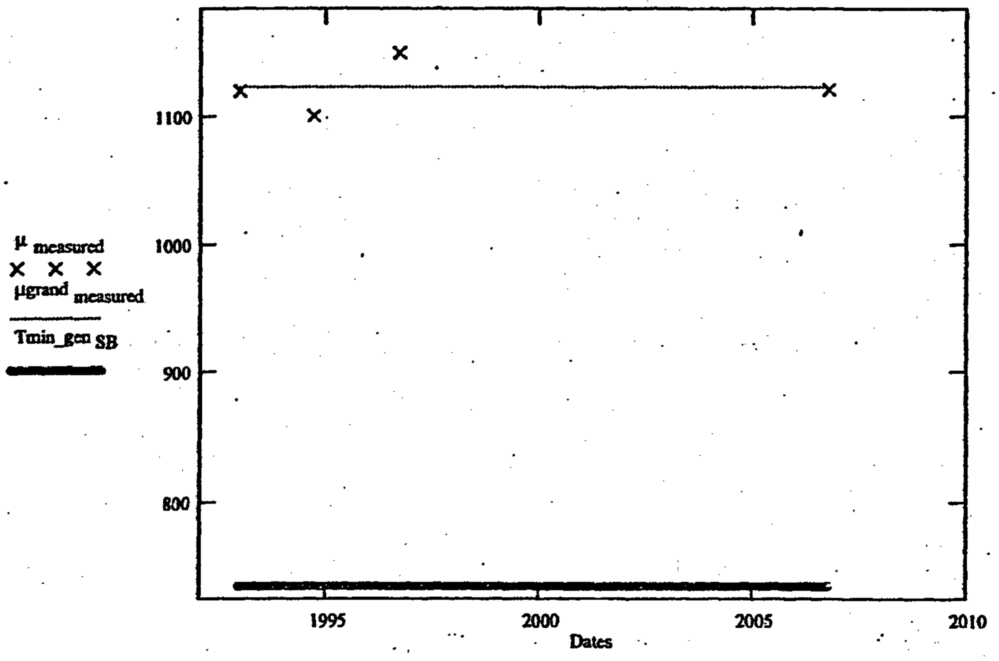
Therefore no conclusion can be made as to whether the data best fits the regression model . The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\qquad$ $\mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$ $\qquad$ $GrandStandard_{error_0} := \dfrac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 2.35)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 1.124 \cdot 10^3$ $\qquad$ $GrandStandard_{error_0} = 10.231$

measured$_0$ error

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}\left(\text{Dates}, \mu_{\text{measured}}\right) \quad m_s = 0.344 \qquad y_b := \text{intercept}\left(\text{Dates}, \mu_{\text{measured}}\right) \; y_b = 436.885$

The 95% Confidence curves are calculated

$\alpha_t := 0.05 \quad k := 2029 - 1985 \qquad f := 0 .. k - 1$

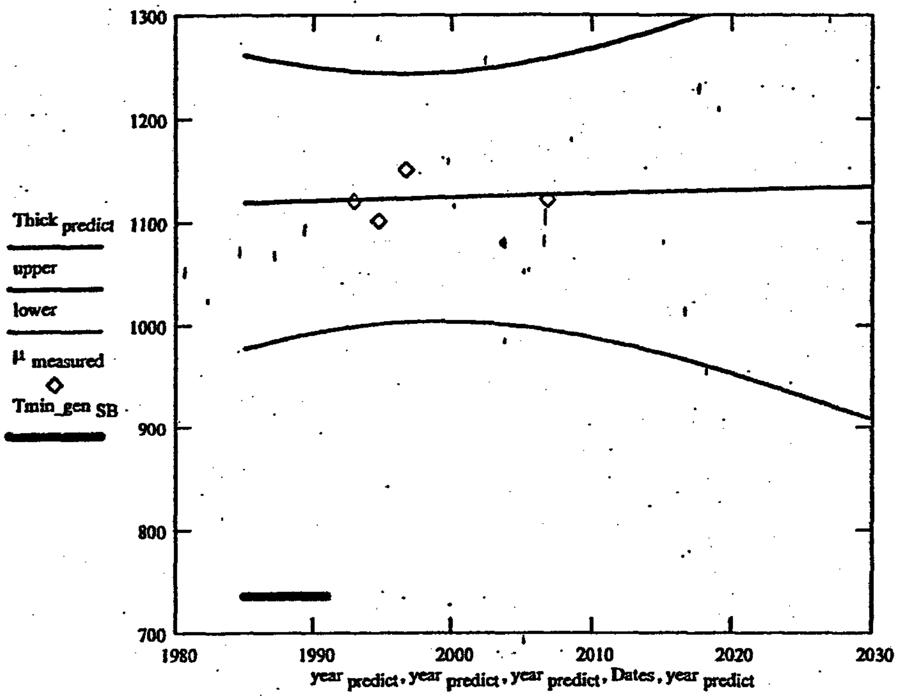
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2 \quad \text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates}) \qquad \text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = 0.344$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 963.467$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{1_i} - mean(Point_1)\right)^2 \qquad SST_{point} = 5.9 \cdot 10^{-5}$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{1_i} - yhat(Dates, Point_1)_i\right)^2 \qquad SSE_{point} = 4.977 \cdot 10^{-5}$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, Point_1)_i - mean(Point_1)\right)^2 \qquad SSR_{point} = 9.234 \cdot 10^{-6}$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 2.488 \cdot 10^{-5} \qquad MSR_{point} = 9.234 \cdot 10^{-6} \qquad MST_{point} = 1.967 \cdot 10^{-5}$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 4.988 \cdot 10^{-3}$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.02$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \text{slope}(\text{Dates}, \text{Point}_1)$ $m_{point} = -2.83\cdot 10^{-4}$ $y_{point} := \text{intercept}(\text{Dates}, \text{Poi}$ $y_{point} = 1.448$

$\text{Point}_{curve} := m_{point} \cdot \text{year}_{predict} + y_{point}$

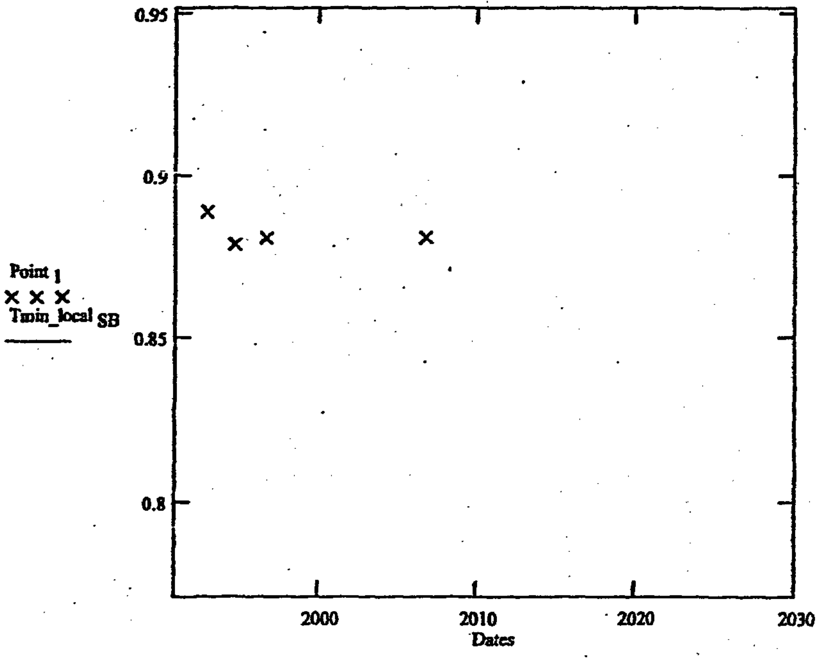
$\text{Point}_{actualmean} := \text{mean}(\text{Dates})$ $\text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

$$\text{uppoint}_f := \text{Point}_{curve_f} \cdots$$
$$+\, qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{predict_f} - \text{Point}_{actualmean}\right)^2}{\text{sum}}}$$

$$\text{lopoint}_f := \text{Point}_{curve_f} \cdots$$
$$+\, -\left[qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{predict_f} - \text{Point}_{actualmean}\right)^2}{\text{sum}}}\right]$$

Local Tmin for this elevation in the Drywell $\text{Tmin\_local}_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 1 Projected to Plant End Of Life



$m_{point} = -2.83\cdot 10^{-4}$

$\text{lopoint}_{22} = 0.829$ $\text{year}_{predict_{22}} = 2.029\cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point}_{1_3} \cdot 1000 - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 722.3$ which is greater than $\text{Tmin\_local}_{SB_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 0.881$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{SB_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{SB_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -16.292$ mils per year

Appendix 14 - Sand Bed Elevation Bay 3D

October 2006 Data

The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB3D.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

$\text{Points}_7 = [\ 1.199\quad 1.189\quad 1.187\quad 1.173\quad 1.156\quad 1.187\quad 1.166\ ]$

$\text{Cells} := \text{con7vert}\left(\text{Points}_7, 7, 1\ \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})\right.$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$

The thinnest point at this location is shown below

$\text{minpoint} := \min\left(\text{Points}_7\right)$

$\text{minpoint} = 1.156$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 1.18 \cdot 10^3$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 15.054$

Standard Error

$$\text{Standard}_{error} := \frac{\sigma_{actual}}{\sqrt{\text{No}_{DataCells}}}$$ $\text{Standard}_{error} = 5.69$

Skewness

$$\text{Skewness} := \frac{(\text{No}_{DataCells}) \cdot \overrightarrow{\Sigma(\text{Cells} - \mu_{actual})^3}}{(\text{No}_{DataCells} - 1) \cdot (\text{No}_{DataCells} - 2) \cdot (\sigma_{actual})^3}$$ $\text{Skewness} = -0.471$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{DataCells} \cdot (\text{No}_{DataCells} + 1) \cdot \overrightarrow{\Sigma(\text{Cells} - \mu_{actual})^4}}{(\text{No}_{DataCells} - 1) \cdot (\text{No}_{DataCells} - 2) \cdot (\text{No}_{DataCells} - 3) \cdot (\sigma_{actual})^4} + -\frac{3 \cdot (\text{No}_{DataCells} - 1)^2}{(\text{No}_{DataCells} - 2) \cdot (\text{No}_{DataCells} - 3)}$$ $\text{Kurtosis} = -0.848$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

$$\alpha := .05 \qquad T\alpha := \text{qt}\left[\left(1 - \frac{\alpha}{2}\right), \text{No}_{\text{DataCells}}\right] \qquad T\alpha = 2.365$$

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 1.166 \cdot 10^3$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 1.193 \cdot 10^3$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$\text{Distribution} = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 1 \\ 1 \\ 2 \\ 1 \\ 1 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

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

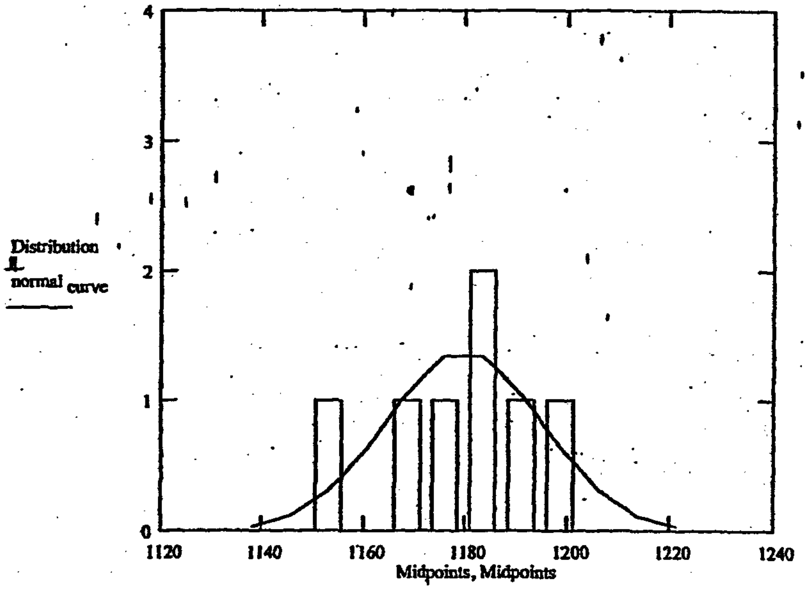
$$\text{normal}_{\text{curve}_0} := \text{pnorm}\left(\text{Bins}_1, \mu_{\text{actual}}, \sigma_{\text{actual}}\right)$$

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

$$\text{normal}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$$

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.



Data Distribution

$\mu_{actual} = 1.18 \cdot 10^3$

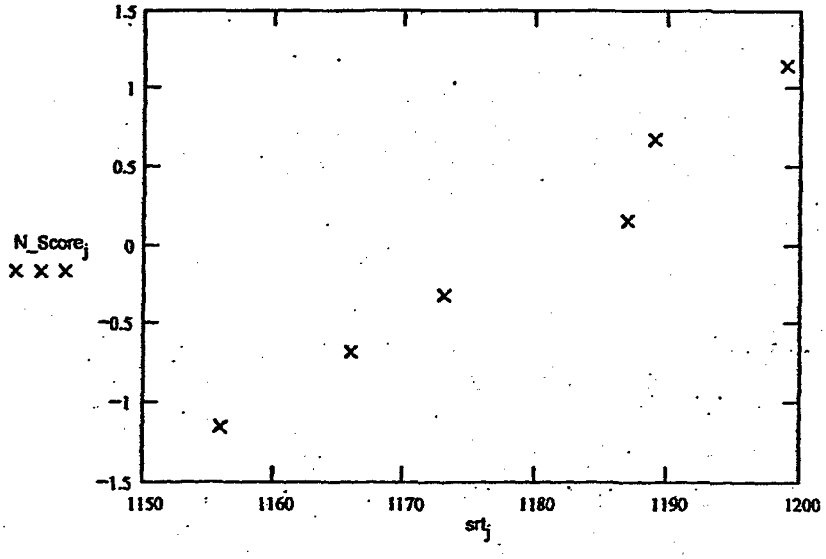
$\sigma_{actual} = 15.054$

$\text{Standard}_{error} = 5.69$

$\text{Skewness} = -0.471$

$\text{Kurtosis} = -0.848$

$\text{Lower}_{95\%Con} = 1.166 \cdot 10^3$ $\text{Upper}_{95\%Con} = 1.193 \cdot 10^3$



Normal Probability Plot

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

Sandbed Location 3D Trend

$d := 0$

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB3D.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\, 1.198 \quad 1.191 \quad 1.191 \quad 1.184 \quad 1.159 \quad 1.182 \quad 1.169 \,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$ $\text{Point}_{5_d} := \text{Cells}_4$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB3D.txt")

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(9, 14, 1994)$

$\mathrm{Points}_7 := \mathrm{show7cells}(\mathrm{page}, 1, 7, 0)$

Data

$\mathrm{Points}_7 = [\, 1.194 \quad 1.194 \quad 1.191 \quad 1.194 \quad 1.164 \quad 1.184 \quad 1.168 \,]$

$\mathrm{nnn} := \mathrm{con7vert}\left(\mathrm{Points}_7, 7, 1\right)$ $\quad \mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mathrm{Point5}_d := \mathrm{Cells}_4$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells}) \quad \sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells}) \quad \mathrm{Standard}_{\mathrm{error}_d} := \dfrac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB3D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\,1.194 \quad 1.192 \quad 1.181 \quad 1.139 \quad 1.158 \quad 1.185 \quad 1.173\,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{5_d} := \text{Cells}_4$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB3D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\, 1.199 \quad 1.189 \quad 1.187 \quad 1.173 \quad 1.156 \quad 1.187 \quad 1.166 \,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{5_d} := \text{Cells}_4$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993\cdot 10^{3} \\ 1.995\cdot 10^{3} \\ 1.997\cdot 10^{3} \\ 2.007\cdot 10^{3} \end{bmatrix} \qquad \text{Point}_{5} = \begin{bmatrix} 1.159\cdot 10^{3} \\ 1.164\cdot 10^{3} \\ 1.158\cdot 10^{3} \\ 1.156\cdot 10^{3} \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.182\cdot 10^{3} \\ 1.184\cdot 10^{3} \\ 1.175\cdot 10^{3} \\ 1.18\cdot 10^{3} \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 5.164 \\ 4.891 \\ 7.518 \\ 5.69 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 13.663 \\ 12.941 \\ 19.89 \\ 15.054 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}\left(\mu_{\text{measured}}\right) \qquad \text{Total}_{\text{means}} = 4$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2 \qquad \text{SST} = 50.796$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i\right)^2 \qquad \text{SSE} = 47.157$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2 \qquad \text{SSR} = 3.639$$

$$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{MSE} = 23.578 \qquad \text{MSR} = 3.639 \qquad \text{MST} = 16.932$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 4.856$$

F Test for Corrosion

$\alpha := 0.05$ $F_{actaul\_Reg} := \frac{MSR}{MSE}$

$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 8.337 \cdot 10^{-3}$

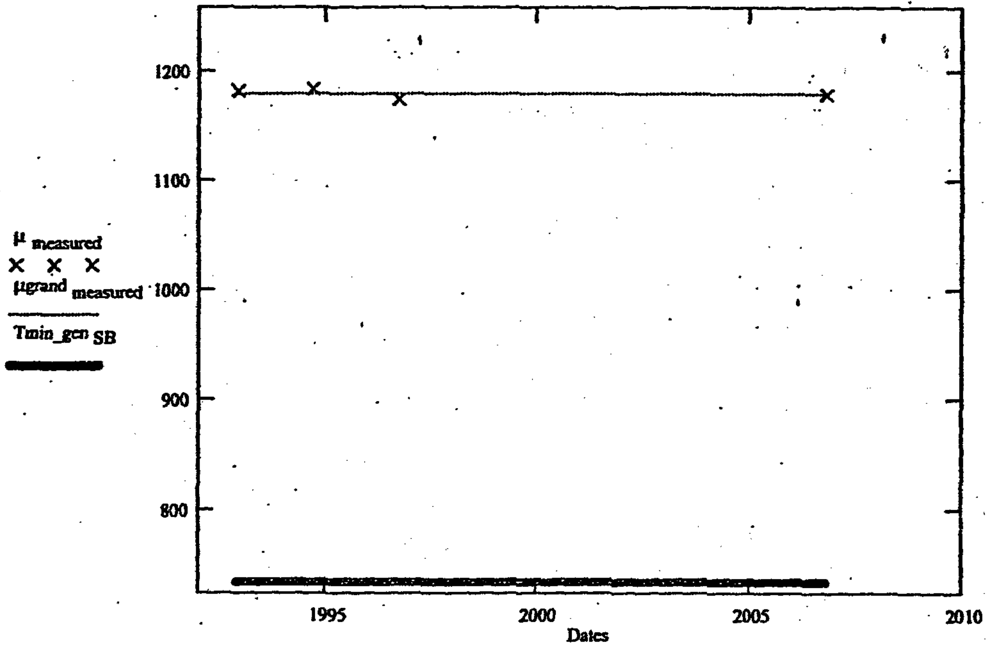
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$ $GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 1.18 \cdot 10^{3}$ $GrandStandard_{error} = 2.057$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \mathrm{slope}(\mathrm{Dates}, \mu_{measured}) \quad m_s = -0.178 \quad y_b := \mathrm{intercept}(\mathrm{Dates}, \mu_{measured}) \; y_b = 1.535 \cdot 10^3$

The 95% Confidence curves are calculated

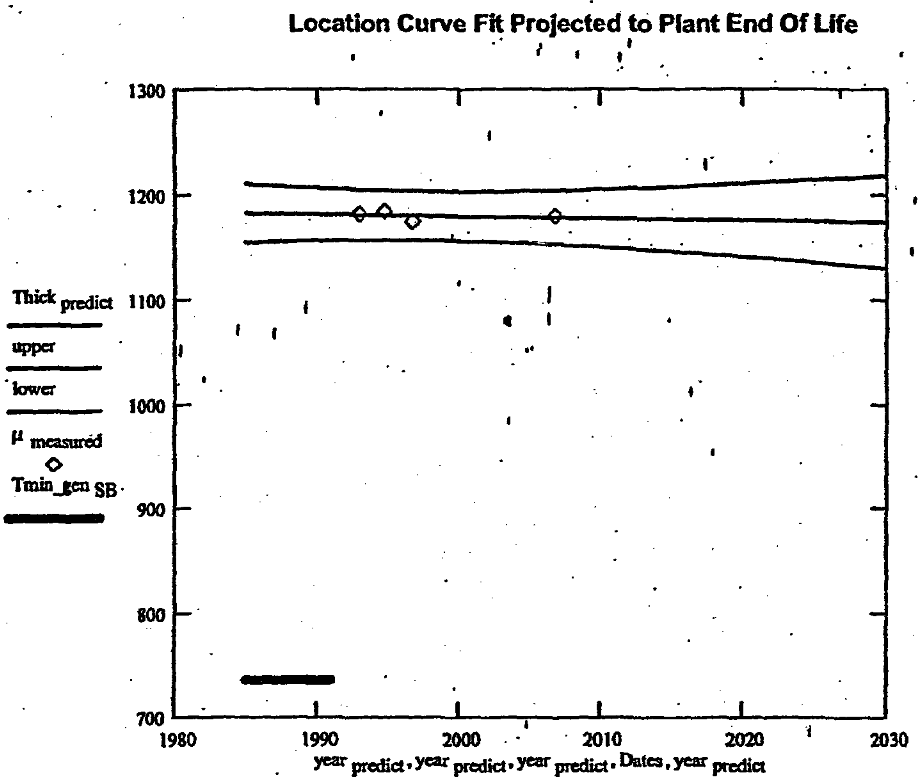
$\alpha_t := 0.05 \quad k := 2029 - 1985 \qquad f := 0 .. k - 1$

$\mathrm{year}_{predict_f} := 1985 + f \cdot 2 \quad \mathrm{Thick}_{predict} := m_s \cdot \mathrm{year}_{predict} + y_b$

$\mathrm{Thick}_{actualmean} := \mathrm{mean(\,Dates\,)} \qquad \mathrm{sum} := \sum_i \left(\mathrm{Dates}_d - \mathrm{mean(\,Dates\,)}\right)^2$

$$\mathrm{upper}_f := \mathrm{Thick}_{predict_f} \cdots + \mathrm{qt}\left(1 - \frac{\alpha_t}{2}, \mathrm{Total}_{means} - 2\right) \cdot \mathrm{StGrand}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{predict_f} - \mathrm{Thick}_{actualmean}\right)^2}{\mathrm{sum}}}$$

$$\mathrm{lower}_f := \mathrm{Thick}_{predict_f} \cdots + -\left[\mathrm{qt}\left(1 - \frac{\alpha_t}{2}, \mathrm{Total}_{means} - 2\right) \cdot \mathrm{StGrand}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{predict_f} - \mathrm{Thick}_{actualmean}\right)^2}{\mathrm{sum}}}\right]$$



$m_s = -0.178$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 1.021 \cdot 10^3$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

$$\text{Point}_{5_d} := \text{Cells}_4$$

$$\text{SST}_{\text{point}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{Point}_{5_i} - \text{mean}(\text{Point}_5)\right)^2 \qquad \text{SST}_{\text{point}} = 34.75$$

$$\text{SSE}_{\text{point}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{Point}_{5_i} - \text{yhat}(\text{Dates}, \text{Point}_5)_i\right)^2 \qquad \text{SSE}_{\text{point}} = 19.917$$

$$\text{SSR}_{\text{point}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \text{Point}_5)_i - \text{mean}(\text{Point}_5)\right)^2 \qquad \text{SSR}_{\text{point}} = 14.833$$

$$\text{MSE}_{\text{point}} := \frac{\text{SSE}_{\text{point}}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR}_{\text{point}} := \frac{\text{SSR}_{\text{point}}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST}_{\text{point}} := \frac{\text{SST}_{\text{point}}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{MSE}_{\text{point}} = 9.959 \qquad \text{MSR}_{\text{point}} = 14.833 \qquad \text{MST}_{\text{point}} = 11.583$$

$$\text{StPoint}_{\text{err}} := \sqrt{\text{MSE}_{\text{point}}} \qquad \text{StPoint}_{\text{err}} = 3.156$$

F Test for Corrosion

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

$$F_{\text{ratio\_reg}} := \frac{F_{\text{actaul\_Reg}}}{F_{\text{critical\_reg}}}$$

$$F_{\text{ratio\_reg}} = 0.08$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \text{slope}\left(\text{Dates}, \text{Point}_5\right)$ $m_{point} = -0.359$ $y_{point} := \text{intercept}\left(\text{Dates}, \text{Point}_5\right)$ $y_{point} = 1.876 \cdot 10^3$

The 95% Confidence curves are calculated

$\text{Point}_{curve} := m_{point} \cdot \text{year}_{predict} + y_{point}$

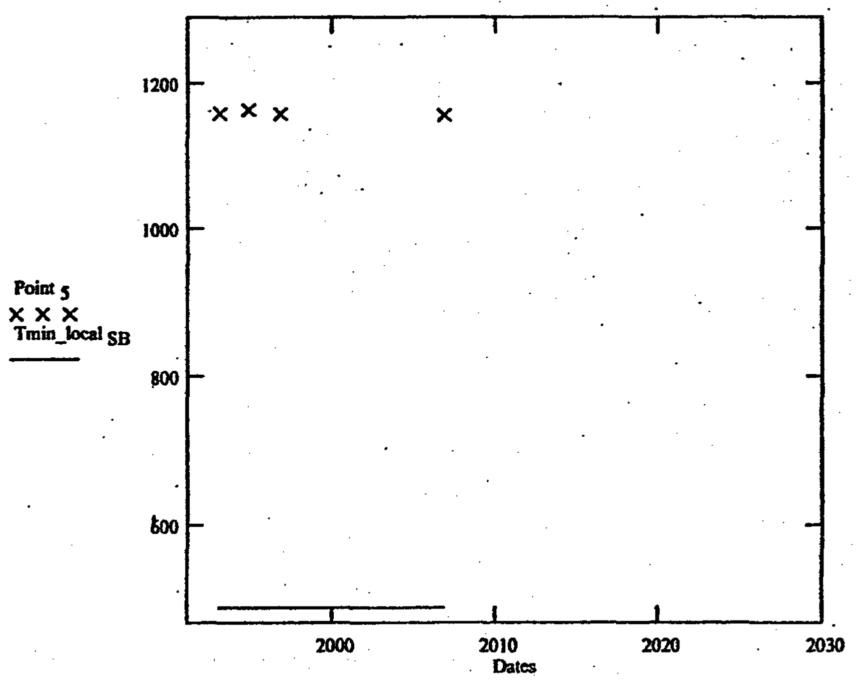
$\text{Point}_{actualmean} := \text{mean}(\text{Dates})$ $\text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

$$\text{uppoint}_f := \text{Point}_{\text{curve}_f} \cdots + qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{\text{predict}_f} - \text{Point}_{actualmean}\right)^2}{\text{sum}}}$$

$$\text{lopoint}_f := \text{Point}_{\text{curve}_f} \cdots + -\left[qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{\text{predict}_f} - \text{Point}_{actualmean}\right)^2}{\text{sum}}}\right]$$

Local Tmin for this elevation in the Drywell $\text{Tmin\_local}_{\text{SB}_f} := 490$ (Ref. 3.25)

Curve Fit For Point 5 Projected to Plant End Of Life



$m_{point} = -0.359$

$\text{lopoint}_{22} = 1.12 \cdot 10^3$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point}_{5_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 997.3$ which is greater than $\text{Tmin\_local}_{SB_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 1.156$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{SB_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{SB_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -27.75$ mils per year

Appendix 15 - Sand Bed Elevation Bay 5D

October 2006 Data

The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB5D.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

$\text{Points}_7 = [\, 1.174 \quad 1.191 \quad 1.186 \quad 1.187 \quad 1.187 \quad 1.184 \quad 1.184 \,]$

$\text{Cells} := \text{con7vert}\left(\text{Points}_7, 7, 1 \; \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})\right.$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$

The thinnest point is at point 1 at this location is shown below

$\text{minpoint} := \min\left(\text{Points}_7\right)$

$\text{minpoint} = 1.174$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 1.185 \cdot 10^{3}$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 5.282$

Standard Error

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

$\text{Standard}_{error} = 1.997$

Skewness

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

$\text{Skewness} = -1.514$

Kurtosis

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

$\text{Kurtosis} = 3.468$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$No_{DataCells} := \text{length}(Cells)$

$\alpha := .05$ $\quad T\alpha := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right]$ $\quad T\alpha = 2.365$

$Lower_{95\%Con} := \mu_{actual} - T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}}$ $\quad Lower_{95\%Con} = 1.18 \cdot 10^{3}$

$Upper_{95\%Con} := \mu_{actual} + T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}}$ $\quad Upper_{95\%Con} = 1.189 \cdot 10^{3}$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$Distribution = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \\ 0 \\ 2 \\ 3 \\ 0 \\ 1 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

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

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

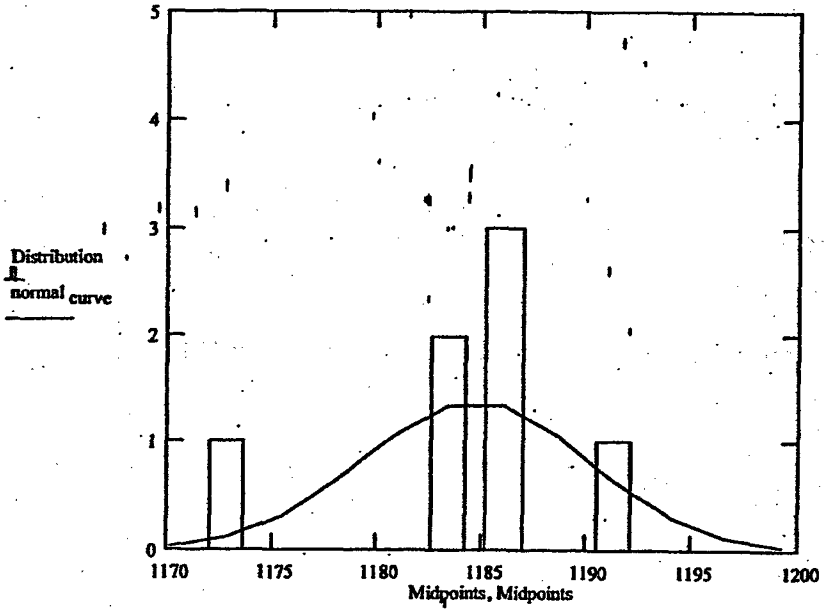
$normal_{curve_k} := \text{pnorm}(Bins_{k+1}, \mu_{actual}, \sigma_{actual}) - \text{pnorm}(Bins_k, \mu_{actual}, \sigma_{actual})$

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

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 1.185\cdot10^3$

$\sigma_{actual} = 5.282$

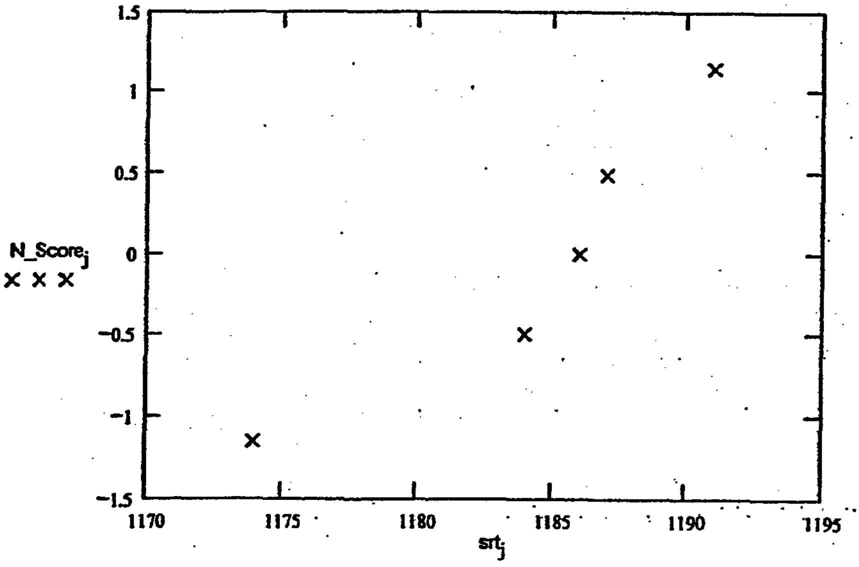
$Standard_{error} = 1.997$

$Skewness = -1.514$

$Kurtosis = 3.468$

$Lower_{95\%Con} = 1.18\cdot10^3$ $Upper_{95\%Con} = 1.189\cdot10^3$

Normal Probability Plot



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

Sandbed Location 5D Trend

$d := 0$

For 1992

$Dates_d := Day_{year}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB5D.txt")

$Points_7 := show7cells(page, 1, 7, 0)$

Data

$Points_7 = [\ 1.164 \quad 1.22 \quad 1.167 \quad 1.185 \quad 1.183 \quad 1.174 \quad 1.178\ ]$

$nnn := con7vert(Points_7, 7, 1)$ $No_{DataCells} := length(nnn)$

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

$Point_{1_d} := Cells_0$

$Point_1 = 1.164 \cdot 10^2$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB5D.txt")

$Dates_d := Day_{year}(9, 14, 1994)$

$Points_7 := show7cells(page, 1, 7, 0)$

Data

$Points_7 = [\, 1.163 \quad 1.172 \quad 1.155 \quad 1.174 \quad 1.171 \quad 1.171 \quad 1.173 \,]$

$nnn := con7vert(Points_7, 7, 1)$ $No_{DataCells} := length(nnn)$

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

$Point\ 1_d := Cells_0$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \dfrac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB5D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.163 \quad 1.18 \quad 1.168 \quad 1.178 \quad 1.174 \quad 1.17 \quad 1.175\ ]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{1_d} := \text{Cells}_0$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB5D.txt")

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(10, 16, 2006)$

$\mathrm{Points}_7 := \mathrm{show7cells}(\mathrm{page}, 1, 7, 0)$

Data

$\mathrm{Points}_7 = \begin{bmatrix} 1.174 & 1.191 & 1.186 & 1.187 & 1.187 & 1.184 & 1.184 \end{bmatrix}$

$\mathrm{nnn} := \mathrm{con7vert}\left(\mathrm{Points}_7, 7, 1\right)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mathrm{Point}_{1_d} := \mathrm{Cells}_0$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$ $\mathrm{Standard}_{\mathrm{error}_d} := \dfrac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\mathrm{Dates} = \begin{bmatrix} 1.993\cdot10^3 \\ 1.995\cdot10^3 \\ 1.997\cdot10^3 \\ 2.007\cdot10^3 \end{bmatrix} \qquad \mathrm{Point}_1 = \begin{bmatrix} 1.164\cdot10^3 \\ 1.163\cdot10^3 \\ 1.163\cdot10^3 \\ 1.174\cdot10^3 \end{bmatrix}$$

$$\mu_{\mathrm{measured}} = \begin{bmatrix} 1.182\cdot10^3 \\ 1.168\cdot10^3 \\ 1.173\cdot10^3 \\ 1.185\cdot10^3 \end{bmatrix} \qquad \mathrm{Standard}_{\mathrm{error}} = \begin{bmatrix} 7.04 \\ 2.617 \\ 2.245 \\ 1.997 \end{bmatrix} \qquad \sigma_{\mathrm{measured}} = \begin{bmatrix} 18.627 \\ 6.925 \\ 5.94 \\ 5.282 \end{bmatrix}$$

$\mathrm{Total}_{\mathrm{means}} := \mathrm{rows}(\mu_{\mathrm{measured}})$ $\qquad$ $\mathrm{Total}_{\mathrm{means}} = 4$

$$\mathrm{SST} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{mean}(\mu_{\mathrm{measured}})\right)^2 \qquad \mathrm{SST} = 173.362$$

$$\mathrm{SSE} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{yhat}(\mathrm{Dates}, \mu_{\mathrm{measured}})_i\right)^2 \qquad \mathrm{SSE} = 119.919$$

$$\mathrm{SSR} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{yhat}(\mathrm{Dates}, \mu_{\mathrm{measured}})_i - \mathrm{mean}(\mu_{\mathrm{measured}})\right)^2 \qquad \mathrm{SSR} = 53.443$$

$\mathrm{DegreeFree}_{\mathrm{ss}} := \mathrm{Total}_{\mathrm{means}} - 2$ $\qquad$ $\mathrm{DegreeFree}_{\mathrm{reg}} := 1$ $\qquad$ $\mathrm{DegreeFree}_{\mathrm{st}} := \mathrm{Total}_{\mathrm{means}} - 1$

$$\mathrm{MSE} := \frac{\mathrm{SSE}}{\mathrm{DegreeFree}_{\mathrm{ss}}} \qquad \mathrm{MSR} := \frac{\mathrm{SSR}}{\mathrm{DegreeFree}_{\mathrm{reg}}} \qquad \mathrm{MST} := \frac{\mathrm{SST}}{\mathrm{DegreeFree}_{\mathrm{st}}}$$

$\mathrm{MSE} = 59.96$ $\qquad$ $\mathrm{MSR} = 53.443$ $\qquad$ $\mathrm{MST} = 57.787$

$\mathrm{StGrand}_{\mathrm{err}} := \sqrt{\mathrm{MSE}}$ $\qquad$ $\mathrm{StGrand}_{\mathrm{err}} = 7.743$

F Test for Corrosion

$\alpha := 0.05$ $F_{actaul\_Reg} := \frac{MSR}{MSE}$

$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 0.048$

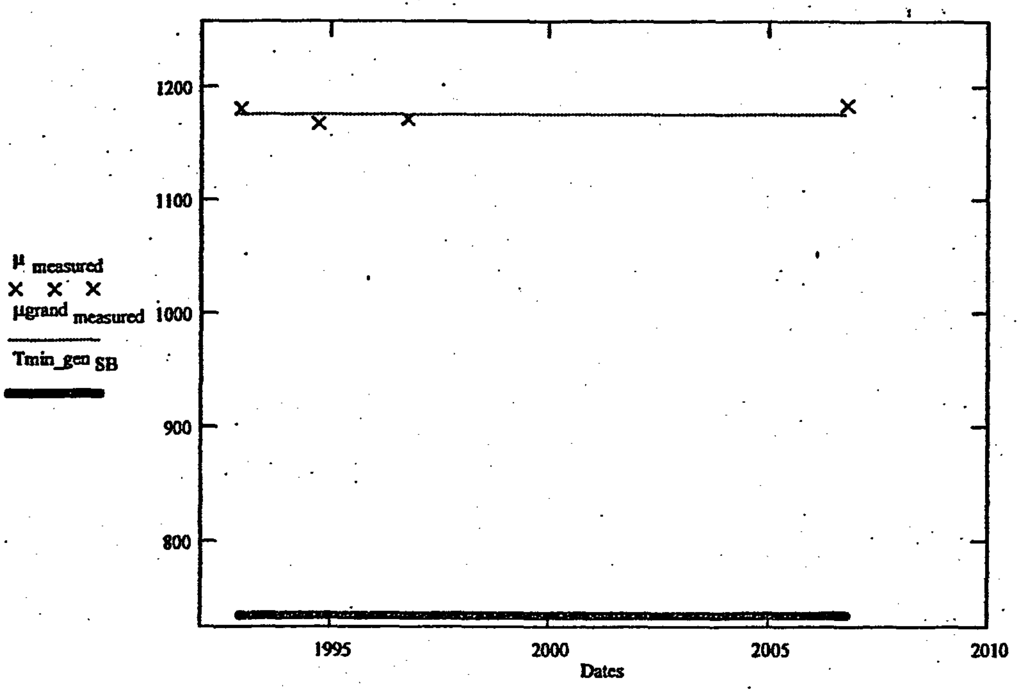
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$ $GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 1.177 \cdot 10^3$ $GrandStandard_{error} = 3.801$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}(\text{Dates}, \mu_{\text{measured}})$ $m_s = 0.681$ $y_b := \text{intercept}(\text{Dates}, \mu_{\text{measured}})$ $y_b = -183.458$

The 95% Confidence curves are calculated

$\alpha_t := 0.05$ $k := 2029 - 1985$ $f := 0 .. k - 1$

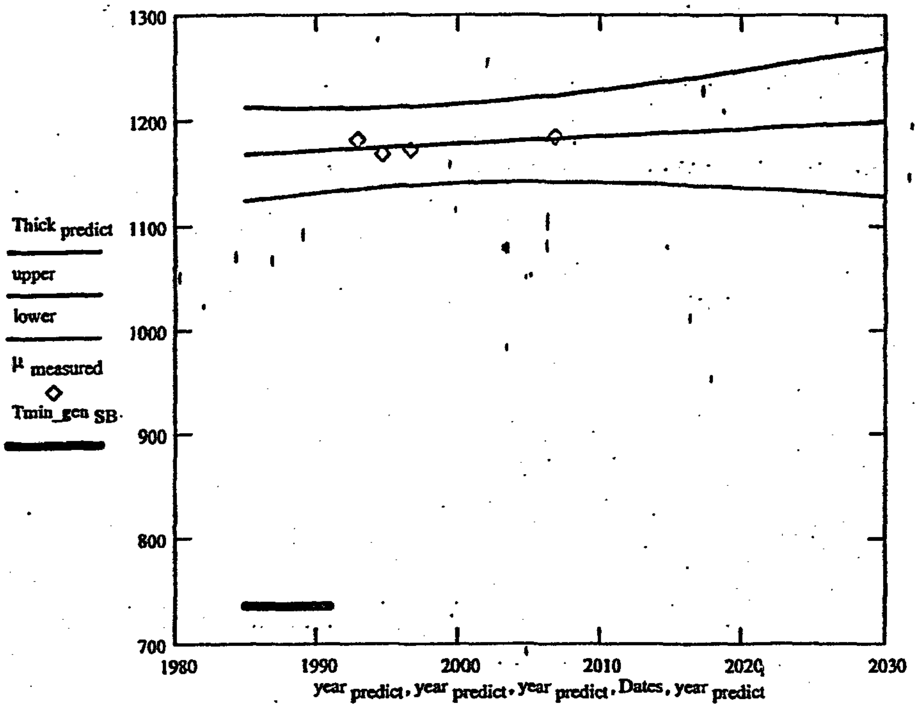
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2$ $\text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates})$ $\text{sum} := \sum_i (\text{Dates}_d - \text{mean}(\text{Dates}))^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = 0.681$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 1.026 \cdot 10^3$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

$$\mathrm{Point}\ 1_d := \mathrm{Cells}_0$$

$$SST_{point} := \sum_{i=0}^{\mathrm{last}(\mathrm{Dates})} \left(\mathrm{Point}\ 1_i - \mathrm{mean}(\mathrm{Point}\ 1)\right)^2 \qquad SST_{point} = 86$$

$$SSE_{point} := \sum_{i=0}^{\mathrm{last}(\mathrm{Dates})} \left(\mathrm{Point}\ 1_i - \mathrm{yhat}(\mathrm{Dates}, \mathrm{Point}\ 1)_i\right)^2 \qquad SSE_{point} = 8.99$$

$$SSR_{point} := \sum_{i=0}^{\mathrm{last}(\mathrm{Dates})} \left(\mathrm{yhat}(\mathrm{Dates}, \mathrm{Point}\ 1)_i - \mathrm{mean}(\mathrm{Point}\ 1)\right)^2 \qquad SSR_{point} = 77.01$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 4.495 \qquad MSR_{point} = 77.01 \qquad MST_{point} = 28.667$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 2.12$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.925$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean and the apparent rate which is positive which is not credible.

$m_{point} := \mathrm{slope}(Dates, Point_1)$ $m_{point} = 0.817$ $y_{point} := \mathrm{intercept}(Dates, Point_1)$ $y_{point} = -466.893$

The 95% Confidence curves are calculated

$$Point_{curve} := m_{point} \cdot year_{predict} + y_{point}$$

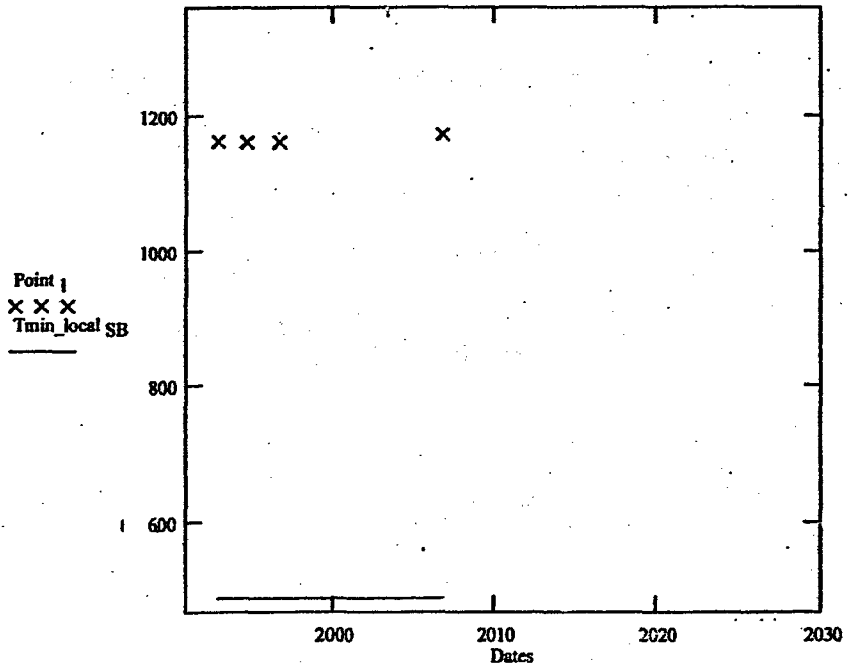
$$Point_{actualmean} := \mathrm{mean}(Dates) \qquad sum := \sum_i \left(Dates_d - \mathrm{mean}(Dates)\right)^2$$

$$uppoint_f := Point_{curve_f} \cdots + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Point_{actualmean}\right)^2}{sum}}$$

$$lopoint_f := Point_{curve_f} \cdots + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Point_{actualmean}\right)^2}{sum}}\right]$$

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 1 Projected to Plant End Of Life



$m_{point} = 0.817$

$lopoint_{22} = 1.173 \cdot 10^3$ $year_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thicknessin}} := \text{Point}_{1_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thicknessin}} = 1.015 \cdot 10^3$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 1.174$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -28.5$ mils per year

Appendix 16 - Sand Bed Elevation Bay 7D

October 2006 Data

The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB7D.txt")

$Points_7$:= show7cells(page , 1 , 7 , 0)

$Points_7 = [\ 1.144\ \ 1.147\ \ 1.147\ \ 1.138\ \ 1.102\ \ 1.135\ \ 1.116\ ]$

Cells := con7vert($Points_7$, 7 , 1 No $_{DataCells}$:= length(Cells)

Cells := deletezero $_{cells}$(Cells , No $_{DataCells}$)

The thinnest point at this location is shown below

minpoint := min($Points_7$)

minpoint = 1.102

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 1.133 \cdot 10^{3}$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 17.279$

Standard Error

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

$\text{Standard}_{error} = 6.531$

Skewness

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

$\text{Skewness} = -1.186$

Kurtosis

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

$\text{Kurtosis} = 0.193$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$No_{DataCells} := \text{length}(Cells)$$

$$\alpha := .05 \qquad T\alpha := qt\left[\left(1-\frac{\alpha}{2}\right), No_{DataCells}\right] \quad T\alpha = 2.365$$

$$Lower_{95\%Con} := \mu_{actual} - T\alpha\cdot\frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 1.117\cdot10^{3}$$

$$Upper_{95\%Con} := \mu_{actual} + T\alpha\cdot\frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 1.148\cdot10^{3}$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

$$Distribution = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 1 \\ 0 \\ 2 \\ 3 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

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

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

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

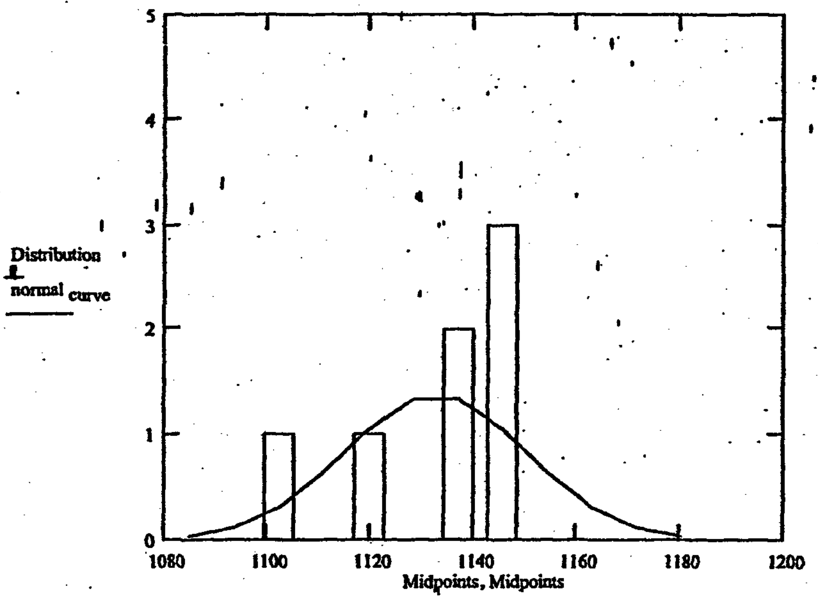
$$normal_{curve_k} := pnorm\left(Bins_{k+1}, \mu_{actual}, \sigma_{actual}\right) - pnorm\left(Bins_k, \mu_{actual}, \sigma_{actual}\right)$$

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

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 1.133 \cdot 10^3$

$\sigma_{actual} = 17.279$

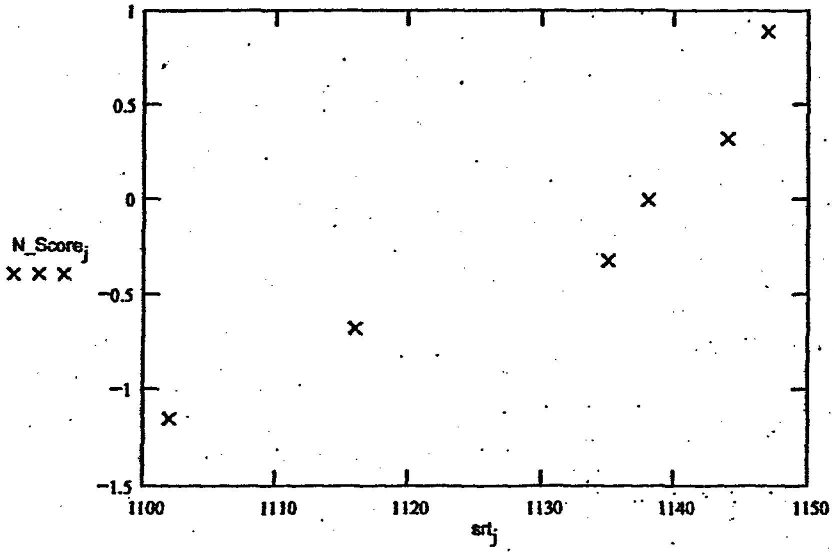
$Standard_{error} = 6.531$

$Skewness = -1.186$

$Kurtosis = 0.193$

$Lower_{95\%Con} = 1.117 \cdot 10^3$ $Upper_{95\%Con} = 1.148 \cdot 10^3$

Normal Probability Plot



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

Sandbed Location 7D Trend

$d := 0$

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB7D.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\,1.147 \quad 1.149 \quad 1.15 \quad 1.15 \quad 1.111 \quad 1.127 \quad 1.122\,]$

$\text{nnn} := \text{con7vert}(\text{Points}_7, 7, 1) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\text{Point}_{5_d} := \text{Cells}_4$

$\text{Point}_5 = 1.111 \cdot 10^3$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB7D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.143 \quad 1.146 \quad 1.137 \quad 1.146 \quad 1.135 \quad 1.134 \quad 1.113\ ]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{5_d} := \text{Cells}_4$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept,1996 Data\sandbed\Data Only\SB7D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\, 1.152 \quad 1.15 \quad 1.146 \quad 1.15 \quad 1.113 \quad 1.126 \quad 1{,}126 \,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{5_d} := \text{Cells}_4$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB7D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\,1.144 \quad 1.147 \quad 1.147 \quad 1.138 \quad 1.102 \quad 1.135 \quad 1.116\,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{5_d} := \text{Cells}_4$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993\cdot10^3 \\ 1.995\cdot10^3 \\ 1.997\cdot10^3 \\ 2.007\cdot10^3 \end{bmatrix} \qquad \text{Point}_5 = \begin{bmatrix} 1.111\cdot10^3 \\ 1.135\cdot10^3 \\ 1.113\cdot10^3 \\ 1.102\cdot10^3 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.137\cdot10^3 \\ 1.136\cdot10^3 \\ 1.138\cdot10^3 \\ 1.133\cdot10^3 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 6.137 \\ 4.319 \\ 5.902 \\ 6.531 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 16.236 \\ 11.427 \\ 15.616 \\ 17.279 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}})$ $\qquad$ $\text{Total}_{\text{means}} = 4$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SST} = 13.592$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 2.987$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 10.605$$

$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2$ $\qquad$ $\text{DegreeFree}_{\text{reg}} := 1$ $\qquad$ $\text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$\text{MSE} = 1.494$ $\qquad$ $\text{MSR} = 10.605$ $\qquad$ $\text{MST} = 4.531$

$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}}$ $\qquad$ $\text{StGrand}_{\text{err}} = 1.222$

F Test for Corrosion

$\alpha := 0.05$

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

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{s}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.384$$

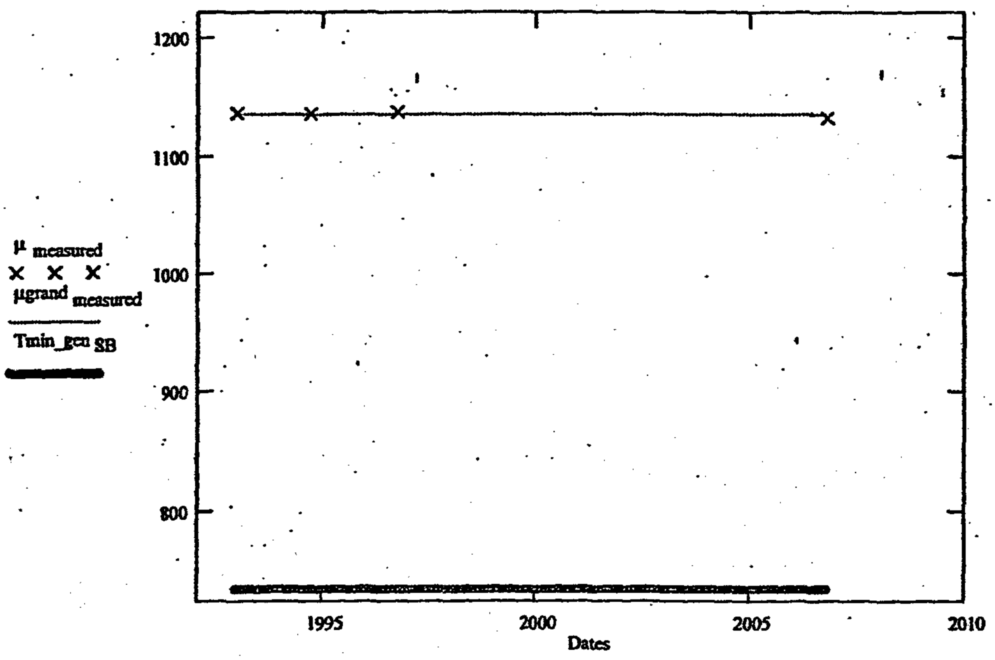
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\qquad \mu grand_{measured_i} := mean(\mu_{measured})$

$\sigma grand_{measured} := Stdev(\mu_{measured})$ $\qquad GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 1.136 \cdot 10^{3}$ $\qquad GrandStandard_{error} = 1.064$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \mathrm{slope}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)$ $m_s = -0.303$ $y_b := \mathrm{intercept}\left(\mathrm{Dates}, \mu_{\mathrm{measured}}\right)$ $y_b = 1.742 \cdot 10^3$

The 95% Confidence curves are calculated

$\alpha_t := 0.05$ $k := 2029 - 1985$ $f := 0 .. k - 1$

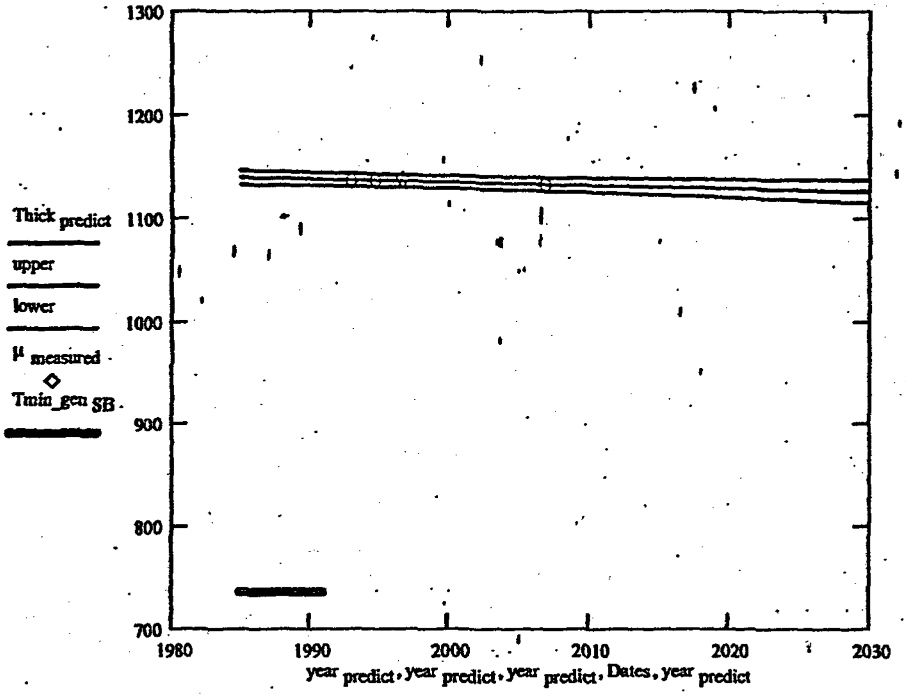
$\mathrm{year}_{\mathrm{predict}_f} := 1985 + f \cdot 2$ $\mathrm{Thick}_{\mathrm{predict}} := m_s \cdot \mathrm{year}_{\mathrm{predict}} + y_b$

$\mathrm{Thick}_{\mathrm{actualmean}} := \mathrm{mean}(\mathrm{Dates})$ $\mathrm{sum} := \sum_i \left(\mathrm{Dates}_d - \mathrm{mean}(\mathrm{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = -0.303$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$Rate_{min\_observed} := 6.9$$

$$Postulated_{meanthickness} := \mu_{measured_3} - Rate_{min\_observed} \cdot (2029 - 2006)$$

$Postulated_{meanthickness} = 974.014$ which is greater than $Tmin\_gen_{SB_3} = 736$

The following addresses the readings at the lowest single point

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point5_i - mean(Point5)\right)^2 \qquad SST_{point} = 588.75$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Point5_i - yhat(Dates, Point5)_i\right)^2 \qquad SSE_{point} = 374.474$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat(Dates, Point5)_i - mean(Point5)\right)^2 \qquad SSR_{point} = 214.276$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 187.237 \qquad MSR_{point} = 214.276 \qquad MST_{point} = 196.25$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 13.683$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.062$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \text{slope}\left(Dates, Point_5\right)$ $m_{point} = -1.363$ $y_{point} := \text{intercept}\left(Dates, Point_5\right)$ $y_{point} = 3.839 \cdot 10^3$

The 95% Confidence curves are calculated

$Point_{curve} := m_{point} \cdot year_{predict} + y_{point}$

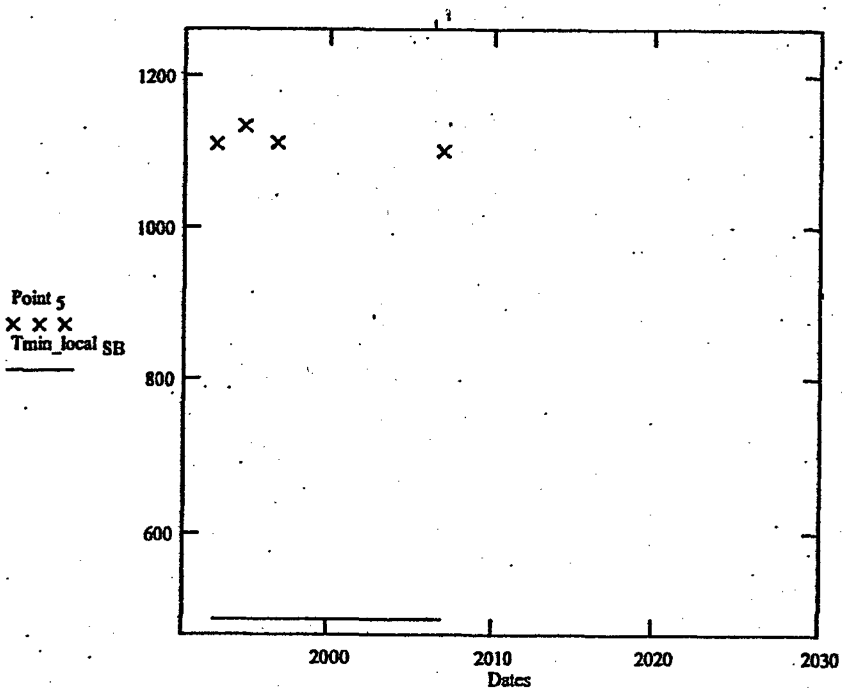
$Point_{actualmean} := \text{mean}(Dates)$ $sum := \sum_i \left(Dates_d - \text{mean}(Dates)\right)^2$

$$uppoint_f := Point_{curve_f} \cdots$$
$$+ \; qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Point_{actualmean}\right)^2}{sum}}$$

$$lopoint_f := Point_{curve_f} \cdots$$
$$+ -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Point_{actualmean}\right)^2}{sum}}\right]$$

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 5 Projected to Plant End Of Life



$m_{point} = -1.363$

$lopoint_{22} = 951.274$ $year_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thicknessin}} := \text{Point}_{5_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thicknessin}} = 943.3$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 1.102$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -25.5$ mils per year

Appendix 17 - Sand Bed Elevation Bay 9A

October 2006 Data

The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB9A.txt")

$Points_7$:= show7cells(page , 1 , 7 , 0)

$Points_7$ = [1.158 1.159 1.162 1.159 1.159 1.153 1.13]

Cells := con7vert($Points_7$, 7 , 1 $No_{DataCells}$:= length(Cells)

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

The thinnest point at this location is shown below

minpoint := min($Points_7$)

minpoint = 1.13

Mean and Standard Deviation

$\mu_{\text{actual}} := \text{mean}(\text{Cells})$ $\mu_{\text{actual}} = 1.154 \cdot 10^{3}$ $\sigma_{\text{actual}} := \text{Stdev}(\text{Cells})$ $\sigma_{\text{actual}} = 11.041$

Standard Error

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

$\text{Standard}_{\text{error}} = 4.173$

Skewness

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

$\text{Skewness} = -2.341$

Kurtosis

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

$\text{Kurtosis} = 5.687$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

$$r_j := j + 1 \qquad \mathrm{rank}_j := \frac{\overrightarrow{\Sigma\left(\overrightarrow{srt = srt_j}\right)\cdot r}}{\Sigma\overrightarrow{srt = srt_j}}$$

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

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

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

Upper and Lower Confidence Values

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

$$\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$$

$$\alpha := .05 \qquad T\alpha := \text{qt}\left[\left(1 - \frac{\alpha}{2}\right), \text{No}_{\text{DataCells}}\right] \qquad T\alpha = 2.365$$

$$\text{Lower}_{95\%\text{Con}} := \mu_{\text{actual}} - T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Lower}_{95\%\text{Con}} = 1.144 \cdot 10^{3}$$

$$\text{Upper}_{95\%\text{Con}} := \mu_{\text{actual}} + T\alpha \cdot \frac{\sigma_{\text{actual}}}{\sqrt{\text{No}_{\text{DataCells}}}} \qquad \text{Upper}_{95\%\text{Con}} = 1.164 \cdot 10^{3}$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

Distribution =

0
1
0
0
0
1
4
1
0
0
0
0

The mid points of the Bins are calculated

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

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

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

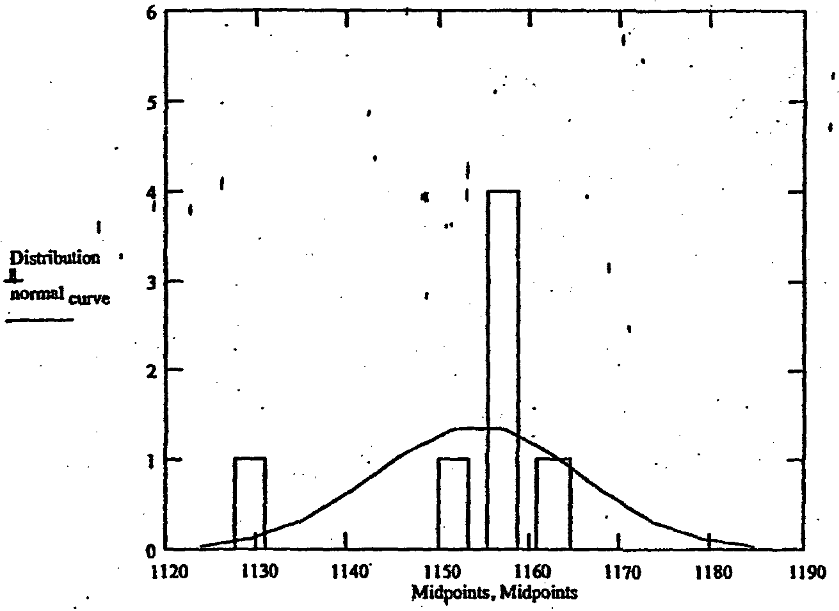
$$\text{normal}_{\text{curve}_k} := \text{pnorm}(\text{Bins}_{k+1}, \mu_{\text{actual}}, \sigma_{\text{actual}}) - \text{pnorm}(\text{Bins}_k, \mu_{\text{actual}}, \sigma_{\text{actual}})$$

$$\text{normal}_{\text{curve}} := \text{No}_{\text{DataCells}} \cdot \text{normal}_{\text{curve}}$$

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 1.154 \cdot 10^3$

$\sigma_{actual} = 11.041$

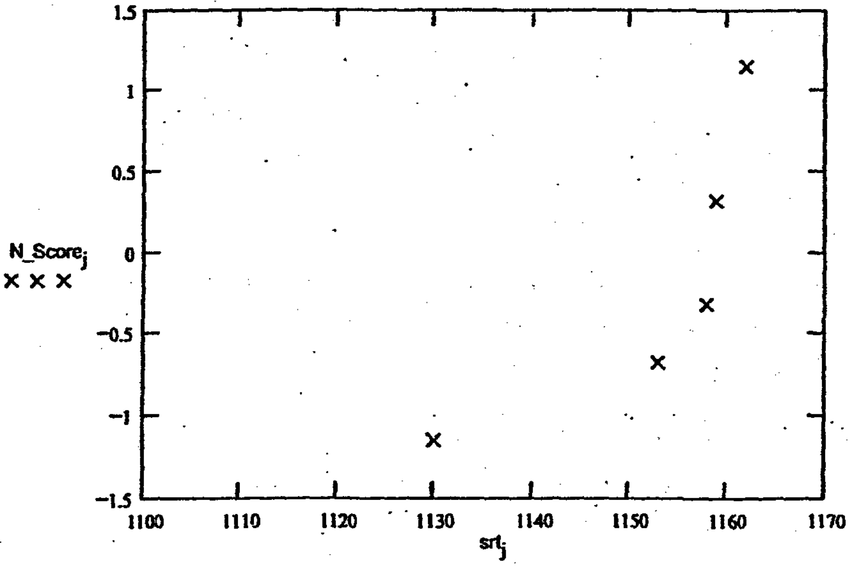
$Standard_{error} = 4.173$

$Skewness = -2.341$

$Kurtosis = 5.687$

$Lower_{95\%Con} = 1.144 \cdot 10^3$ $Upper_{95\%Con} = 1.164 \cdot 10^3$

Normal Probability Plot



Sandbed Location 9A Trend

$d := 0$

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB9A.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.162 \quad 1.161 \quad 1.164 \quad 1.162 \quad 1.161 \quad 1.157 \quad 1.133\ ]$

$\text{nnn} := \text{con7vert}(\text{Points}_7, 7, 1) \qquad \text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\text{Point}_{7_d} := \text{Cells}_6$

$\text{Point}_7 = 1.133 \cdot 10^3$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB9A.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.162 \quad 1.164 \quad 1.168 \quad 1.163 \quad 1.157 \quad 1.155 \quad 1.132\ ]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{7_d} := \text{Cells}_6$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB9A.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.163\ \ 1.161\ \ 1.162\ \ 1.159\ \ 1.159\ \ 1.153\ \ 1.127\ ]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{7_d} := \text{Cells}_6$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB9A.txt")

$\text{Dates}_{d_1} := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.158\ \ 1.159\ \ 1.162\ \ 1.159\ \ 1.159\ \ 1.153\ \ 1.13\ ]$

$\text{nnn} := \text{con7vert}(\text{Points}_7, 7, 1)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\text{Point}_{7_d} := \text{Cells}_6$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993\cdot10^3 \\ 1.995\cdot10^3 \\ 1.997\cdot10^3 \\ 2.007\cdot10^3 \end{bmatrix} \qquad \text{Point}_7 = \begin{bmatrix} 1.133\cdot10^3 \\ 1.132\cdot10^3 \\ 1.127\cdot10^3 \\ 1.13\cdot10^3 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.157\cdot10^3 \\ 1.157\cdot10^3 \\ 1.155\cdot10^3 \\ 1.154\cdot10^3 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 4.102 \\ 4.524 \\ 4.803 \\ 4.173 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 10.854 \\ 11.968 \\ 12.707 \\ 11.041 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}\left(\mu_{\text{measured}}\right) \qquad \text{Total}_{\text{means}} = 4$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2 \qquad \text{SST} = 7.158$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i\right)^2 \qquad \text{SSE} = 2.28$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2 \qquad \text{SSR} = 4.878$$

$$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{MSE} = 1.14 \qquad \text{MSR} = 4.878 \qquad \text{MST} = 2.386$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 1.068$$

F Test for Corrosion

$\alpha := 0.05$

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

$$F_{critical\_reg} := qF\left(1-\alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.231$$

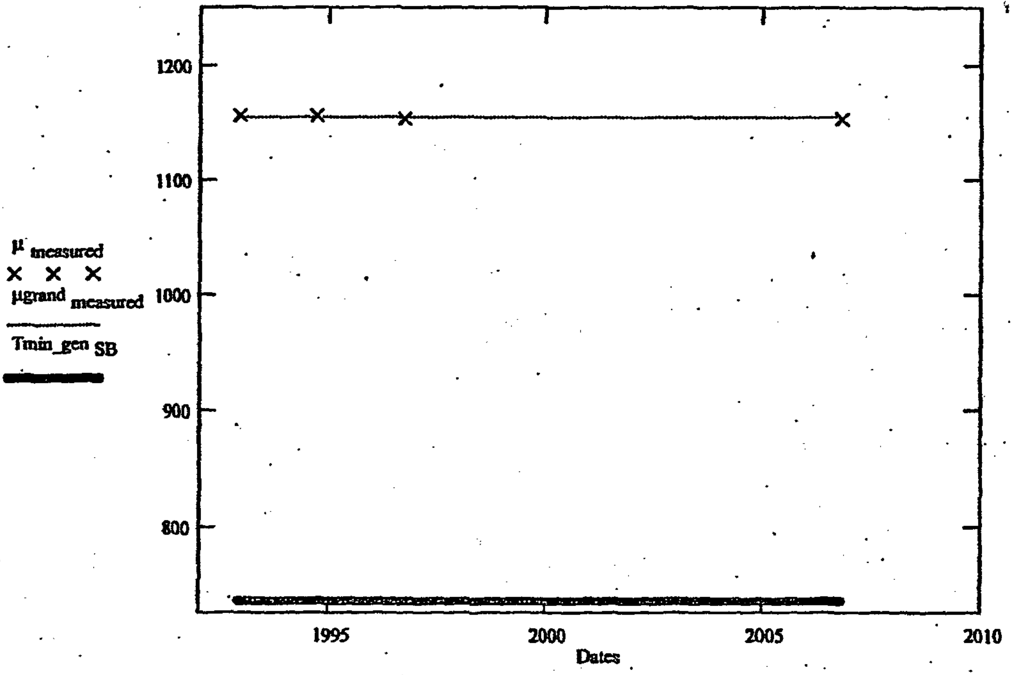
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$ $GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand.mean and the actual means over time



$\mu grand_{measured_0} = 1.156 \cdot 10^3$ $GrandStandard_{error} = 0.772$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}(\text{Dates}, \mu_{\text{measured}})$ $m_s = -0.206$ $y_b := \text{intercept}(\text{Dates}, \mu_{\text{measured}})$ $y_b = 1.567 \cdot 10^3$

The 95% Confidence curves are calculated

$\alpha_t := 0.05$ $k := 2029 - 1985$ $f := 0 .. k - 1$

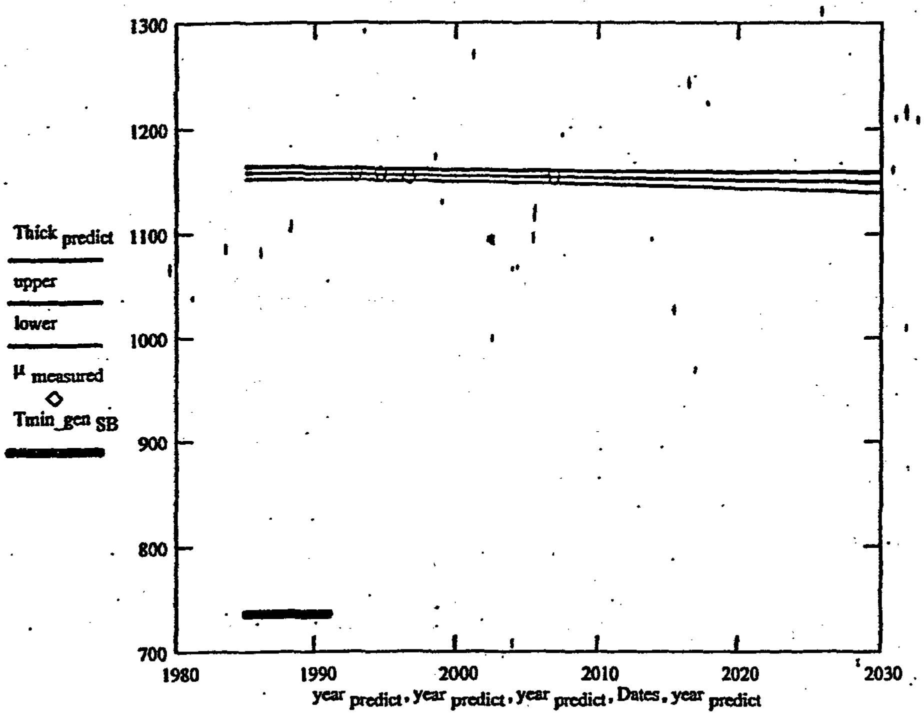
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2$ $\text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates})$ $\text{sum} := \sum_i (\text{Dates}_d - \text{mean}(\text{Dates}))^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = -0.206$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$Rate_{min\_observed} := 6.9$$

$$Postulated_{meanthickness} := \mu_{measured_3} - Rate_{min\_observed} \cdot (2029 - 2006)$$

$Postulated_{meanthickness} = 995.586$ which is greater than $Tmin\_gen_{SB_3} = 736$

The following addresses the readings at the lowest single point

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{7_i} - mean\left(Point_7\right)\right)^2 \qquad SST_{point} = 21$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{7_i} - yhat\left(Dates, Point_7\right)_i\right)^2 \qquad SSE_{point} = 18.349$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, Point_7\right)_i - mean\left(Point_7\right)\right)^2 \qquad SSR_{point} = 2.651$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 9.175 \qquad MSR_{point} = 2.651 \qquad MST_{point} = 7$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 3.029$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.016$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \text{slope}(Dates, Point_7)$ $m_{point} = -0.152$ $y_{point} := \text{intercept}(Dates, Point_7)$ $y_{point} = 1.433 \cdot 10^3$

The 95% Confidence curves are calculated

$Point_{curve} := m_{point} \cdot year_{predict} + y_{point}$

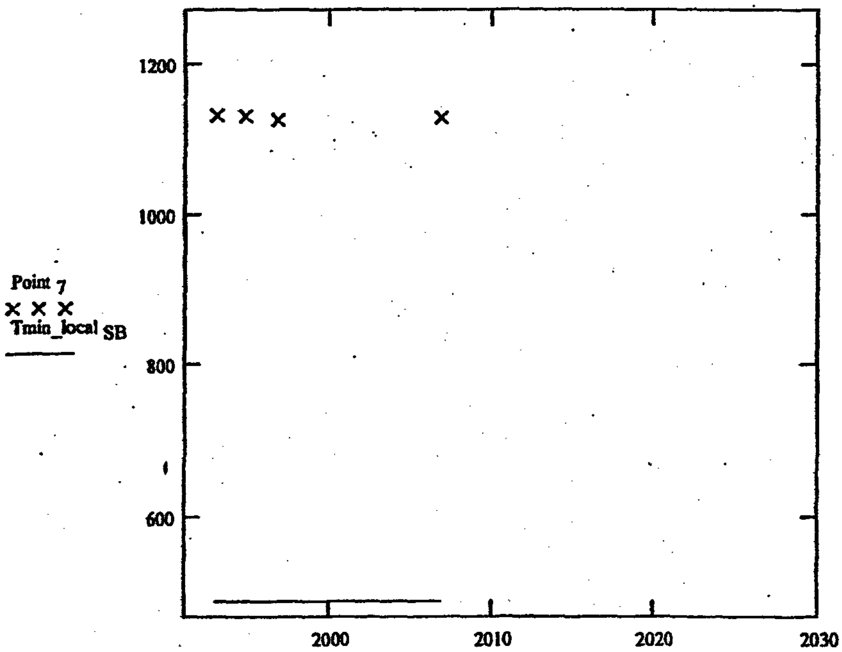
$Point_{actualmean} := \text{mean}(Dates)$ $sum := \sum_i \left(Dates_d - \text{mean}(Dates)\right)^2$

$$uppoint_f := Point_{curve_f} - \\ + qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Point_{actualmean}\right)^2}{sum}}$$

$$lopoint_f := Point_{curve_f} - \\ + -\left[qt\left(1 - \frac{\alpha_t}{2}, Total_{means} - 2\right) \cdot StPoint_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(year_{predict_f} - Point_{actualmean}\right)^2}{sum}}\right]$$

Local Tmin for this elevation in the Drywell $Tmin\_local_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 7 Projected to Plant End Of Life



$m_{point} = -0.152$

$lopoint_{22} = 1.099 \cdot 10^3$ $year_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point}_{7_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 971.3$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 1.13$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -26.667$ mils per year

Appendix 18 - Sand Bed Elevation Bay 13C

October 2006 Data

The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB13c.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

$\text{Points}_7 = [\ 1.146\quad 1.148\quad 1.148\quad 1.149\quad 1.144\quad 1.128\quad 1.134\ ]$

$\text{Cells} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$

The thinnest point at this location is shown below

$\text{minpoint} := \min\left(\text{Points}_7\right)$

$\text{minpoint} = 1.128$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 1.142\cdot10^3$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 8.162$

Standard Error

$$\text{Standard}_{error} := \frac{\sigma_{actual}}{\sqrt{\text{No}_{DataCells}}}$$ $\text{Standard}_{error} = 3.085$

Skewness

$$\text{Skewness} := \frac{\left(\text{No}_{DataCells}\right)\cdot\overrightarrow{\Sigma\left(\text{Cells} - \mu_{actual}\right)^3}}{\left(\text{No}_{DataCells} - 1\right)\cdot\left(\text{No}_{DataCells} - 2\right)\cdot\left(\sigma_{actual}\right)^3}$$ $\text{Skewness} = -1.255$

Kurtosis

$$\text{Kurtosis} := \frac{\text{No}_{DataCells}\cdot\left(\text{No}_{DataCells} + 1\right)\cdot\overrightarrow{\Sigma\left(\text{Cells} - \mu_{actual}\right)^4}}{\left(\text{No}_{DataCells} - 1\right)\cdot\left(\text{No}_{DataCells} - 2\right)\cdot\left(\text{No}_{DataCells} - 3\right)\cdot\left(\sigma_{actual}\right)^4} + -\frac{3\cdot\left(\text{No}_{DataCells} - 1\right)^2}{\left(\text{No}_{DataCells} - 2\right)\cdot\left(\text{No}_{DataCells} - 3\right)}$$ $\text{Kurtosis} = 0.104$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{Cells})$$

$$\alpha := .05 \qquad T\alpha := \mathrm{qt}\left[\left(1 - \frac{\alpha}{2}\right), \mathrm{No}_{\mathrm{DataCells}}\right] \qquad T\alpha = 2.365$$

$$\mathrm{Lower}_{95\%\mathrm{Con}} := \mu_{\mathrm{actual}} - T\alpha \cdot \frac{\sigma_{\mathrm{actual}}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}} \qquad \mathrm{Lower}_{95\%\mathrm{Con}} = 1.135 \cdot 10^{3}$$

$$\mathrm{Upper}_{95\%\mathrm{Con}} := \mu_{\mathrm{actual}} + T\alpha \cdot \frac{\sigma_{\mathrm{actual}}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}} \qquad \mathrm{Upper}_{95\%\mathrm{Con}} = 1.15 \cdot 10^{3}$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

$$\mathrm{Bins} := \mathrm{Make}_{\mathrm{bins}}\left(\mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right)$$

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

$$\mathrm{Distribution} = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 1 \\ 0 \\ 0 \\ 2 \\ 3 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

The mid points of the Bins are calculated

$$k := 0 .. 11 \qquad \mathrm{Midpoints}_{k} := \frac{\left(\mathrm{Bins}_{k} + \mathrm{Bins}_{k+1}\right)}{2}$$

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

$$\mathrm{normal}_{\mathrm{curve}_{0}} := \mathrm{pnorm}\left(\mathrm{Bins}_{1}, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right)$$

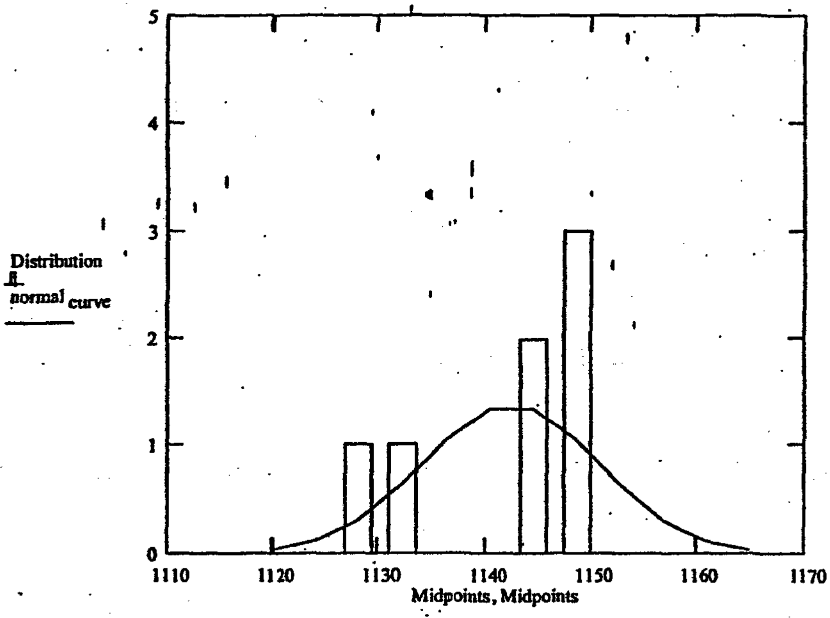
$$\mathrm{normal}_{\mathrm{curve}_{k}} := \mathrm{pnorm}\left(\mathrm{Bins}_{k+1}, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right) - \mathrm{pnorm}\left(\mathrm{Bins}_{k}, \mu_{\mathrm{actual}}, \sigma_{\mathrm{actual}}\right)$$

$$\mathrm{normal}_{\mathrm{curve}} := \mathrm{No}_{\mathrm{DataCells}} \cdot \mathrm{normal}_{\mathrm{curve}}$$

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 1.142 \cdot 10^3$

$\sigma_{actual} = 8.162$

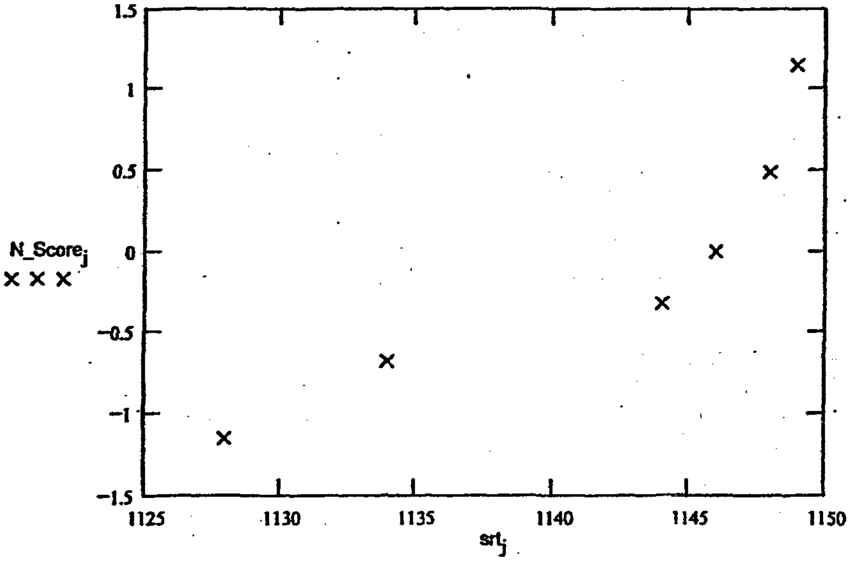
$Standard_{error} = 3.085$

$Skewness = -1.255$

$Kurtosis = 0.104$

$Lower_{95\%Con} = 1.135 \cdot 10^3$ $Upper_{95\%Con} = 1.15 \cdot 10^3$

Normal Probability Plot



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

Sandbed Location 13C Trend

$d := 0$

For 1992 $\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB13C.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\, 1.148 \quad 1.151 \quad 1.151 \quad 1.153 \quad 1.149 \quad 1.138 \quad 1.152 \,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$ $\text{point}_{6_d} := \text{Cells}_5$

$\text{point}_6 = 1.138 \cdot 10^3$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB13C.txt")

$Dates_d := Day_{year}(9, 14, 1994)$

$Points_7 := show7cells(page, 1, 7, 0)$

Data

$Points_7 = [\ 1.147 \quad 1.147 \quad 1.146 \quad 1.147 \quad 1.128 \quad 1.123 \quad 1.139\ ]$

$nnn := con7vert(Points_7, 7, 1)$ $No_{DataCells} := length(nnn)$

$Cells := deletezero_{cells}(nnn, No_{DataCells})$ $point6_d := Cells_5$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB13C.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.157 \quad 1.151 \quad 1.157 \quad 1.169 \quad 1.156 \quad 1.147 \quad 1.143\ ]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{point}_{6_d} := \text{Cells}_5$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB13C.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\,1.146 \quad 1.148 \quad 1.148 \quad 1.149 \quad 1.144 \quad 1.128 \quad 1.134\,]$

$\text{nnn} := \text{con7vert}(\text{Points}_7, 7, 1)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\text{point}_{6_d} := \text{Cells}_5$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \qquad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \qquad \text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\mathrm{Dates} = \begin{bmatrix} 1.993\cdot 10^3 \\ 1.995\cdot 10^3 \\ 1.997\cdot 10^3 \\ 2.007\cdot 10^3 \end{bmatrix} \qquad \mathrm{point}_6 = \begin{bmatrix} 1.138\cdot 10^3 \\ 1.123\cdot 10^3 \\ 1.147\cdot 10^3 \\ 1.128\cdot 10^3 \end{bmatrix}$$

$$\mu_{\mathrm{measured}} = \begin{bmatrix} 1.149\cdot 10^3 \\ 1.14\cdot 10^3 \\ 1.154\cdot 10^3 \\ 1.142\cdot 10^3 \end{bmatrix} \qquad \mathrm{Standard}_{\mathrm{error}} = \begin{bmatrix} 1.92 \\ 3.829 \\ 3.183 \\ 3.085 \end{bmatrix} \qquad \sigma_{\mathrm{measured}} = \begin{bmatrix} 5.08 \\ 10.13 \\ 8.42 \\ 8.162 \end{bmatrix}$$

$$\mathrm{Total}_{\mathrm{means}} := \mathrm{rows}(\mu_{\mathrm{measured}}) \qquad \mathrm{Total}_{\mathrm{means}} = 4$$

$$\mathrm{SST} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{mean}(\mu_{\mathrm{measured}})\right)^2 \qquad \mathrm{SST} = 130.571$$

$$\mathrm{SSE} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mu_{\mathrm{measured}_i} - \mathrm{yhat}(\mathrm{Dates}, \mu_{\mathrm{measured}})_i\right)^2 \qquad \mathrm{SSE} = 119.869$$

$$\mathrm{SSR} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{yhat}(\mathrm{Dates}, \mu_{\mathrm{measured}})_i - \mathrm{mean}(\mu_{\mathrm{measured}})\right)^2 \qquad \mathrm{SSR} = 10.702$$

$$\mathrm{DegreeFree}_{\mathrm{ss}} := \mathrm{Total}_{\mathrm{means}} - 2 \qquad \mathrm{DegreeFree}_{\mathrm{reg}} := 1 \qquad \mathrm{DegreeFree}_{\mathrm{st}} := \mathrm{Total}_{\mathrm{means}} - 1$$

$$\mathrm{MSE} := \frac{\mathrm{SSE}}{\mathrm{DegreeFree}_{\mathrm{ss}}} \qquad \mathrm{MSR} := \frac{\mathrm{SSR}}{\mathrm{DegreeFree}_{\mathrm{reg}}} \qquad \mathrm{MST} := \frac{\mathrm{SST}}{\mathrm{DegreeFree}_{\mathrm{st}}}$$

$$\mathrm{MSE} = 59.935 \qquad \mathrm{MSR} = 10.702 \qquad \mathrm{MST} = 43.524$$

$$\mathrm{StGrand}_{\mathrm{err}} := \sqrt{\mathrm{MSE}} \qquad \mathrm{StGrand}_{\mathrm{err}} = 7.742$$

F Test for Corrosion

$d := 0.05$ $F_{actaul\_Reg} := \frac{MSR}{MSE}$

$F_{critical\_reg} := qF(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss})$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 9.646 \cdot 10^{-3}$

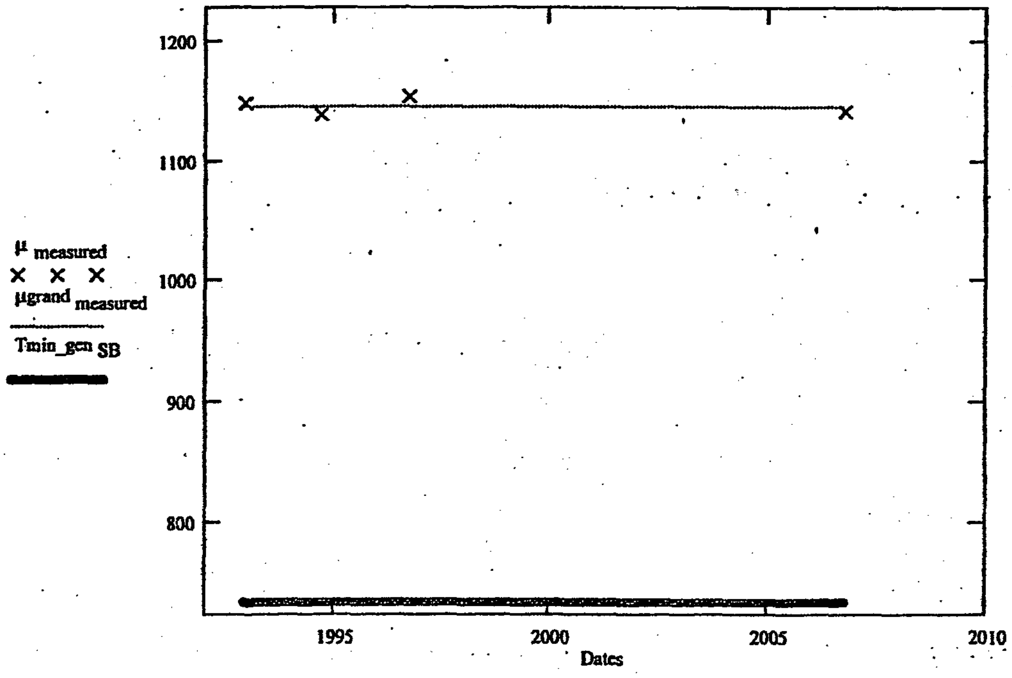
Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$ $\mu grand_{measured_i} := mean(\mu_{measured})$

$\sigma grand_{measured} := Stdev(\mu_{measured})$ $GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 1.146 \cdot 10^3$ $GrandStandard_{error} = 3.299$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}\left(\text{Dates}, \mu_{\text{measured}}\right)$ $m_s = -0.305$ $y_b := \text{intercept}\left(\text{Dates}, \mu_{\text{measured}}\right)$ $y_b = 1.755 \cdot 10^3$

The 95% Confidence curves are calculated

$\alpha_t := 0.05$ $k := 2029 - 1985$ $f := 0..k - 1$

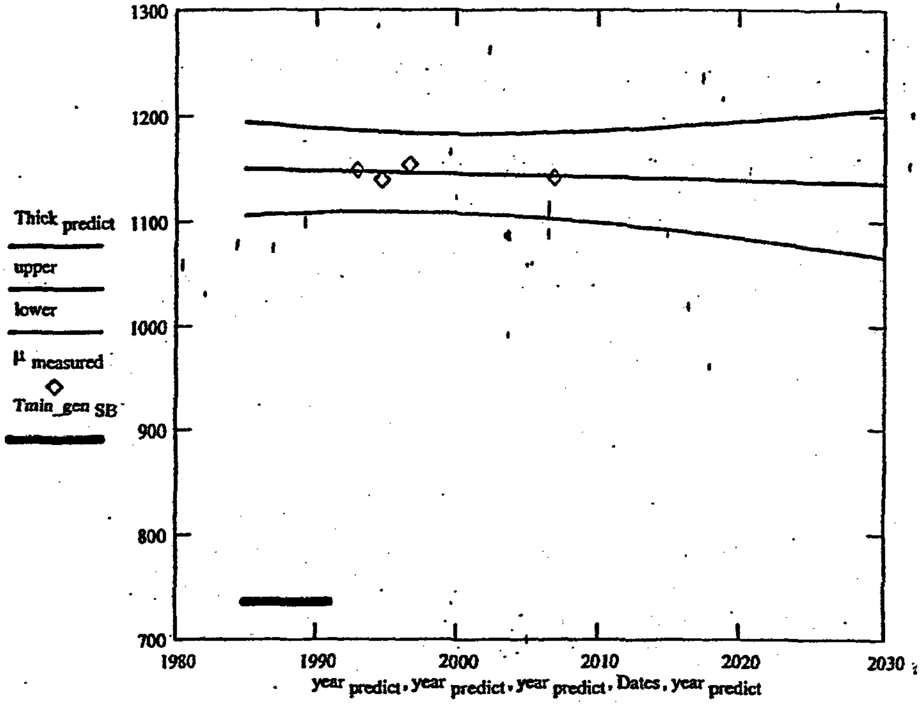
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2$ $\text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates})$ $\text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = -0.305$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 983.729$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

$$\mathrm{point}_{6_d} := \mathrm{Cells}_6$$

$$\mathrm{SST}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{point}_{6_i} - \mathrm{mean}\left(\mathrm{point}_6\right)\right)^2 \qquad \mathrm{SST}_{\mathrm{point}} = 297$$

$$\mathrm{SSE}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{point}_{6_i} - \mathrm{yhat}\left(\mathrm{Dates}, \mathrm{point}_6\right)_i\right)^2 \qquad \mathrm{SSE}_{\mathrm{point}} = 296.998$$

$$\mathrm{SSR}_{\mathrm{point}} := \sum_{i=0}^{\mathrm{last(Dates)}} \left(\mathrm{yhat}\left(\mathrm{Dates}, \mathrm{point}_6\right)_i - \mathrm{mean}\left(\mathrm{point}_6\right)\right)^2 \qquad \mathrm{SSR}_{\mathrm{point}} = 2.289 \cdot 10^{-3}$$

$$\mathrm{MSE}_{\mathrm{point}} := \frac{\mathrm{SSE}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{ss}}} \qquad \mathrm{MSR}_{\mathrm{point}} := \frac{\mathrm{SSR}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{reg}}} \qquad \mathrm{MST}_{\mathrm{point}} := \frac{\mathrm{SST}_{\mathrm{point}}}{\mathrm{DegreeFree}_{\mathrm{st}}}$$

$$\mathrm{MSE}_{\mathrm{point}} = 148.499 \qquad \mathrm{MSR}_{\mathrm{point}} = 2.289 \cdot 10^{-3} \qquad \mathrm{MST}_{\mathrm{point}} = 99$$

$$\mathrm{Stpoint}_{\mathrm{err}} := \sqrt{\mathrm{MSE}_{\mathrm{point}}} \qquad \mathrm{Stpoint}_{\mathrm{err}} = 12.186$$

F Test for Corrosion

$$F_{\mathrm{actaul\_Reg}} := \frac{\mathrm{MSR}_{\mathrm{point}}}{\mathrm{MSE}_{\mathrm{point}}}$$

$$F_{\mathrm{ratio\_reg}} := \frac{F_{\mathrm{actaul\_Reg}}}{F_{\mathrm{critical\_reg}}}$$

$$F_{\mathrm{ratio\_reg}} = 8.327 \cdot 10^{-7}$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$$m_{\mathrm{point}} := \mathrm{slope}\left(\mathrm{Dates}, \mathrm{point}_6\right) \quad m_{\mathrm{point}} = 4.456 \cdot 10^{-5} \quad y_{\mathrm{point}} := \mathrm{intercept}\left(\mathrm{Dates}, \mathrm{point}_6\right) \quad y_{\mathrm{point}} = 1.127 \cdot 10^{3}$$

The 95% Confidence curves are calculated

$$\text{point}_{\text{curve}} := m_{\text{point}} \cdot \text{year}_{\text{predict}} + y_{\text{point}}$$

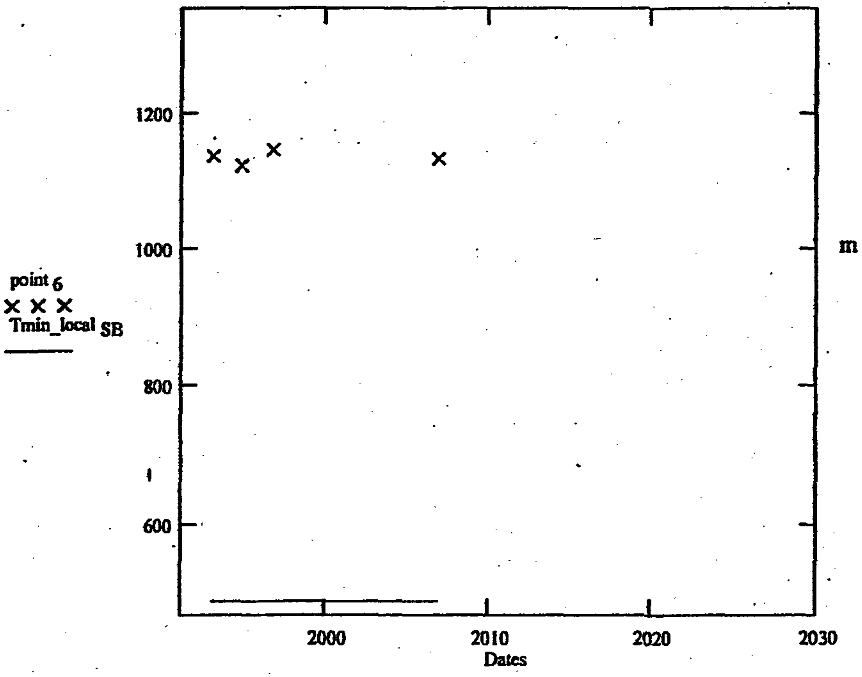
$$\text{point}_{\text{actualmean}} := \text{mean}(\text{Dates}) \qquad \text{sum} := \sum_{i} \left(\text{Dates}_{d} - \text{mean}(\text{Dates})\right)^2$$

$$\text{uppoint}_{f} := \text{point}_{\text{curve}_{f}} \cdots$$
$$+ \text{qt}\left(1 - \frac{\alpha_{t}}{2}, \text{Total}_{\text{means}} - 2\right) \cdot \text{Stpoint}_{\text{err}} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{\text{predict}_{f}} - \text{point}_{\text{actualmean}}\right)^2}{\text{sum}}}$$

$$\text{lopoint}_{f} := \text{point}_{\text{curve}_{f}} \cdots$$
$$+ -\left[\text{qt}\left(1 - \frac{\alpha_{t}}{2}, \text{Total}_{\text{means}} - 2\right) \cdot \text{Stpoint}_{\text{err}} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\text{year}_{\text{predict}_{f}} - \text{point}_{\text{actualmean}}\right)^2}{\text{sum}}}\right]$$

Local Tmin for this elevation in the Drywell $\text{Tmin\_local}_{\text{SB}_{f}} := 490$ (Ref. 3.25)

Curve Fit For Point 6 Projected to Plant End Of Life



$m_{\text{point}} = 4.456 \cdot 10^{-3}$

$\text{lopoint}_{22} = 1.028 \cdot 10^{3}$ $\qquad$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^{3}$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$Rate_{min\_observed} := 6.9$$

$$Postulated_{thickness} := point\,6_3 - Rate_{min\_observed} \cdot (2029 - 2006)$$

$Postulated_{thickness} = 975.3$ which is greater than $Tmin\_local_{SB_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$minpoint = 1.128$ $year_{predict_{22}} = 2.029 \cdot 10^3$ $Tmin\_local_{SB_{22}} = 490$

$$required_{rate.} := \frac{\left(1000 \cdot minpoint - Tmin\_local_{SB_{22}}\right)}{(2005 - 2029)}$$

$required_{rate.} = -26.583$ mils per year

Appendix 19 - Sand Bed Elevation Bay 15A

October 2006 Data

The data shown below was collected on 10/18/06.

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB15A.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

$\text{Points}_7 = [\,1.18 \quad 1.129 \quad 1.136 \quad 1.129 \quad 1.146 \quad 1.077 \quad 1.049\,]$

$\text{Cells} := \text{con7vert}\left(\text{Points}_7, 7, 1\right) \quad \text{No}_{\text{DataCells}} := \text{length}(\text{Cells})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{Cells}, \text{No}_{\text{DataCells}}\right)$

The thinnest point at this location is shown below

$\text{minpoint} := \min\left(\text{Points}_7\right) \quad \text{minpoint} = 1.049$

Mean and Standard Deviation

$\mu_{actual} := \text{mean}(\text{Cells})$ $\mu_{actual} = 1.121 \cdot 10^{3}$ $\sigma_{actual} := \text{Stdev}(\text{Cells})$ $\sigma_{actual} = 43.93$

Standard Error

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

$\text{Standard}_{error} = 16.604$

Skewness

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

$\text{Skewness} = -0.628$

Kurtosis

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

$\text{Kurtosis} = -4.623 \cdot 10^{-3}$

Normal Probability Plot

In a normal plot, each data value is plotted against what its value would be if it actually came from a normal distribution. The expected normal values, called normal scores, and can be estimated by first calculating the rank scores of the sorted data.

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

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

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

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

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

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

Upper and Lower Confidence Values

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

$$No_{DataCells} := \text{length}(Cells)$$

$$\alpha := .05 \qquad T\alpha := qt\left[\left(1 - \frac{\alpha}{2}\right), No_{DataCells}\right] \quad T\alpha = 2.365$$

$$Lower_{95\%Con} := \mu_{actual} - T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Lower_{95\%Con} = 1.082 \cdot 10^3$$

$$Upper_{95\%Con} := \mu_{actual} + T\alpha \cdot \frac{\sigma_{actual}}{\sqrt{No_{DataCells}}} \qquad Upper_{95\%Con} = 1.16 \cdot 10^3$$

These values represent a range on the calculated mean in which there is 95% confidence.

Graphical Representation

Distribution of the "Cells" data points are sorted in 1/2 standard deviation increments (bins) within +/- 3 standard deviations

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

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

Distribution =

0
0
0
1
0
1
0
3
1
1
0
0
0

The mid points of the Bins are calculated

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

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

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

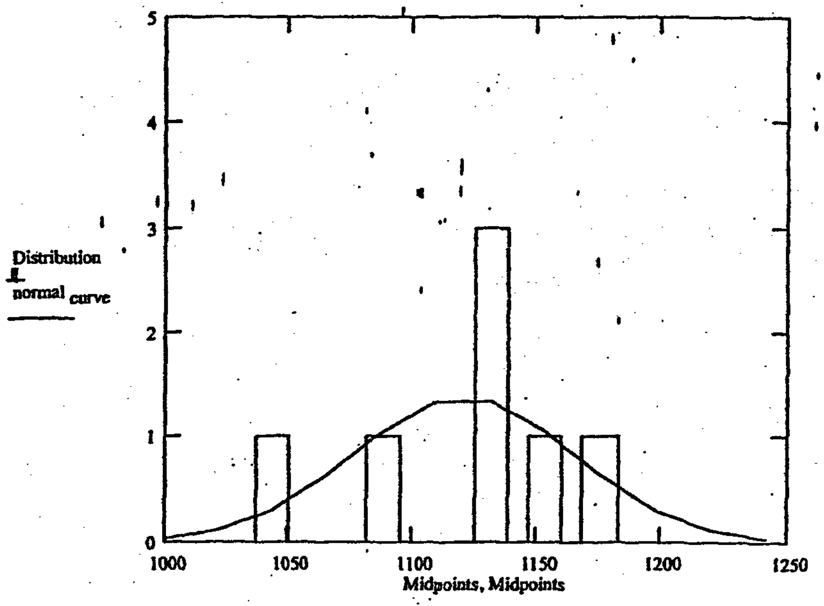
$$normal_{curve_k} := pnorm(Bins_{k+1}, \mu_{actual}, \sigma_{actual}) - pnorm(Bins_k, \mu_{actual}, \sigma_{actual})$$

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

Results For Elevation Sandbed elevation Location Oct. 2006

The following schematic shows: the the distribution of the samples, the normal curve based on the actual mean and standard deviation, the kurtosis, the skewness, the number of data points, and the the lower and upper 95% confidence values. Below is the Normal Plot for the data.

Data Distribution



$\mu_{actual} = 1.121 \cdot 10^3$

$\sigma_{actual} = 43.93$

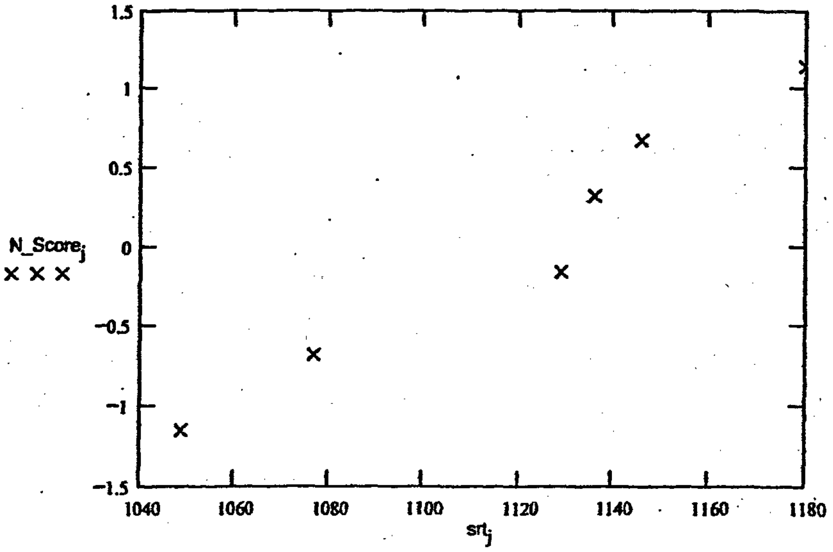
$Standard_{error} = 16.604$

$Skewness = -0.628$

$Kurtosis = -4.623 \cdot 10^{-3}$

$Lower_{95\%Con} = 1.082 \cdot 10^3$ $Upper_{95\%Con} = 1.16 \cdot 10^3$

Normal Probability Plot



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

Sandbed Location 15A Trend

$d := 0$

Data from the 1992, 1994 and 1996 (ref calcs) is retrieved Point $_{19}$.

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB15A.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\,1.139 \quad 1.145 \quad 1.166 \quad 1.162 \quad 1.136 \quad 1.102 \quad 1.083\,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{7_d} := \text{Cells}_6$

$\text{Point}_7 = 1.083 \cdot 10^3$

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

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB15A.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\,1.142 \quad 1.142 \quad 1.14 \quad 1.134 \quad 1.138 \quad 1.064 \quad 1.04\,]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$ $\text{Point}_{7_d} := \text{Cells}_6$

$$\text{Point}_7 = \begin{bmatrix} 1.083 \cdot 10^3 \\ 1.04 \cdot 10^3 \end{bmatrix}$$

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

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

For 1996

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1996 Data\sandbed\Data Only\SB15A.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 16, 1996)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.141 \quad 1.152 \quad 1.136 \quad 1.132 \quad 1.152 \quad 1.076 \quad 1.1\ ]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right) \quad \text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right) \quad \text{Point}_{7_d} := \text{Cells}_6 \quad \text{Point}_7 = \begin{bmatrix} 1.083 \cdot 10^3 \\ 1.04 \cdot 10^3 \\ 1.1 \cdot 10^3 \end{bmatrix}$

$$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \quad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \quad \text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$d := d + 1$

For 2006

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB15A.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$\text{Points}_7 = [\ 1.18 \quad 1.129 \quad 1.136 \quad 1.129 \quad 1.146 \quad 1.077 \quad 1.049\ ]$

$\text{nnn} := \text{con7vert}\left(\text{Points}_7, 7, 1\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\text{Point}_{7_d} := \text{Cells}_6$

$$\mu_{\text{measured}_d} := \text{mean}(\text{Cells}) \quad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells}) \quad \text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^3 \\ 1.995 \cdot 10^3 \\ 1.997 \cdot 10^3 \\ 2.007 \cdot 10^3 \end{bmatrix} \qquad \text{Point}_7 = \begin{bmatrix} 1.083 \cdot 10^3 \\ 1.04 \cdot 10^3 \\ 1.1 \cdot 10^3 \\ 1.049 \cdot 10^3 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.133 \cdot 10^3 \\ 1.114 \cdot 10^3 \\ 1.127 \cdot 10^3 \\ 1.121 \cdot 10^3 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 11.526 \\ 16.327 \\ 10.781 \\ 16.604 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 30.494 \\ 43.196 \\ 28.525 \\ 43.93 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}})$ $\qquad \text{Total}_{\text{means}} = 4$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SST} = 199.388$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 180.532$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 18.856$$

$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2$ $\qquad \text{DegreeFree}_{\text{reg}} := 1$ $\qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$\text{MSE} = 90.266$ $\qquad \text{MSR} = 18.856$ $\qquad \text{MST} = 66.463$

$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}}$ $\qquad \text{StGrand}_{\text{err}} = 9.501$

F Test for Corrosion

$\alpha := 0.05$

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

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.011$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$i := 0 .. Total_{means} - 1$

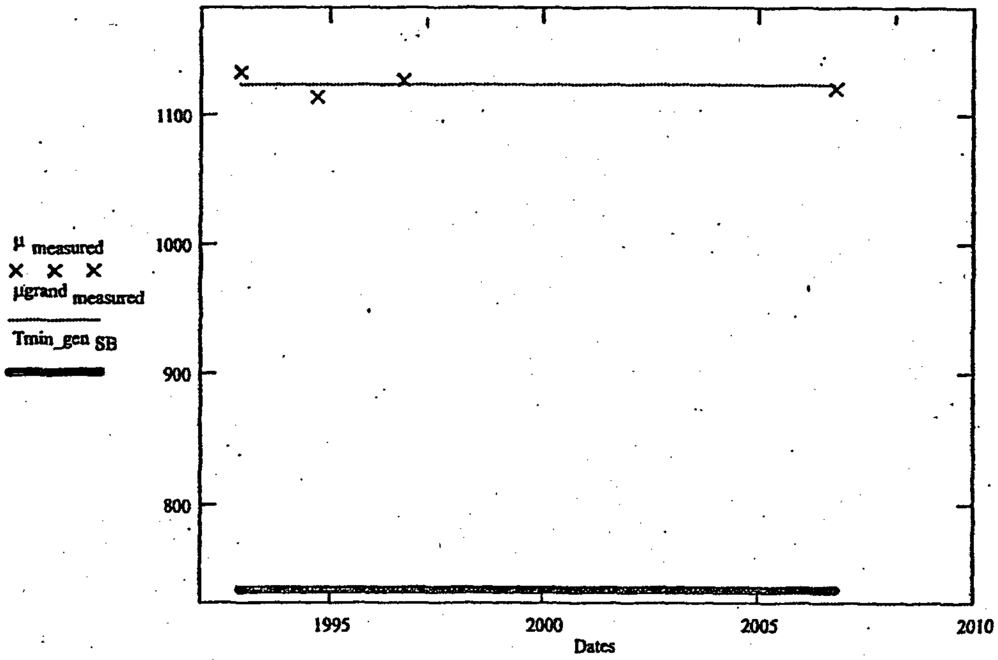
$\mu grand_{measured_i} := mean\left(\mu_{measured}\right)$

$\sigma grand_{measured} := Stdev\left(\mu_{measured}\right)$

$GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time



$\mu grand_{measured_0} = 1.124 \cdot 10^3$ $GrandStandard_{error} = 4.076$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \text{slope}\left(\text{Dates}, \mu_{\text{measured}}\right) \quad m_s = -0.404 \quad y_b := \text{intercept}\left(\text{Dates}, \mu_{\text{measured}}\right) \; y_b = 1.932 \cdot 10^3$

The 95% Confidence curves are calculated

$\alpha_t := 0.05 \quad k := 2029 - 1985 \qquad f := 0 .. k - 1$

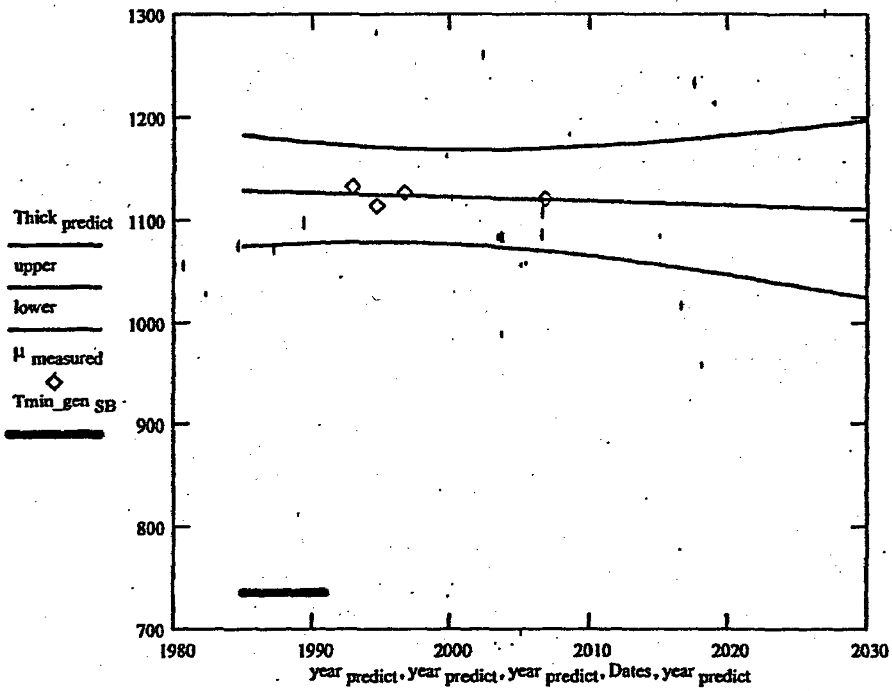
$\text{year}_{\text{predict}_f} := 1985 + f \cdot 2 \quad \text{Thick}_{\text{predict}} := m_s \cdot \text{year}_{\text{predict}} + y_b$

$\text{Thick}_{\text{actualmean}} := \text{mean}(\text{Dates}) \qquad \text{sum} := \sum_i \left(\text{Dates}_d - \text{mean}(\text{Dates})\right)^2$

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

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

Location Curve Fit Projected to Plant End Of Life



$m_s = -0.404$

Therefore even though F-ratio does not support the regression model the above curve shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

The section below calculates what the postulated mean thickness would be if this grid were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{meanthickness}} := \mu_{\text{measured}_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{meanthickness}} = 962.157$ which is greater than $\text{Tmin\_gen}_{\text{SB}_3} = 736$

The following addresses the readings at the lowest single point

$$SST_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{7_i} - mean\left(Point_7\right)\right)^2 \qquad SST_{point} = 2.394 \cdot 10^3$$

$$SSE_{point} := \sum_{i=0}^{last(Dates)} \left(Point_{7_i} - yhat\left(Dates, Point_7\right)_i\right)^2 \qquad SSE_{point} = 2.074 \cdot 10^3$$

$$SSR_{point} := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, Point_7\right)_i - mean\left(Point_7\right)\right)^2 \qquad SSR_{point} = 319.786$$

$$MSE_{point} := \frac{SSE_{point}}{DegreeFree_{ss}} \qquad MSR_{point} := \frac{SSR_{point}}{DegreeFree_{reg}} \qquad MST_{point} := \frac{SST_{point}}{DegreeFree_{st}}$$

$$MSE_{point} = 1.037 \cdot 10^3 \qquad MSR_{point} = 319.786 \qquad MST_{point} = 798$$

$$StPoint_{err} := \sqrt{MSE_{point}} \qquad StPoint_{err} = 32.204$$

F Test for Corrosion

$$F_{actaul\_Reg} := \frac{MSR_{point}}{MSE_{point}}$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 0.017$$

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

$m_{point} := \text{slope}(\text{Dates}, \text{Point}_7)$ $m_{point} = -1.666$ $y_{point} := \text{intercept}(\text{Dates}, \text{Point}_7)$ $y_{point} = 4.395 \cdot 10^3$

The 95% Confidence curves are calculated

$\text{Point}_{curve} := m_{point} \cdot \text{year}_{predict} + y_{point}$

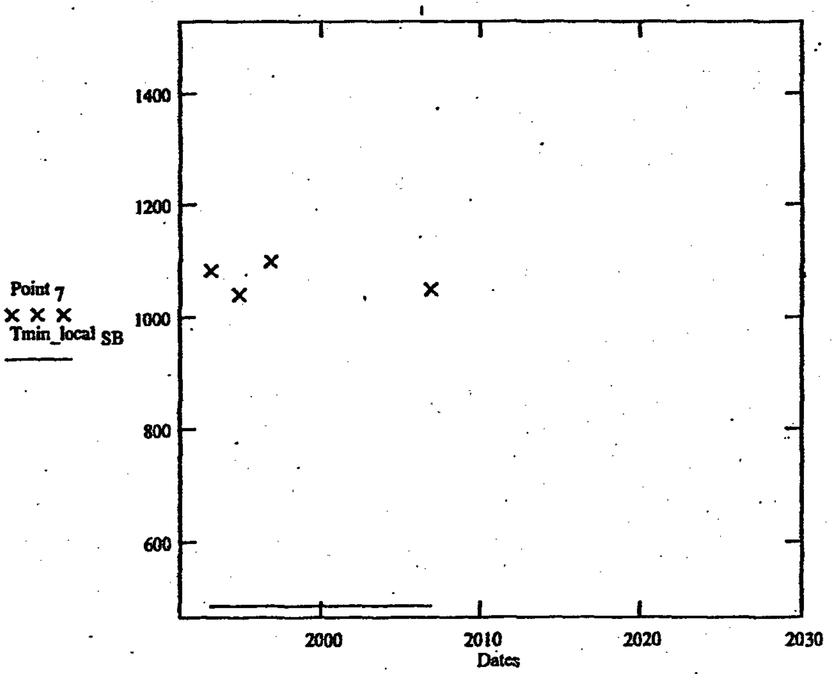
$\text{Point}_{actualmean} := \text{mean}(\text{Dates})$ $\text{sum} := \sum_i (\text{Dates}_d - \text{mean}(\text{Dates}))^2$

$$\text{uppoint}_f := \text{Point}_{curve_f} + qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year}_{predict_f} - \text{Point}_{actualmean})^2}{\text{sum}}}$$

$$\text{lopoint}_f := \text{Point}_{curve_f} + -\left[qt\left(1 - \frac{\alpha_t}{2}, \text{Total}_{means} - 2\right) \cdot \text{StPoint}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{(\text{year}_{predict_f} - \text{Point}_{actualmean})^2}{\text{sum}}}\right]$$

Local Tmin for this elevation in the Drywell $\text{Tmin\_local}_{SB_f} := 490$ (Ref. 3.25)

Curve Fit For Point 19 Projected to Plant End Of Life



$m_{point} = -1.666$

$\text{lopoint}_{22} = 730.25$ $\text{year}_{predict_{22}} = 2.029 \cdot 10^3$

The section below calculates what the postulated individual thickness would be if this point were to corrode at a minimum observable rate observed in appendix 22.

$$\text{Rate}_{\text{min\_observed}} := 6.9$$

$$\text{Postulated}_{\text{thickness}} := \text{Point}_{7_3} - \text{Rate}_{\text{min\_observed}} \cdot (2029 - 2006)$$

$\text{Postulated}_{\text{thickness}} = 890.3$ which is greater than $\text{Tmin\_local}_{\text{SB}_3} = 490$

The section below calculates what the postulated corrosion rate necessary for the thinnest individual point to reach the local required thickness by 2029.

$\text{minpoint} = 1.049$ $\text{year}_{\text{predict}_{22}} = 2.029 \cdot 10^3$ $\text{Tmin\_local}_{\text{SB}_{22}} = 490$

$$\text{required}_{\text{rate.}} := \frac{\left(1000 \cdot \text{minpoint} - \text{Tmin\_local}_{\text{SB}_{22}}\right)}{(2005 - 2029)}$$

$\text{required}_{\text{rate.}} = -23.292$ mils per year

Bays	Number of Points Specified	Data Reviewd No further action	Data under Review	IR	Data Point Sat	Comments
1	23	23	0		23	
3	8	8	0		8	
5	8	8	0		8	
7	7	5	0		5	
9	10	10	0		10	
11	8	8	0		8	
13	19	15	0		15	
15	11	10	0		10	
17	11	10	0		10	
19	10	9	0		9	
Total	115	106			106	

Highest rate	**0.0335**
Thinnest reading	**0.602**
Projected thickness in 2008 based on the above corrosion rate and a 20 uncertainly	**0.515**

BAY 1

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data Sheet	2006 Value	Delta	Sat	Non Sat
1	Yes	D16	R30	Yes			0.72	0.598	1R21LR-022	0.71	0.010	Yes	
2	Yes	D22	R17	Yes			0.716	0.598	1R21LR-022	0.69	0.026	Yes	
3	Yes	D23	L3	Yes			0.705	0.598	1R21LR-022	0.665	0.040	Yes	
4		D24	L33	Yes			0.76	0.598	1R21LR-022	0.738	0.022	Yes	
5	Yes	D24	L45	Yes			0.71	0.598	1R21LR-022	0.68	0.030	Yes	
6		D48	R16	Yes	Yes	Yes	0.76	0.598	1R21LR-022	0.731	0.029	Yes	
7	Yes	D39	R5	Yes	Yes	Yes	0.7	0.598	1R21LR-022	0.669	0.031	Yes	
8		D48	R0	Yes	Yes	Yes	0.805	0.598	1R21LR-022	0.783	0.022	Yes	
9		D36	L38	Yes	Yes		0.805	0.598	1R21LR-022	0.754	0.051	Yes	
10		D16	R23	Yes			0.839	0.598	1R21LR-022	0.824	0.015	Yes	
11	Yes	D23	R12				0.714	0.598	1R21LR-022	0.711	0.003	Yes	
12	Yes	D24	L5				0.724	0.598	1R21LR-022	0.722	0.002	Yes	
13		D24	L40				0.792	0.598	1R21LR-022	0.719	0.073	Yes	
14		D2	R35				1.147	0.598	1R21LR-022	1.157	-0.010	Yes	
15		D8	L51				1.156	0.598	1R21LR-022	1.16	-0.004	Yes	
16		D50	R40	Yes	Yes	Yes	0.796	0.598	1R21LR-022	0.795	0.001	Yes	
17		D48	R16	Yes	Yes	Yes	0.86	0.598	1R21LR-022	0.846	0.014	Yes	
18		D38	L2	Yes	Yes		0.917	0.598	1R21LR-022	0.899	0.018	Yes	
19		D38	L24	Yes	Yes		0.89	0.598	1R21LR-022	0.865	0.025	Yes	
20		D18	R13				0.965	0.598	1R21LR-022	0.912	0.053	Yes	
21	Yes	D24	R15				0.726	0.598	1R21LR-022	0.712	0.014	Yes	
22		D32	R13	Yes	Yes		0.852	0.598	1R21LR-022	0.854	-0.002	Yes	
23		D48	R15	Yes	Yes	Yes	0.85	0.598	1R21LR-022	0.828	0.022	Yes	

Data obtained from
NDE Data Sheets 92-072-12 page 1 of 1
NDE Data Sheets 92-072-18 page 1 of 1
NDE Data Sheets 92-072-19 page 1 of 1

	0.021
Max Delta	0.073
Rate	0.005
Min 2006 Thickness Value	0.665

BAY 3

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data sheet	2006 Value	Delta	Sat	Non Sat
1		D5	R63				0.795	0.598	92-072-14 page 1 of 1	0.795	0.000	Yes	
2		D9	R50				1	0.598	92-072-14 page 1 of 1	0.999	0.001	Yes	
3		D9	R33				0.857	0.598	92-072-14 page 1 of 1	0.85	0.007	Yes	
4		D13	L5				0.898	0.598	92-072-14 page 1 of 1	0.903	-0.005	Yes	
5		D15	L8	Yes			0.823	0.598	92-072-14 page 1 of 1	0.819	0.004	Yes	
6		D15	L56	Yes			0.968	0.598	92-072-14 page 1 of 1	0.972	-0.004	Yes	
7		D17	R4 *1	Yes			0.826	0.598	92-072-14 page 1 of 1	0.816	0.010	Yes	
8		D24	L6 *1	Yes			0.78	0.598	92-072-14 page 1 of 1	0.764	0.016	Yes	
											0.004		
										Max Delta	0.016		
										Rate	0.000		
									Min 2006 Thickness Value		0.764		

Data obtained from
NDE Data Sheets 92-072-14 page 1 of 1
*1 - estimated from data sheet 92-072 page 6 of 9

BAY 5

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data sheet	2006 Value	Delta	Sat	Non Sat
1		D40	R13 *1	Yes	Yes	Yes	0.97	0.598	1R21LR-019	0.948	0.022	Yes	
2		D42	R3 *1	Yes	Yes	Yes	1.04	0.598	1R21LR-019	0.955	0.085	Yes	
3		D44	R10 *1	Yes	Yes	Yes	1.02	0.598	1R21LR-019	0.989	0.031	Yes	
4		D44	R/L7 *1 *2	Yes	Yes	Yes	0.97	0.598	1R21LR-019	0.948	0.022	Yes	
5		D46	R/L11 *1 *2	Yes	Yes	Yes	0.89	0.598	1R21LR-019	0.88	0.010	Yes	
6		D44	L4	Yes	Yes	Yes	1.06	0.598	1R21LR-019	0.981	0.079	Yes	
7		D48	L24	Yes	Yes	Yes	0.99	0.598	1R21LR-019	0.974	0.016	Yes	
8		D46	L28	Yes	Yes	Yes	1.01	0.598	1R21LR-019	1.007	0.003	Yes	
											0.034		

Max Delta	0.085
Rate	0.006
Min 2006 Thickness Value	0.88

Data obtained from
NDE Data Sheets 92-072-16 page 1 of 1

*1 - Reference off the weld 62" to the right of the centerline of the bay.
*2 The original data sheet is not clear as to whether this point is to the right or left of the weld.
Therefore NDE shall verify this dimension.

BAY 7

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data sheet	2006 Value	Delta	Sat	Non Sat
1		D21	R39	Yes			0.92	0.598	92-072-20 Page 1 fo 1	Not Located			
2		D21	R32	Yes			1.016	0.598	92-072-20 Page 1 fo 2	Not Located			
3		D10	R20				0.984	0.598	92-072-20 Page 1 fo 3	0.964	0.020	Yes	
4		D10	R10				1.04	0.598	92-072-20 Page 1 fo 4	1.04	0.000	Yes	
5		D21	L6	Yes			1.03	0.598	92-072-20 Page 1 fo 5	1.003	0.027	Yes	
6		D10	L23	Yes			1.045	0.598	92-072-20 Page 1 fo 6	1.023	0.022	Yes	
7		D21	L12				1	0.598	92-072-20 Page 1 fo 7	1.003	-0.003	Yes	
											0.013		
										Max Delta	0.027		
										Rate	0.00193		
									Min 2006 Thickness Value		0.964		

Data obtained from
NDE Data Sheets 92-072-20 page 1 of 1

BAY 9

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data sheet	2006 Value	Delta	Sat	Non Sat
1		D21	R32	Yes			0.96	0.598	92-072-22 Page 1 fo 1	0.968	-0.008	Yes	
2		D12	R17				0.94	0.598	92-072-22 Page 1 fo 2	0.934	0.006	Yes	
3		D18	R8	Yes			0.994	0.598	92-072-22 Page 1 fo 3	0.989	0.005	Yes	
4		D21	R17	Yes			1.02	0.598	92-072-22 Page 1 fo 4	1.016	0.004	Yes	
5		D36	L4	Yes	Yes		0.985	0.598	92-072-22 Page 1 fo 5	0.964	0.021	Yes	
6		D16	L30	Yes			0.82	0.598	92-072-22 Page 1 fo 6	0.802	0.018	Yes	
7		D18	L35*	Yes			0.825	0.598	92-072-22 Page 1 fo 7	0.82	0.005	Yes	
8		D22	L45*	Yes	Yes	Yes	0.791	0.598	92-072-22 Page 1 fo 8	0.781	0.010	Yes	
9		D15	L53				0.832	0.598	92-072-22 Page 1 fo 9	0.823	0.009	Yes	
10		D32	L8	Yes			0.98	0.598	92-072-22 Page 1 fo 1(	0.955	0.025	Yes	
											0.009		

Data obtained from
NDE Data Sheets 92-072-22 page 1 of 1

* estimated from data sheet 92-072-09 page 1 of 1

Max Delta	0.025
Rate	0.00179
Min 2006 Thickness Value	0.781

BAY 11

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data sheet	2006 Value	Delta	Sat	Non Sat
1	Yes	D20	R29	Yes			0.705	0.598	92-072-10 page 1 of 1	0.7	0.005	Yes	
2		D25	R32	Yes			0.77	0.598	92-072-10 page 1 of 1	0.76	0.010	Yes	
3		D21	L4	Yes			0.832	0.598	92-072-10 page 1 of 2	0.83	0.002	Yes	
4		D24	L6	Yes			0.755	0.598	92-072-10 page 1 of 3	0.751	0.004	Yes	
5		D32	L14	Yes	Yes		0.831	0.598	92-072-10 page 1 of 4	0.823	0.008	Yes	
6		D27	L22	Yes	Yes		0.8	0.598	92-072-10 page 1 of 5	0.756	0.044	Yes	
7		D31	R20	Yes	Yes		0.831	0.598	92-072-10 page 1 of 6	0.817	0.014	Yes	
8		D40	R13	Yes	Yes	Yes	0.85	0.598	92-072-10 page 1 of 7	0.825	0.025	Yes	
											0.014		

Data obtained from
NDE Data Sheets 92-072-10 page 1 of 1

Max Delta 0.044

Rate 0.00314.

Min 2006 Thickness Value 0.7

BAY 13

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data sheet	2006 Value	Delta	Sat	Non Sat
1	Yes	U1	R45				0.672	0.598	92-072-24 page 1 of 2	Not Located			
2	Yes	U1	R38				0.729	0.598	92-072-24 page 1 of 3	Not Located			
3		D21	R48	Yes			0.941	0.598	92-072-24 page 1 of 4	0.923	0.018	Yes	
4		D12	R36	Yes			0.915	0.598	92-072-24 page 1 of 5	0.873	0.042	Yes	
5	Yes	D21	R6	Yes			0.718	0.598	92-072-24 page 1 of 6	0.708	0.010	Yes	
6	Yes	D24	L8	Yes			0.655	0.598	92-072-24 page 1 of 7	0.658	-0.003	Yes	
7	Yes	D17	L23	Yes			0.618	0.598	92-072-24 page 1 of 8	0.602	0.016	Yes	
8	Yes	D24	L20	Yes			0.718	0.598	92-072-24 page 1 of 9	0.704	0.014	Yes	
9		D28	R41	Yes	Yes		0.924	0.598	92-072-24 page 1 of 10	0.915	0.009	Yes	
10	Yes	D28	R12	Yes	Yes		0.728	0.598	92-072-24 page 1 of 11	0.741	-0.013	Yes	
11	Yes	D28	L15	Yes	Yes		0.685	0.598	92-072-24 page 1 of 12	0.669	0.016	Yes	
12		D28	L23				0.885	0.598	92-072-24 page 1 of 13	0.886	-0.001	Yes	
13		D18	D40				0.932	0.598	92-072-24 page 1 of 14	0.814	0.118	Yes	
14		D18	R8				0.868	0.598	92-072-24 page 1 of 15	0.87	-0.002	Yes	
15	Yes	D20	L9				0.683	0.598	92-072-24 page 1 of 16	0.666	0.017	Yes	
16		D20	L29				0.829	0.598	92-072-24 page 1 of 17	0.814	0.015	Yes	
17		D9	R38				0.807	0.598	92-072-24 page 1 of 18	Not Locate			
18		D22	R38				0.825	0.598	92-072-24 page 1 of 19	Not Locate			
19		D37	R38	Yes			0.912	0.598	92-072-24 page 1 of 20	0.916	-0.004	Yes	
											0.017		
										Max Delta	0.118		
										Rate	0.00843		
									Min 2006 Thickness Value		0.602		

Data obtained from
NDE Data Sheets 92-072-24 page 1 of 2

BAY 15

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data Sheet	2006 Value	Delta	Sat	Non Sat
1		D12	R26				0.786	0.598	1R21LR-015	0.779	0.007	Yes	
2		D22	R24	Yes			0.829	0.598	1R21LR-015	0.798	0.031	Yes	
3		D33	R17	Yes	Yes		0.932	0.598	1R21LR-015	0.935	-0.003	Yes	
4		D33	R7	Yes			0.795	0.598	1R21LR-015	0.791	0.004	Yes	
5		D26	L3	Yes	Yes		0.85	0.598	1R21LR-015	0.855	-0.005	Yes	
6		D6	L8				0.794	0.598	1R21LR-015	0.787	0.007	Yes	
7		D24	L17	Yes			0.808	0.598	1R21LR-015	0.805	0.003	Yes	
8		D24	L36	Yes			0.77	0.598	1R21LR-015	0.76	0.010	Yes	
9	Yes	D36	L40	Yes	Yes		0.722	0.598	1R21LR-015	0.749	-0.027	Yes	
10		D24	L48	Yes			0.86	0.598	1R21LR-015	0.852	0.008	Yes	
11		D24	L65	Yes			0.825	0.598	1R21LR-015	0.843	-0.018	Yes	
											0.002		

Max Delta	0.031
Rate	0.00221
Min 2006 Thickness Value	0.749

Data obtained from
NDE Data Sheets 92-072-21 page 1 of 1

BAY 17

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data sheet	2006 Value	Delta	Sat	Non Sat
1		D30	R52	Yes			0.916	0.598	1R21LR-021	0.909	0.007	Yes	
2		D12	R42				1.15	0.598	1R21LR-021	0.681	0.469	Yes	
3		D32	R28	Yes	Yes		0.898	0.598	1R21LR-021	0.894	0.004	Yes	
4		D52	R30	Yes	Yes	Yes	0.951	0.598	1R21LR-021	0.963	-0.012	Yes	
5		D36	R12	Yes	Yes		0.913	0.598	1R21LR-021	0.822	0.091	Yes	
6		D52	L6	Yes	Yes	Yes	0.992	0.598	1R21LR-021	0.909	0.083	Yes	
7		D36	L26	Yes	Yes		0.97	0.598	1R21LR-021	0.97	0.000	Yes	
8		D52	L40	Yes	Yes	Yes	0.99	0.598	1R21LR-021	0.96	0.030	Yes	
9	Yes	D27	R30	Yes			0.72	0.598	1R21LR-021	0.97	-0.250	Yes	
10		D26	R11	Yes			0.83	0.598	1R21LR-021	0.844	-0.014	Yes	
11		D21	R12	Yes			0.76	0.598	1R21LR-021	Not Located			
											0.041		
										Max Delta	0.469		
										Rate	0.03350		
									Min 2006 Thickness Value		0.681		

Data obtained from
NDE Data Sheets 92-072-08 page 1 of 1

BAY 19

Point	Less than 0.736 in 1992	Vertical	Horizontal	Under Inside Concrete	Under Inside Floor	Under Wetted Concrete	1992 value	Criteria	NDE Data sheet	2006 Value	Delta	Sat	Non Sat
1		D30	R70	Yes			0.932	0.598	1R21LR-020	0.904	0.028	Yes	
2		D52	R66	Yes	Yes	Yes	0.924	0.598	1R21LR-020	0.921	0.003	Yes	
3		D33	R49	Yes	Yes		0.955	0.598	1R21LR-020	0.932	0.023	Yes	
4		D32	R11	Yes	Yes		0.94	0.598	1R21LR-020	Not Located			
5		D53	R2	Yes	Yes	Yes	0.95	0.598	1R21LR-020	0.932	0.018	Yes	
6		D52	L65	Yes	Yes	Yes	0.86	0.598	1R21LR-020	Not Located			
7		D39	L12	Yes	Yes	Yes	0.969	0.598	1R21LR-020	0.891	0.078	Yes	
8		D16	R63	Yes			0.793	0.598	1R21LR-020	0.745		Yes	
9		D18	R12	Yes			0.776	0.598	1R21LR-020	0.78	-0.004	Yes	
10		D19	R0	Yes			0.79	0.598	1R21LR-020	0.791	-0.001	Yes	
11		D20	L18				N/A	0.598	1R21LR-020	0.738		Yes	
											0.021		

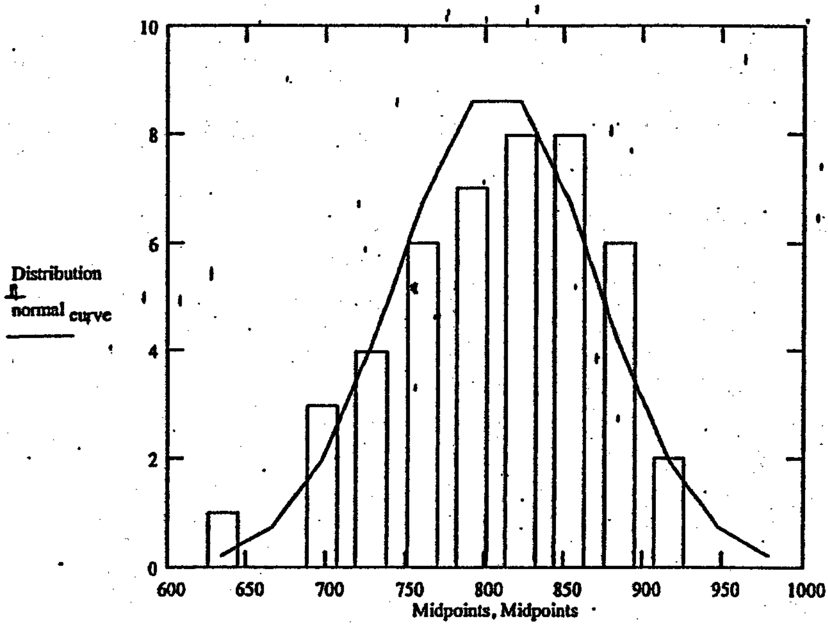
Data obtained from
NDE Data Sheets 92-072-05 page 1 of 1
NDE Data Sheets 92-072-07 page 1 of 1

Max Delta 0.078

Rate 0.00557

Min 2006 Thickness Value 0.738

Internal Grid 19A 2006 Data Distribution



$\mu_{actual} = 806.578$

$\sigma_{actual} = 62.384$

$Standard_{error_0} = 8.366$

Skewness = −0.377

Kurtosis = −0.572

Assuming a normal distribution shown above over the the entire population, the percentage of the population with a local area less than 0.648 inches is estimated below.

$100 \cdot pnorm(648, \mu_{actual}, \sigma_{actual}) = 0.5511$ Percent

Assuming a normal distribution shown above over the the entire population, the percentage of the population with a local area less than 0.602 inches is estimated below.

$100 \cdot pnorm(602, \mu_{actual}, \sigma_{actual}) = 0.052026$ Percent

Assuming a normal distribution shown above over the the entire population, the percentage of the population with a local area less than 0.490 inches is estimated below.

$100 \cdot pnorm(490, \mu_{actual}, \sigma_{actual}) = 1.940824 \cdot 10^{-5}$ Percent

Appendix 21 - Location 11C Sensitivity Study without 1996 data

The data shown below was collected on 10/18/06

Sandbed 11C

$d := 0$

For Dec 31 1992

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\DATA ONLY\SB11C.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 31, 1992)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.941 & 0.839 & 0.806 & 0.917 & 0.776 & 0.86 & 0.926 \\ 1.105 & 1.044 & 0.997 & 0.975 & 1.076 & 1.12 & 1.045 \\ 1.091 & 1.175 & 1.018 & 0.942 & 0.94 & 0.874 & 0.896 \\ 0.847 & 0.845 & 0.794 & 0.833 & 0.838 & 0.838 & 0.87 \\ 0.845 & 0.829 & 0.863 & 0.87 & 0.85 & 0.85 & 0.827 \\ 0.941 & 0.817 & 0.858 & 0.839 & 0.876 & 0.879 & 0.854 \\ 0.603 & 0.893 & 0.905 & 0.901 & 0.913 & 0.877 & 0.845 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 43)$

The thinnest point is captured

$\text{Point}_{5_d} := \text{nnn}_4$

$\text{Point}_5 = 776$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{Cells})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$

$\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\mu_{\text{measured}} = 908.83$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$

$\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\DATA ONLY\SB11C.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 26, 1994)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0.855 & 0.866 \\ 0 & 0 & 1.042 & 1.095 & 1.036 & 1.093 & 1.032 \\ 1.042 & 1.085 & 0.945 & 0.938 & 0.938 & 0.895 & 0.889 \\ 0.836 & 0.846 & 0.795 & 0.828 & 0.833 & 0.843 & 0.869 \\ 0.823 & 0.842 & 0.873 & 0.872 & 0.837 & 0.822 & 0.879 \\ 0.855 & 0.836 & 0.862 & 0.824 & 0.872 & 0.857 & 0.823 \\ 0.86 & 0.874 & 0.899 & 0.876 & 0.88 & 0.84 & 0.851 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

The thinnest point is captured

$\text{Point}_{5_d} := \text{nnn}_4$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$

$\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$

$\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$$

For 2006

$d := d + 1$

$\text{page} := \text{READPRN}(\text{"U:\textbackslash MSOFFICE\textbackslash Drywell Program data\textbackslash Oct 2006 Data\textbackslash Sandbed\textbackslash SB11C.txt"})$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 18, 2006)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0 & 0.771 & 0.803 & 0.912 & 0.767 & 0.858 & 0.886 \\ 1.056 & 1.046 & 0.984 & 1.094 & 1.036 & 1.118 & 1.029 \\ 1.073 & 1.113 & 1.002 & 0.935 & 0.942 & 0.888 & 0.853 \\ 0.837 & 0.836 & 0.79 & 0.874 & 0.834 & 0.846 & 0.838 \\ 0.85 & 0.825 & 0.869 & 0.889 & 0.833 & 0.866 & 0.875 \\ 0.856 & 0.84 & 0.864 & 0.829 & 0.872 & 0.876 & 0.844 \\ 0.861 & 0.877 & 0.879 & 0.885 & 0.88 & 0.849 & 0.876 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

The thinnest point is captured

$\text{Point}_{5_d} := \text{nnn}_4$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$

$\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$

$\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$$

Below are the results

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^{3} \\ 1.995 \cdot 10^{3} \\ 2.007 \cdot 10^{3} \end{bmatrix} \qquad \text{Point}_5 = \begin{bmatrix} 776 \\ 0 \\ 767 \end{bmatrix}$$

$$\text{Standard}_{\text{error}} = \begin{bmatrix} 13.414 \\ 11.742 \\ 12.843 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 908.83 \\ 894.238 \\ 898.25 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 93.897 \\ 82.191 \\ 89.898 \end{bmatrix}$$

$$\mu\text{high}_{\text{measured}} = \begin{bmatrix} 969.667 \\ 982.214 \\ 958.3 \end{bmatrix} \qquad \sigma\text{high}_{\text{measured}} = \begin{bmatrix} 109.211 \\ 87.424 \\ 112.838 \end{bmatrix} \qquad \text{Standardhigh}_{\text{error}} = \begin{bmatrix} 23.832 \\ 23.365 \\ 24.623 \end{bmatrix}$$

$$\mu\text{low}_{\text{measured}} = \begin{bmatrix} 859.692 \\ 850.25 \\ 855.357 \end{bmatrix} \qquad \sigma\text{low}_{\text{measured}} = \begin{bmatrix} 32.576 \\ 23.629 \\ 23.008 \end{bmatrix} \qquad \text{Standardlow}_{\text{error}} = \begin{bmatrix} 6.389 \\ 4.466 \\ 4.348 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}})$ $\text{Total}_{\text{means}} = 3$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2$$

$$\text{SST}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{mean}(\mu\text{low}_{\text{measured}})\right)^2$$

$$\text{SST}_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{mean}(\mu\text{high}_{\text{measured}})\right)^2$$

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

$$\text{SSE}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu\text{low}_{\text{measured}})_i\right)^2$$

$$\text{SSE}_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu\text{high}_{\text{measured}})_i\right)^2$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2$$

$$\text{SSR}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu\text{low}_{\text{measured}})_i - \text{mean}(\mu\text{low}_{\text{measured}})\right)^2$$

$$\text{SSR}_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu\text{high}_{\text{measured}})_i - \text{mean}(\mu\text{high}_{\text{measured}})\right)^2$$

$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2$ $\text{DegreeFree}_{\text{reg}} := 1$ $\text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$

$$MSE := \frac{SSE}{DegreeFree_{ss}} \qquad MSE_{low} := \frac{SSE_{low}}{DegreeFree_{ss}} \qquad MSE_{high} := \frac{SSE_{high}}{DegreeFree_{ss}}$$

$$Standard_{error} := \sqrt{MSE} \qquad Standard_{lowerror} := \sqrt{MSE_{low}} \qquad Standard_{higherror} := \sqrt{MSE_{high}}$$

$$MSR := \frac{SSR}{DegreeFree_{reg}} \qquad MSR_{low} := \frac{SSR_{low}}{DegreeFree_{reg}} \qquad MSR_{high} := \frac{SSR_{high}}{DegreeFree_{reg}}$$

$$MST := \frac{SST}{DegreeFree_{st}} \qquad MST_{low} := \frac{SST_{low}}{DegreeFree_{st}} \qquad MST_{high} := \frac{SST_{high}}{DegreeFree_{st}}$$

Test the means with all points

F Test for Corrosion

$\alpha := 0.05$

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

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 9.322 \cdot 10^{-4}$$

Test the low points

F Test for Corrosion

$$F_{actaul\_Reg.low} := \frac{MSR_{low}}{MSE_{low}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.low} := \frac{F_{actaul\_Reg.low}}{F_{critical\_reg}}$$

$$F_{ratio\_reg.low} = 2.929 \cdot 10^{-5}$$

Test the high points

F Test for Corrosion

$$F_{actaul\_Reg.high} := \frac{MSR_{high}}{MSE_{high}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.high} := \frac{F_{actaul\_Reg.high}}{F_{critical\_reg}}$$

$$F_{ratio\_reg.high} = 9.952 \cdot 10^{-3}$$

Appendix 21 - Location 13D Sensitivity Study without 1996 data
The data shown below was collected on 10/18/06

Sandbed 13D

Data from . 1992 to 2006 is retrieved. $d := 0$

For Dec 31 1992

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\DATA ONLY\SB13C-D.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(12, 31, 1992)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.064 & 1.117 & 1.134 & 1.103 & 1.105 & 1.106 & 1.117 \\ 0.949 & 1.081 & 1 & 1.054 & 1.151 & 1.118 & 1.121 \\ 0.984 & 0.948 & 0.868 & 0.834 & 0.979 & 1.048 & 1.067 \\ 0.963 & 0.98 & 0.893 & 0.855 & 0.913 & 0.981 & 1.012 \\ 0.957 & 0.958 & 0.869 & 0.879 & 0.917 & 0.913 & 0.911 \\ 0.963 & 0.948 & 0.895 & 0.88 & 0.915 & 0.862 & 0.905 \\ 1.016 & 0.918 & 0.927 & 0.92 & 0.918 & 0.825 & 0.824 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{Point}_{49_d} := \text{nnn}_{48}$ $\text{Point}_{49} = 824$

The two groups are named as follows: $\text{Botstar} := 28$ $\text{Stoptop} := 16$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{DataCells}}, \text{Botstar})$ $\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{DataCells}}, \text{Stoptop})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 19, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 20, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 21, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 22, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 27, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$\text{high}_{\text{points}} := \text{Add}(\text{nnn}, \text{No}_{\text{DataCells}}, 28, \text{length}(\text{high}_{\text{points}}), \text{high}_{\text{points}})$

$$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 17, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$$

$$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 18, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$$

$$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 23, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$$

$$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 24, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$$

$$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 25, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$$

$$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 26, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$$

$$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{Cells}}\right)$$

$$\mathrm{high}_{\mathrm{points}} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{high}_{\mathrm{points}}, \mathrm{length}\left(\mathrm{high}_{\mathrm{points}}\right)\right)$$

$$\mathrm{low}_{\mathrm{points}} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{low}_{\mathrm{points}}, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right)\right)$$

$$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells}) \qquad \sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells}) \qquad \mathrm{Standard}_{\mathrm{error}_d} := \frac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$$

$$\mu\mathrm{high}_{\mathrm{measured}_d} := \mathrm{mean}\left(\mathrm{high}_{\mathrm{points}}\right) \qquad \mu\mathrm{low}_{\mathrm{measured}_d} := \mathrm{mean}\left(\mathrm{low}_{\mathrm{points}}\right)$$

$$\sigma\mathrm{high}_{\mathrm{measured}_d} := \mathrm{Stdev}\left(\mathrm{high}_{\mathrm{points}}\right) \qquad \sigma\mathrm{low}_{\mathrm{measured}_d} := \mathrm{Stdev}\left(\mathrm{low}_{\mathrm{points}}\right)$$

$$\mathrm{Standardhigh}_{\mathrm{error}_d} := \frac{\sigma\mathrm{high}_{\mathrm{measured}_d}}{\sqrt{\mathrm{length}\left(\mathrm{high}_{\mathrm{points}}\right)}} \qquad \mathrm{Standardlow}_{\mathrm{error}_d} := \frac{\sigma\mathrm{low}_{\mathrm{measured}_d}}{\sqrt{\mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right)}}$$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\DATA ONLY\SB13C-D.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 26, 1994)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.1 & 1.114 & 1.11 & 1.078 & 1.062 & 1.103 & 1.113 \\ 0.944 & 1.075 & 0.995 & 1.015 & 1.003 & 1.112 & 1.125 \\ 0.977 & 0.941 & 0.834 & 0.827 & 0.992 & 1.033 & 1.028 \\ 0.943 & 0.973 & 0.879 & 0.847 & 0.915 & 0.974 & 0.986 \\ 0.951 & 0.911 & 0.871 & 0.873 & 0.923 & 0.903 & 0.889 \\ 0.938 & 0.942 & 0.894 & 0.875 & 0.915 & 0.859 & 0.877 \\ 0.956 & 0.911 & 0.922 & 0.924 & 0.918 & 0.825 & 0.811 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{49_d} := \text{nnn}_{48}$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

The two groups are named as follows: $\text{Botstar} := 28$ $\text{Stoptop} := 16$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{nnn}, \text{No}_{\text{DataCells}}, \text{Botstar}\right)$

$\text{high}_{\text{points}} := \text{TOPROWS}\left(\text{nnn}, \text{No}_{\text{DataCells}}, \text{Stoptop}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 19, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 20, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 21, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 22, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 27, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 28, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$low_{points} := Add(nnn, No_{DataCells}, 17, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 18, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 23, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 24, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 25, length(low_{points}), low_{points})$

$low_{points} := Add(nnn, No_{DataCells}, 26, length(low_{points}), low_{points})$

$Cells := deletezero_{cells}(nnn, No_{Cells})$

$high_{points} := deletezero_{cells}(high_{points}, length(high_{points}))$

$low_{points} := deletezero_{cells}(low_{points}, length(low_{points}))$

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$\mu high_{measured_d} := mean(high_{points})$ $\mu low_{measured_d} := mean(low_{points})$

$\sigma high_{measured_d} := Stdev(high_{points})$ $\sigma low_{measured_d} := Stdev(low_{points})$

$Standardhigh_{error_d} := \frac{\sigma high_{measured_d}}{\sqrt{length(high_{points})}}$ $Standardlow_{error_d} := \frac{\sigma low_{measured_d}}{\sqrt{length(low_{points})}}$

For 2006 $d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB13C-D.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(9, 23, 2006)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.114 & 1.117 & 1.132 & 1.083 & 1.068 & 1.106 & 1.119 \\ 0.95 & 1.041 & 0.999 & 1.061 & 1.007 & 1.117 & 1.1 \\ 0.986 & 0.95 & 0.837 & 0.833 & 0.949 & 1.088 & 1.085 \\ 1.005 & 0.977 & 0.878 & 0.851 & 0.911 & 0.958 & 0.997 \\ 0.96 & 0.907 & 0.874 & 0.874 & 0.915 & 0.916 & 0.905 \\ 0.944 & 0.947 & 0.897 & 0.887 & 0.92 & 0.865 & 0.892 \\ 0.996 & 0.939 & 0.929 & 0.958 & 0.944 & 0.832 & 0.821 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{49_d} := \text{nnn}_{48}$

The two groups are named as follows: $\text{Botstar} := 28$ $\text{Stoptop} := 16$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{nnn}, \text{No}_{\text{DataCells}}, \text{Botstar}\right)$ $\text{high}_{\text{points}} := \text{TOPROWS}\left(\text{nnn}, \text{No}_{\text{DataCells}}, \text{Stoptop}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 19, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 20, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 21, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 22, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 27, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{high}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 28, \text{length}\left(\text{high}_{\text{points}}\right), \text{high}_{\text{points}}\right)$

$\text{low}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 17, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$

$\text{low}_{\text{points}} := \text{Add}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 18, \text{length}\left(\text{low}_{\text{points}}\right), \text{low}_{\text{points}}\right)$

$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 23, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$

$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 24, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$

$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 25, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$

$\mathrm{low}_{\mathrm{points}} := \mathrm{Add}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 26, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right), \mathrm{low}_{\mathrm{points}}\right)$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{Cells}}\right)$

$\mathrm{high}_{\mathrm{points}} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{high}_{\mathrm{points}}, \mathrm{length}\left(\mathrm{high}_{\mathrm{points}}\right)\right)$

$\mathrm{low}_{\mathrm{points}} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{low}_{\mathrm{points}}, \mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right)\right)$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$ $\mathrm{Standard}_{\mathrm{error}_d} := \dfrac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$

$\mu\mathrm{high}_{\mathrm{measured}_d} := \mathrm{mean}\left(\mathrm{high}_{\mathrm{points}}\right)$ $\mu\mathrm{low}_{\mathrm{measured}_d} := \mathrm{mean}\left(\mathrm{low}_{\mathrm{points}}\right)$

$\sigma\mathrm{high}_{\mathrm{measured}_d} := \mathrm{Stdev}\left(\mathrm{high}_{\mathrm{points}}\right)$ $\sigma\mathrm{low}_{\mathrm{measured}_d} := \mathrm{Stdev}\left(\mathrm{low}_{\mathrm{points}}\right)$

$\mathrm{Standardhigh}_{\mathrm{error}_d} := \dfrac{\sigma\mathrm{high}_{\mathrm{measured}_d}}{\sqrt{\mathrm{length}\left(\mathrm{high}_{\mathrm{points}}\right)}}$ $\mathrm{Standardlow}_{\mathrm{error}_d} := \dfrac{\sigma\mathrm{low}_{\mathrm{measured}_d}}{\sqrt{\mathrm{length}\left(\mathrm{low}_{\mathrm{points}}\right)}}$

Below are the results

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^3 \\ 1.995 \cdot 10^3 \\ 2.007 \cdot 10^3 \end{bmatrix} \qquad \text{Point}_{49} = \begin{bmatrix} 824 \\ 811 \\ 821 \end{bmatrix}$$

$$\text{Standard}_{\text{error}} = \begin{bmatrix} 13.307 \\ 12.681 \\ 12.877 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 972.755 \\ 958.898 \\ 968.184 \end{bmatrix}$$

$$\sigma_{\text{measured}} = \begin{bmatrix} 93.149 \\ 88.766 \\ 90.136 \end{bmatrix}$$

$$\mu\text{high}_{\text{measured}} = \begin{bmatrix} 1.055 \cdot 10^3 \\ 1.037 \cdot 10^3 \\ 1.047 \cdot 10^3 \end{bmatrix} \qquad \sigma\text{high}_{\text{measured}} = \begin{bmatrix} 66.239 \\ 63.573 \\ 64.111 \end{bmatrix} \qquad \text{Standardhigh}_{\text{error}} = \begin{bmatrix} 14.122 \\ 13.554 \\ 13.99 \end{bmatrix}$$

$$\mu\text{low}_{\text{measured}} = \begin{bmatrix} 906.037 \\ 894.926 \\ 904.037 \end{bmatrix} \qquad \sigma\text{low}_{\text{measured}} = \begin{bmatrix} 46.682 \\ 42.624 \\ 46.499 \end{bmatrix} \qquad \text{Standardlow}_{\text{error}} = \begin{bmatrix} 8.984 \\ 8.203 \\ 8.949 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}\left(\mu_{\text{measured}}\right) \qquad \text{Total}_{\text{means}} = 3$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2$$

$$\text{SST}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{mean}\left(\mu\text{low}_{\text{measured}}\right)\right)^2$$

$$\text{SST}_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{mean}\left(\mu\text{high}_{\text{measured}}\right)\right)^2$$

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

$$\text{SSE}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu\text{low}_{\text{measured}}\right)_i\right)^2$$

$$\text{SSE}_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{yhat}\left(\text{Dates}, \mu\text{high}_{\text{measured}}\right)_i\right)^2$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu_{\text{measured}}\right)_i - \text{mean}\left(\mu_{\text{measured}}\right)\right)^2$$

$$\text{SSR}_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu\text{low}_{\text{measured}}\right)_i - \text{mean}\left(\mu\text{low}_{\text{measured}}\right)\right)^2$$

$$\text{SSR}_{\text{high}} := \sum^{\text{last(Dates)}} \left(\text{yhat}\left(\text{Dates}, \mu\text{high}_{\text{measured}}\right) - \text{mean}\left(\mu\text{high}_{\text{measured}}\right)\right)^2$$

$$\cdots_{high} \quad \sum_{i=0} \left(\cdots \text{measured} \right)_i \quad \cdots \left(\cdots \text{measured} \right))$$

$\text{DegreeFree}_{ss} := \text{Total}_{means} - 2$ $\text{DegreeFree}_{reg} := 1$ $\text{DegreeFree}_{st} := \text{Total}_{means} - 1$

$\text{MSE} := \dfrac{\text{SSE}}{\text{DegreeFree}_{ss}}$ $\text{MSE}_{low} := \dfrac{\text{SSE}_{low}}{\text{DegreeFree}_{ss}}$ $\text{MSE}_{high} := \dfrac{\text{SSE}_{high}}{\text{DegreeFree}_{ss}}$

$\text{Standard}_{error} := \sqrt{\text{MSE}}$ $\text{Standard}_{lowerror} := \sqrt{\text{MSE}_{low}}$ $\text{Standard}_{higherror} := \sqrt{\text{MSE}_{high}}$

$\text{MSR} := \dfrac{\text{SSR}}{\text{DegreeFree}_{reg}}$ $\text{MSR}_{low} := \dfrac{\text{SSR}_{low}}{\text{DegreeFree}_{reg}}$ $\text{MSR}_{high} := \dfrac{\text{SSR}_{high}}{\text{DegreeFree}_{reg}}$

$\text{MST} := \dfrac{\text{SST}}{\text{DegreeFree}_{st}}$ $\text{MST}_{low} := \dfrac{\text{SST}_{low}}{\text{DegreeFree}_{st}}$ $\text{MST}_{high} := \dfrac{\text{SST}_{high}}{\text{DegreeFree}_{st}}$

Test the means with all points

F Test for Corrosion

$\alpha := 0.05$ $F_{actaul\_Reg} := \dfrac{\text{MSR}}{\text{MSE}}$

$$F_{critical\_reg} := qF\left(1 - \alpha, \text{DegreeFree}_{reg}, \text{DegreeFree}_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$F_{ratio\_reg} = 3.736 \cdot 10^{5}$$

Test the low points

F Test for Corrosion

$$F_{actaul\_Reg.low} := \frac{MSR_{low}}{MSE_{low}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.low} := \frac{F_{actaul\_Reg.low}}{F_{critical\_reg}}$$

$$F_{ratio\_reg.low} = 3.63 \cdot 10^{-4}$$

Test the high points

F Test for Corrosion

$$F_{actaul\_Reg.high} := \frac{MSR_{high}}{MSE_{high}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.high} := \frac{F_{actaul\_Reg.high}}{F_{critical\_reg}}$$

$$F_{ratio\_reg.high} = 2.024 \cdot 10^{-5}$$

Appendix 21 - Location 17A Sensitivity Study without 1996 data

$d := 0$

The data shown below was collected on 10/18/06

For Dec 31 1992

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\DATA ONLY\SB17A.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 31, 1992)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.159 & 1.153 & 1.158 & 1.138 & 1.127 & 1.169 & 1.167 \\ 1.121 & 1.155 & 1.121 & 1.143 & 1.125 & 1.151 & 1.12 \\ 1.071 & 1.095 & 1.112 & 1.115 & 1.097 & 1.07 & 1.053 \\ 1.02 & 0.995 & 0.977 & 1.012 & 1.048 & 1.029 & 0.951 \\ 0.976 & 0.919 & 0.881 & 0.935 & 0.871 & 0.936 & 0.964 \\ 0.866 & 0.961 & 0.892 & 0.822 & 0.804 & 0.946 & 0.991 \\ 0.934 & 0.97 & 0.923 & 0.925 & 0.871 & 0.952 & 0.986 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$ $\quad \text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$ $\quad \text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 43)$

$\text{Point}_{40_d} := \text{nnn}_{39}$ $\quad \text{Point}_{40} = 804$

The two groups are named as follows:

$\text{StopCELL} := 21$ $\quad \text{No}_{\text{Cells}} := \text{length}(\text{Cells})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$ $\quad \text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$ $\quad \text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\quad \sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\quad \text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$ $\quad \mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$ $\quad \sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$\text{Standardhigh}_{\text{error}_d} := \dfrac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$ $\quad \text{Standardlow}_{\text{error}_d} := \dfrac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\DATA ONLY\SB17A.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$ $\text{Dates}_d := \text{Day}_{\text{year}}(9, 26, 1994)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.163 & 1.146 & 1.158 & 1.141 & 1.136 & 1.168 & 1.172 \\ 1.122 & 1.155 & 1.122 & 1.144 & 1.128 & 1.157 & 1.133 \\ 1.121 & 1.088 & 1.108 & 1.116 & 1.102 & 1.071 & 1.055 \\ 0.977 & 0.993 & 0.981 & 0.989 & 1.046 & 1.001 & 0.956 \\ 0.962 & 0.914 & 0.869 & 0.942 & 0.877 & 0.938 & 0.962 \\ 0.861 & 0.963 & 0.894 & 0.82 & 0.809 & 0.947 & 0.984 \\ 0.927 & 0.97 & 0.866 & 0.895 & 0.893 & 0.956 & 0.953 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{40_d} := \text{nnn}_{39}$

The two groups are named as follows: $\text{StopCELL} := 21$ $\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$ $\text{high}_{\text{points}} := \text{TOPROWS}(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL})$

$\text{No}_{\text{lowCells}} := \text{length}(\text{low}_{\text{points}})$ $\text{No}_{\text{highCells}} := \text{length}(\text{high}_{\text{points}})$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{Cells}})$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}})$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}(\text{high}_{\text{points}}, \text{No}_{\text{highCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

$\mu\text{high}_{\text{measured}_d} := \text{mean}(\text{high}_{\text{points}})$ $\mu\text{low}_{\text{measured}_d} := \text{mean}(\text{low}_{\text{points}})$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}(\text{high}_{\text{points}})$ $\sigma\text{low}_{\text{measured}_d} := \text{Stdev}(\text{low}_{\text{points}})$

$\text{Standardhigh}_{\text{error}_d} := \dfrac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}(\text{high}_{\text{points}})}}$ $\text{Standardlow}_{\text{error}_d} := \dfrac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}(\text{low}_{\text{points}})}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Oct 2006 Data\Sandbed\SB17A.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 23, 2006)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 1.11 & 1.149 & 1.154 & 1.138 & 1.13 & 1.17 & 1.169 \\ 1.121 & 1.159 & 1.114 & 1.144 & 1.134 & 1.148 & 1.123 \\ 1.068 & 1.073 & 1.111 & 1.114 & 1.094 & 1.083 & 1.053 \\ 0.976 & 0.991 & 0.98 & 1.03 & 1.046 & 0.994 & 0.95 \\ 0.962 & 0.926 & 0.909 & 0.95 & 0.869 & 0.938 & 0.967 \\ 0.903 & 0.956 & 0.891 & 0.835 & 0.802 & 0.95 & 0.963 \\ 0.954 & 0.972 & 0.877 & 0.89 & 0.875 & 0.891 & 0.945 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{40_d} := \text{nnn}_{39}$

The two groups are named as follows:

$\text{StopCELL} := 21$

$\text{No}_{\text{Cells}} := \text{length}(\text{nnn})$

$\text{low}_{\text{points}} := \text{LOWROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{high}_{\text{points}} := \text{TOPROWS}\left(\text{nnn}, \text{No}_{\text{Cells}}, \text{StopCELL}\right)$

$\text{No}_{\text{lowCells}} := \text{length}\left(\text{low}_{\text{points}}\right)$

$\text{No}_{\text{highCells}} := \text{length}\left(\text{high}_{\text{points}}\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{Cells}}\right)$

$\text{low}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{low}_{\text{points}}, \text{No}_{\text{lowCells}}\right)$

$\text{high}_{\text{points}} := \text{deletezero}_{\text{cells}}\left(\text{high}_{\text{points}}, \text{No}_{\text{highCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$\mu\text{high}_{\text{measured}_d} := \text{mean}\left(\text{high}_{\text{points}}\right)$

$\mu\text{low}_{\text{measured}_d} := \text{mean}\left(\text{low}_{\text{points}}\right)$

$\sigma\text{high}_{\text{measured}_d} := \text{Stdev}\left(\text{high}_{\text{points}}\right)$

$\sigma\text{low}_{\text{measured}_d} := \text{Stdev}\left(\text{low}_{\text{points}}\right)$

$$\text{Standardhigh}_{\text{error}_d} := \frac{\sigma\text{high}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{high}_{\text{points}}\right)}}$$

$$\text{Standardlow}_{\text{error}_d} := \frac{\sigma\text{low}_{\text{measured}_d}}{\sqrt{\text{length}\left(\text{low}_{\text{points}}\right)}}$$

Below are the results

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^{3} \\ 1.995 \cdot 10^{3} \\ 2.007 \cdot 10^{3} \end{bmatrix} \qquad \text{Point}_{40} = \begin{bmatrix} 804 \\ 809 \\ 802 \end{bmatrix}$$

$$\text{Standard}_{\text{error}} = \begin{bmatrix} 14.971 \\ 15.472 \\ 14.911 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.022 \cdot 10^{3} \\ 1.017 \cdot 10^{3} \\ 1.015 \cdot 10^{3} \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 104.798 \\ 108.306 \\ 104.378 \end{bmatrix}$$

$$\mu\text{high}_{\text{measured}} = \begin{bmatrix} 1.125 \cdot 10^{3} \\ 1.129 \cdot 10^{3} \\ 1.122 \cdot 10^{3} \end{bmatrix} \qquad \sigma\text{high}_{\text{measured}} = \begin{bmatrix} 33.118 \\ 31.283 \\ 33.194 \end{bmatrix} \qquad \text{Standardhigh}_{\text{error}} = \begin{bmatrix} 7.227 \\ 6.827 \\ 7.243 \end{bmatrix}$$

$$\mu\text{low}_{\text{measured}} = \begin{bmatrix} 941.593 \\ 933.75 \\ 935.429 \end{bmatrix} \qquad \sigma\text{low}_{\text{measured}} = \begin{bmatrix} 61.37 \\ 56.659 \\ 55.725 \end{bmatrix} \qquad \text{Standardlow}_{\text{error}} = \begin{bmatrix} 11.811 \\ 10.708 \\ 10.531 \end{bmatrix}$$

$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}})$ $\text{Total}_{\text{means}} = 3$

$$SST := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2$$

$$SST_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{mean}(\mu\text{low}_{\text{measured}})\right)^2$$

$$SST_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{mean}(\mu\text{high}_{\text{measured}})\right)^2$$

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

$$SSE_{\text{low}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{low}_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu\text{low}_{\text{measured}})_i\right)^2$$

$$SSE_{\text{high}} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu\text{high}_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu\text{high}_{\text{measured}})_i\right)^2$$

$$SSR := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2$$

last(Dates)

$$SSR_{low} := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, \mu low_{measured}\right)_i - mean\left(\mu low_{measured}\right)\right)^2$$

$$SSR_{high} := \sum_{i=0}^{last(Dates)} \left(yhat\left(Dates, \mu high_{measured}\right)_i - mean\left(\mu high_{measured}\right)\right)^2$$

$DegreeFree_{ss} := Total_{means} - 2$ $DegreeFree_{reg} := 1$ $DegreeFree_{st} := Total_{means} - 1$

$MSE := \frac{SSE}{DegreeFree_{ss}}$ $MSE_{low} := \frac{SSE_{low}}{DegreeFree_{ss}}$ $MSE_{high} := \frac{SSE_{high}}{DegreeFree_{ss}}$

$Standard_{error} := \sqrt{MSE}$ $Standard_{lowerror} := \sqrt{MSE_{low}}$ $Standard_{higherror} := \sqrt{MSE_{high}}$

$MSR := \frac{SSR}{DegreeFree_{reg}}$ $MSR_{low} := \frac{SSR_{low}}{DegreeFree_{reg}}$ $MSR_{high} := \frac{SSR_{high}}{DegreeFree_{reg}}$

$MST := \frac{SST}{DegreeFree_{st}}$ $MST_{low} := \frac{SST_{low}}{DegreeFree_{st}}$ $MST_{high} := \frac{SST_{high}}{DegreeFree_{st}}$

Test the means with all points

F Test for No Corrosion

$F_{actaul\_Gradnmean} := \frac{MST}{MSR}$

$\alpha := 0.05$

$F_{critical\_GM} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{st}\right)$

$F_{ratio\_GM} := \frac{F_{actaul\_Gradnmean}}{F_{critical\_GM}}$

F Test for Corrosion

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

$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_GM} = 0.04$

$F_{ratio\_reg} = 0.012$

Therefore no conclusion can be made as to whether the data best fits the regression model or the grandmean model. However the grandmean ratio is significantly greater than the regression ratio indicating a line without a slope may be the a better fit. The figure below provides a trend of the data and the grandmean

Test the low points

F Test for No Corrosion

$$F_{actaul\_Gradnmean.low} := \frac{MST_{low}}{MSR_{low}}$$

$$F_{critical\_GM} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{st}\right)$$

$$F_{ratio\_GM.low} := \frac{F_{actaul\_Gradnmean.low}}{F_{critical\_GM}}$$

$F_{ratio\_GM.low} = 0.152$

F Test for Corrosion

$$F_{actaul\_Reg.low} := \frac{MSR_{low}}{MSE_{low}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.low} := \frac{F_{actaul\_Reg.low}}{F_{critical\_reg}}$$

$F_{ratio\_reg.low} = 1.34 \cdot 10^{-3}$

The conclusion can be made that the low points best fit the grandmean model. The grandmean ratio is greater than one. The figure below provides a trend of the data and the grandmean

Test the high points

F Test for No Corrosion

$$F_{actaul\_Gradnmean.high} := \frac{MST_{high}}{MSR_{high}}$$

$$F_{critical\_GM} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{st}\right)$$

$$F_{ratio\_GM.high} := \frac{F_{actaul\_Gradnmean.high}}{F_{critical\_GM}}$$

$F_{ratio\_GM.high} = 0.049$

F Test for Corrosion

$$F_{actaul\_Reg.high} := \frac{MSR_{high}}{MSE_{high}}$$

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg.high} := \frac{F_{actaul\_Reg.high}}{F_{critical\_reg}}$$

$F_{ratio\_reg.high} = 7.492 \cdot 10^{-3}$

Therefore no conclusion can be made as to whether the data best fits the regression model or the grandmean model. However the grandmean ratio is significantly greater than the regression ratio indicating a line without a slope may be the a better fit. The figure below provides a trend of the data and the grandmean

Appendix 21 - Location 17D Sensitivity Study without 1996 data
The data shown below was collected on 10/18/06

$d := 0$

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB17D.txt")

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.839 & 0.802 & 0.853 & 0.905 & 0.955 & 0.877 & 0.71 \\ 0.804 & 0.802 & 0.71 & 0.806 & 0.737 & 0.762 & 0.648 \\ 1.029 & 0.814 & 0.752 & 0.802 & 0.819 & 0.737 & 0.668 \\ 1.069 & 1.069 & 0.748 & 0.803 & 0.784 & 0.806 & 0.785 \\ 0.809 & 0.845 & 0.845 & 0.816 & 0.846 & 0.845 & 0.84 \\ 0.79 & 0.833 & 0.892 & 0.846 & 0.878 & 0.855 & 0.792 \\ 0.832 & 0.896 & 0.835 & 0.882 & 0.886 & 0.936 & 0.862 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{point}_{13_d} := \text{nnn}_{13}$

$\text{point}_{13} = 648$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 15)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 16)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 22)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 23)$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB17D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.797 & 0.815 & 0.853 & 0.887 & 0.925 & 0.878 & 0.696 \\ 0.807 & 0.806 & 0.698 & 0.802 & 0.729 & 0.734 & 0.646 \\ 1.008 & 0.243 & 0.749 & 0.741 & 0.816 & 0.735 & 0.662 \\ 1.068 & 1.066 & 0.739 & 0.812 & 0.772 & 0.793 & 0.785 \\ 0.804 & 0.836 & 0.838 & 0.794 & 0.853 & 0.828 & 0.842 \\ 0.79 & 0.825 & 0.885 & 0.847 & 0.872 & 0.853 & 0.795 \\ 0.827 & 0.899 & 0.826 & 0.863 & 0.922 & 0.934 & 0.835 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{point }13_d := \text{nnn}_{13}$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 15\right)$ $\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 16\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 22\right)$ $\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 23\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB17D.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(10, 16, 2006)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.849 & 0.828 & 0.861 & 0.894 & 0.93 & 0.888 & 0.702 \\ 0.806 & 0.802 & 0.717 & 0.806 & 0.736 & 0.756 & 0.648 \\ 0.998 & 0.823 & 0.752 & 0.733 & 0.822 & 0.73 & 0.667 \\ 1.072 & 1.074 & 0.742 & 0.812 & 0.812 & 0.803 & 0.791 \\ 0.814 & 0.841 & 0.85 & 0.816 & 0.852 & 0.856 & 0.869 \\ 0.792 & 0.829 & 0.888 & 0.846 & 0.888 & 0.855 & 0.8 \\ 0.824 & 0.897 & 0.837 & 0.887 & 0.891 & 0.935 & 0.886 \end{bmatrix}$$

$\text{nnn} := \text{convert}\left(\text{Points}_{49}, 7\right)$

$\text{point}_{13_d} := \text{nnn}_{13}$

For this location point 15, 16, 22, and 23 are over a plug (refer 3.22)

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 15\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 16\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 22\right)$

$\text{nnn} := \text{Zero}_{\text{one}}\left(\text{nnn}, \text{No}_{\text{DataCells}}, 23\right)$

$\text{Cells} := \text{deletezero}_{\text{cells}}\left(\text{nnn}, \text{No}_{\text{DataCells}}\right)$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^3 \\ 1.995 \cdot 10^3 \\ 2.007 \cdot 10^3 \end{bmatrix} \qquad \text{point}_{13} = \begin{bmatrix} 648 \\ 646 \\ 648 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 817.2222 \\ 809.8889 \\ 818.6667 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 9.214 \\ 9.448 \\ 9.476 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 64.496 \\ 66.133 \\ 66.335 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}}) \qquad \text{Total}_{\text{means}} = 3$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SST} = 44.305$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 31.795$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 12.51$$

$$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$MSE = 31.795$ $MSR = 12.51$ $MST = 22.152$

$StGrand_{err} := \sqrt{MSE}$ $StGrand_{err} = 5.639$

F Test for Corrosion

$\alpha := 0.05$ $F_{actaul\_Reg} := \frac{MSR}{MSE}$

$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 2.437 \cdot 10^{-3}$

Appendix 21 - Location 19C Sensitivity Study without 1996 data
The data shown below was collected on 10/18/06

$d := 0$

Data from the 1992, 1994 and 1996 is retrieved.

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB19C.txt")

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

For 1992

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.822 & 0.757 & 0.792 & 0.994 & 0.922 & 0.979 & 0.931 \\ 0.683 & 0.716 & 0.693 & 0.797 & 0.753 & 0.887 & 0.838 \\ 0.815 & 0.744 & 0.879 & 0.859 & 0.856 & 0.222 & 0.888 \\ 0.785 & 0.65 & 0.713 & 0.766 & 1.147 & 1.152 & 0.907 \\ 0.839 & 0.782 & 0.732 & 0.762 & 0.859 & 0.791 & 0.838 \\ 0.867 & 0.833 & 0.88 & 0.756 & 0.852 & 0.736 & 0.752 \\ 0.835 & 0.861 & 0.889 & 0.842 & 0.896 & 0.884 & 0.809 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}\left(\mathrm{Points}_{49}, 7\right)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

For this location point 20, 26, 27, and 33 are over a plug (refer 3.22)

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 20\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 26\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 27\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 33\right)$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mathrm{minpoint} := \min(\mathrm{Cells})$ $\mathrm{minpoint} = 650$ $\mathrm{Point}_{21_d} := \mathrm{Cells}_{21}$ $\mathrm{Point}_{21} = 650$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$

$$\mathrm{Standard}_{\mathrm{error}_d} := \frac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$$

For 1994

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB19C.txt")

$\text{Dates}_d := \text{Day}_{\text{year}}(9, 14, 1994)$

$\text{Points}_{49} := \text{showcells}(\text{page}, 7, 0)$

Data

$$\text{Points}_{49} = \begin{bmatrix} 0.816 & 0.757 & 0.82 & 0.979 & 0.904 & 0.952 & 0.917 \\ 0.677 & 0.738 & 0.694 & 0.798 & 0.762 & 0.897 & 0.831 \\ 0.813 & 0.736 & 0.876 & 0.855 & 0.838 & 0.221 & 0.884 \\ 0.787 & 0.666 & 0.718 & 0.762 & 1.153 & 1.149 & 0.906 \\ 0.841 & 0.782 & 0.734 & 0.764 & 0.856 & 0.787 & 0.834 \\ 0.871 & 0.832 & 0.886 & 0.766 & 0.867 & 0.735 & 0.748 \\ 0.836 & 0.853 & 0.892 & 0.851 & 0.9 & 0.902 & 0.831 \end{bmatrix}$$

$\text{nnn} := \text{convert}(\text{Points}_{49}, 7)$ $\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

For this location point 20, 26, 27, and 33 are over a plug (refer 3.22)

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 20)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 26)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 27)$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 33)$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\text{Point}_{21_d} := \text{Cells}_{21}$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$ $\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$ $\text{Standard}_{\text{error}_d} := \dfrac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$

For 2006

$d := d + 1$

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB19C.txt")

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(10, 16, 2006)$

$\mathrm{Points}_{49} := \mathrm{showcells}(\mathrm{page}, 7, 0)$

Data

$$\mathrm{Points}_{49} = \begin{bmatrix} 0.809 & 0.768 & 0.862 & 1.059 & 0.968 & 0.961 & 0.92 \\ 0.679 & 0.745 & 0.695 & 0.814 & 0.766 & 0.865 & 0.845 \\ 0.816 & 0.775 & 0.87 & 0.871 & 0.863 & 0 & 0.896 \\ 0.791 & 0.66 & 0.715 & 0.793 & 1.151 & 1.164 & 0.918 \\ 0.851 & 0.781 & 0.733 & 0.762 & 0.862 & 0.787 & 0.796 \\ 0.866 & 0.83 & 0.88 & 0.757 & 0.867 & 0.75 & 0.753 \\ 0.801 & 0.794 & 0.852 & 0.841 & 0.901 & 0.906 & 0.84 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{convert}\left(\mathrm{Points}_{49}, 7\right)$

$\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

For this location point 20, 26, 27, and 33 are over a plug (refer 3.22)

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 20\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 26\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 27\right)$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 33\right)$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$\mathrm{Point}_{21_d} := \mathrm{Cells}_{21}$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$ $\mathrm{Standard}_{\mathrm{error}_d} := \dfrac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^3 \\ 1.995 \cdot 10^3 \\ 2.007 \cdot 10^3 \end{bmatrix} \qquad \text{Point}_{21} = \begin{bmatrix} 650 \\ 666 \\ 660 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 819.156 \\ 819.889 \\ 823.822 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 11.01 \\ 10.485 \\ 11.303 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 77.068 \\ 73.396 \\ 79.123 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}}) \qquad \text{Total}_{\text{means}} = 3$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 0.011$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 12.585$$

$$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{MSE} = 0.011 \qquad \text{MSR} = 12.585 \qquad \text{MST} = 6.298$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 0.104$$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^3 \\ 1.995 \cdot 10^3 \\ 2.007 \cdot 10^3 \end{bmatrix} \qquad \text{Point}_{21} = \begin{bmatrix} 650 \\ 666 \\ 660 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 819.156 \\ 819.889 \\ 823.822 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 11.01 \\ 10.485 \\ 11.303 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 77.068 \\ 73.396 \\ 79.123 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}}) \qquad \text{Total}_{\text{means}} = 3$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 0.011$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 12.585$$

$$\text{DegreeFree}_{ss} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{reg} := 1 \qquad \text{DegreeFree}_{st} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{ss}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{reg}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{st}}$$

$$\text{MSE} = 0.011 \qquad \text{MSR} = 12.585 \qquad \text{MST} = 6.298$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 0.104$$

F Test for Corrosion

$\alpha := 0.05$ $F_{actaul\_Reg} := \frac{MSR}{MSE}$

$F_{critical\_reg} := qF(1-\alpha, DegreeFree_{reg}, DegreeFree_{ss})$

$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$

$F_{ratio\_reg} = 7.263$

The conclusion can be made that the mean best fits the grandmean model.

Therefore no conclusion can be made as to whether the data best fits the regression model. The figure below provides a trend of the data and the grandmean

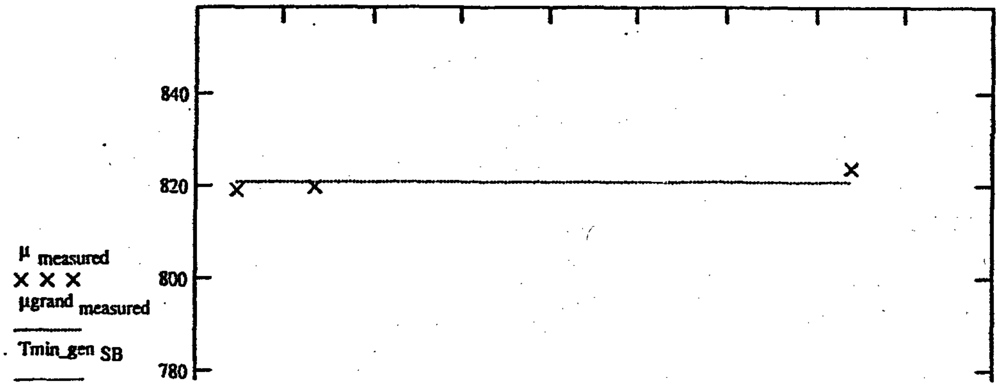
Therefore the curve fit of the means does not have a slope and the grandmean is an accurate measure of the thickness at this location

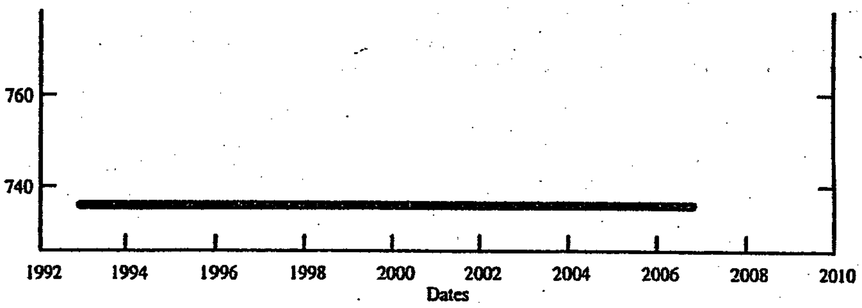
$i := 0 .. Total_{means} - 1$ $\mu grand_{measured_i} := mean(\mu_{measured})$

$\sigma grand_{measured} := Stdev(\mu_{measured})$ $GrandStandard_{error_0} := \frac{\sigma grand_{measured}}{\sqrt{Total_{means}}}$

The minimum required thickness at this elevation is $Tmin\_gen_{SB_i} := 736$ (Ref. 3.25)

Plot of the grand mean and the actual means over time





$\mu grand_{measured_0} = 820.956$ $GrandStandard_{error} = 1.449$

To conservatively address the location, the apparent corrosion rate is calculated and compared to the minimum required wall thickness at this elevation

$m_s := \mathrm{slope}\left(\mathrm{Dates}, \mu_{measured}\right)$ $m_s = 0.333$ $y_b := \mathrm{intercept}\left(\mathrm{Dates}, \mu_{measured}\right)$ $y_b = 156.275$

The 95% Confidence curves are calculated

$\alpha_t := 0.05$ $k := 2029 - 1985$ $f := 0 .. k - 1$

$\mathrm{year}_{predict_f} := 1985 + f \cdot 2$ $\mathrm{Thick}_{predict} := m_s \cdot \mathrm{year}_{predict} + y_b$

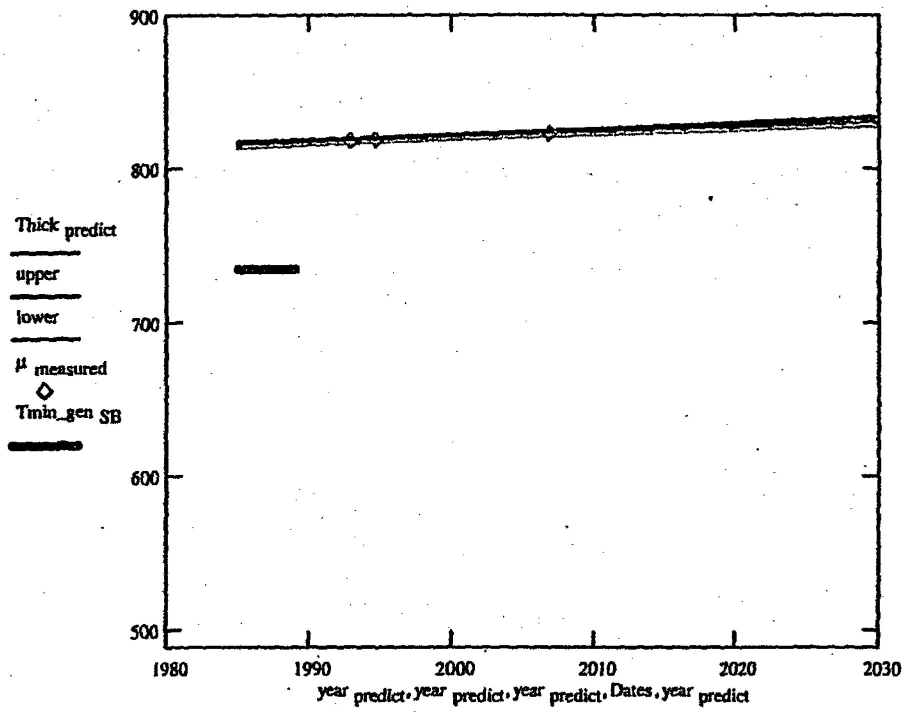
$\mathrm{Thick}_{actualmean} := \mathrm{mean(Dates)}$ $\mathrm{sum} := \sum_i \left(\mathrm{Dates}_d - \mathrm{mean(Dates)}\right)^2$

$$\mathrm{upper}_f := \mathrm{Thick}_{predict_f} -$$

$$+\, \mathrm{qt}\left(1 - \frac{\alpha_t}{2}, \mathrm{Total}_{means} - 2\right) \cdot \mathrm{StGrand}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{predict_f} - \mathrm{Thick}_{actualmean}\right)^2}{\mathrm{sum}}}$$

$$\mathrm{lower}_f := \mathrm{Thick}_{predict_f} -$$

$$+\, -\left[\mathrm{qt}\left(1 - \frac{\alpha_t}{2}, \mathrm{Total}_{means} - 2\right) \cdot \mathrm{StGrand}_{err} \cdot \sqrt{1 + \frac{1}{(d+1)} + \frac{\left(\mathrm{year}_{predict_f} - \mathrm{Thick}_{actualmean}\right)^2}{\mathrm{sum}}}\right]$$



Location Curve Fit Projected to Plant End Of Life

$m_s = 0.333$

Therefore even though *F-ratio does not support* the regression model *the above curve* shows that even at the lower 95% confidence band this location will not corrode to below Drywell Vessel Minimum required thickness by the plant end of life.

Appendix 21 - Location 1D Sensitivity Study without 1996 data

The data shown below was collected on 10/18/06

$d := 0$

For 1992

$\text{Dates}_d := \text{Day}_{\text{year}}(12, 8, 1992)$

page := READPRN("U:\MSOFFICE\Drywell Program data\Dec. 1992 Data\sandbed\Data Only\SB1D.txt")

$\text{Points}_7 := \text{show7cells}(\text{page}, 1, 7, 0)$

Data

$$\text{Points}_7 = [\, 0.889 \;\; 1.138 \;\; 1.112 \;\; 1.114 \;\; 1.132 \;\; 1.103 \;\; 1.126 \,]$$

$\text{nnn} := \text{con7vert}(\text{Points}_7, 7, 1)$

$\text{No}_{\text{DataCells}} := \text{length}(\text{nnn})$

$\text{Point}_{1_d} := \text{Points}_{7_0}$

$\text{nnn} := \text{Zero}_{\text{one}}(\text{nnn}, \text{No}_{\text{DataCells}}, 1)$

$\text{Cells} := \text{deletezero}_{\text{cells}}(\text{nnn}, \text{No}_{\text{DataCells}})$

$\text{Point}_1 = 0.889$

$\mu_{\text{measured}_d} := \text{mean}(\text{Cells})$

$\sigma_{\text{measured}_d} := \text{Stdev}(\text{Cells})$

$$\text{Standard}_{\text{error}_d} := \frac{\sigma_{\text{measured}_d}}{\sqrt{\text{No}_{\text{DataCells}}}}$$

$d := d + 1$

For 1994

page := READPRN("U:\MSOFFICE\Drywell Program data\Sept.1994 Data\sandbed\Data Only\SB1D.txt")

$Dates_d := Day_{year}(9, 14, 1994)$

$Points_7 := show7cells(page, 1, 7, 0)$

Data

$Points_7 = [\,0.879 \quad 1.054 \quad 1.105 \quad 1.119 \quad 1.124 \quad 1.088 \quad 1.118\,]$

$nnn := con7vert(Points_7, 7, 1)$

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

$Point1_d := Points7_0$

$nnn := Zero_{one}(nnn, No_{DataCells}, 1)$

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

$\mu_{measured_d} := mean(Cells)$ $\sigma_{measured_d} := Stdev(Cells)$ $Standard_{error_d} := \frac{\sigma_{measured_d}}{\sqrt{No_{DataCells}}}$

$d := d + 1$

For 2006

page := READPRN("U:\MSOFFICE\Drywell Program data\OCT 2006 Data\Sandbed\SB1D.txt")

$\mathrm{Dates}_d := \mathrm{Day}_{\mathrm{year}}(10, 16, 2006)$

$\mathrm{Points}_7 := \mathrm{show7cells}(\mathrm{page}, 1, 7, 0)$

Data

$$\mathrm{Points}_7 = \begin{bmatrix} 0.881 & 1.156 & 1.104 & 1.124 & 1.134 & 1.093 & 1.122 \end{bmatrix}$$

$\mathrm{nnn} := \mathrm{con7vert}\left(\mathrm{Points}_7, 7, 1\right)$ $\mathrm{No}_{\mathrm{DataCells}} := \mathrm{length}(\mathrm{nnn})$

$\mathrm{Point}_{1_d} := \mathrm{Points}_{7_0}$

$\mathrm{nnn} := \mathrm{Zero}_{\mathrm{one}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}, 0\right)$

$\mathrm{Cells} := \mathrm{deletezero}_{\mathrm{cells}}\left(\mathrm{nnn}, \mathrm{No}_{\mathrm{DataCells}}\right)$

$$\mathrm{Point}_1 = \begin{bmatrix} 0.889 \\ 0.879 \\ 0.881 \end{bmatrix}$$

$\mu_{\mathrm{measured}_d} := \mathrm{mean}(\mathrm{Cells})$ $\sigma_{\mathrm{measured}_d} := \mathrm{Stdev}(\mathrm{Cells})$ $\mathrm{Standard}_{\mathrm{error}_d} := \dfrac{\sigma_{\mathrm{measured}_d}}{\sqrt{\mathrm{No}_{\mathrm{DataCells}}}}$

Below are matrices which contain the date when the data was collected, Mean, Standard Deviation, Standard Error for each date.

$$\text{Dates} = \begin{bmatrix} 1.993 \cdot 10^3 \\ 1.995 \cdot 10^3 \\ 2.007 \cdot 10^3 \end{bmatrix} \qquad \text{Point}_1 = \begin{bmatrix} 0.889 \\ 0.879 \\ 0.881 \end{bmatrix}$$

$$\mu_{\text{measured}} = \begin{bmatrix} 1.12083 \cdot 10^3 \\ 1.10133 \cdot 10^3 \\ 1.08771 \cdot 10^3 \end{bmatrix} \qquad \text{Standard}_{\text{error}} = \begin{bmatrix} 5.039 \\ 10.05 \\ 35.295 \end{bmatrix} \qquad \sigma_{\text{measured}} = \begin{bmatrix} 13.333 \\ 26.591 \\ 93.382 \end{bmatrix}$$

$$\text{Total}_{\text{means}} := \text{rows}(\mu_{\text{measured}}) \qquad \text{Total}_{\text{means}} = 3$$

$$\text{SST} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{mean}(\mu_{\text{measured}})\right)^2$$

$$\text{SSE} := \sum_{i=0}^{\text{last(Dates)}} \left(\mu_{\text{measured}_i} - \text{yhat}(\text{Dates}, \mu_{\text{measured}})_i\right)^2 \qquad \text{SSE} = 131.284$$

$$\text{SSR} := \sum_{i=0}^{\text{last(Dates)}} \left(\text{yhat}(\text{Dates}, \mu_{\text{measured}})_i - \text{mean}(\mu_{\text{measured}})\right)^2 \qquad \text{SSR} = 422.916$$

$$\text{DegreeFree}_{\text{ss}} := \text{Total}_{\text{means}} - 2 \qquad \text{DegreeFree}_{\text{reg}} := 1 \qquad \text{DegreeFree}_{\text{st}} := \text{Total}_{\text{means}} - 1$$

$$\text{MSE} := \frac{\text{SSE}}{\text{DegreeFree}_{\text{ss}}} \qquad \text{MSR} := \frac{\text{SSR}}{\text{DegreeFree}_{\text{reg}}} \qquad \text{MST} := \frac{\text{SST}}{\text{DegreeFree}_{\text{st}}}$$

$$\text{MSE} = 131.284 \qquad \text{MSR} = 422.916 \qquad \text{MST} = 277.1$$

$$\text{StGrand}_{\text{err}} := \sqrt{\text{MSE}} \qquad \text{StGrand}_{\text{err}} = 11.458$$

F Test for Corrosion

$\alpha := 0.05$

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

$$F_{critical\_reg} := qF\left(1 - \alpha, DegreeFree_{reg}, DegreeFree_{ss}\right)$$

$$F_{ratio\_reg} := \frac{F_{actaul\_Reg}}{F_{critical\_reg}}$$

$$\boxed{F_{ratio\_reg} = 0.02}$$

The following Mathcad Program ($Iterate_{means}$) is used to perform the simulation for successful corrosion test for the mean rates.

```
$rate_{means}(Target_{Rate}, \mu_{1992}, \sigma_{input}, Total_{means}, It) :=$
    $i \leftarrow 0$
    $Succesful_{Ftest} \leftarrow 0$
    while $i < It$
        $DegreeFree_{se} \leftarrow Total_{means} - 2$
        $DegreeFree_{reg} \leftarrow 1$
        $Date_0 \leftarrow 1992$
        $Date_1 \leftarrow 1994$
        $Date_2 \leftarrow 1996$
        $Date_3 \leftarrow 2006$
        $Confidence \leftarrow 0.95$
        $F_{critical} \leftarrow qF(Confidence, DegreeFree_{reg}, DegreeFree_{se})$
        $j \leftarrow 0$
        for $observ \in 0 .. Total_{means} - 1$
            $\left[\mu_{in_j} \leftarrow \mu_{1992} - \left[\left(Target_{Rate}\right) \cdot \left(Date_j - Date_0\right)\right]\right]$
            $Cells_j \leftarrow rnorm(49, \mu_{in_j}, \sigma_{input})$
            $\mu_{test_j} \leftarrow mean(Cells_j)$
            $j \leftarrow j + 1$
        $SSE \leftarrow \sum_{k=0}^{last(Date)} \left(\mu_{test_k} - yhat(Date, \mu_{test})_k\right)^2$
        $SSR \leftarrow \sum_{k=0}^{last(Date)} \left(yhat(Date, \mu_{test})_k - mean(\mu_{test})\right)^2$
        $MSE \leftarrow \frac{SSE}{DegreeFree_{se}}$
        $MSR \leftarrow \frac{SSR}{DegreeFree_{reg}}$
        $F_{actaul} \leftarrow \frac{MSR}{MSE}$
        $F_{ratio} \leftarrow \frac{F_{actaul}}{F_{critical}}$
        $m_i \leftarrow slope(Date, \mu_{test})$
        $(Succesful_{Ftest} \leftarrow Succesful_{Ftest} + 1)$ if $F_{ratio} > 1$
        $i \leftarrow i + 1$
    $Succesful_{Ftest}$
```

function required the following inputs: the target corrosion rate ($\text{Target}_{\text{Rate}}$), the 1992 calculated mean (μ_{1992}), the target ndard deviation (σ_{input}), the number of inspections ($\text{Total}_{\text{means}}$) and the number of iteration (It).

For each iteration

The function generates 49 point arrays using the Mathcad function "rnorm". The function "norm(49, μ_{in}, σ_{input})" - returns an array of "49" random numbers generated from a normal distribution with mean of "μ_{in}" and and a standard deviation of "σ_{input}".

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 target standard deviation of σ_{input}(65 mils). This target standard deviation is the average the of 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 valve μ_{1992} minus the target 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 valve μ_{1992} minus the target 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 valve μ_{1992} minus the target rate (in mils per year) times 14 (years; 2006-1992) a standard deviation of 65 mils. A simulated mean (for 2006) will then be calculated from the simulated 49 point array.

e four simulated means are 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 be consider a successful valid iteration and the term $\text{Succesful}_{\text{Ftest}}$ is increased by 1.

End of iteration

100 iterations are run at each of the input rates of 5, 6, 7, 8, and 9 mils per year. The resulting number of successful (passes the corrosion test) iterations will then be considered as probability of observing that rate given the 19A data.

The following Mathcad Program (run_10_time(times, rate, σ_{input}, dates, It, tolerance) runs the $\text{Iterate}_{\text{means}}$ program 10 times and returns an array (Sim) which documents the number of successful "F test" in each of the 10, 100 iteration simulations.

```
Runs(Target_Rate, μ_1992, σ_input, Inspections, It) := | Goodtest ← 0
                                                       | j ← 0
                                                       | for test ∈ 0..9
                                                       |     | xx ← Iterate_means(Target_Rate, μ_1992, σ_input, Inspections, It)
                                                       |     | Goodtest_j ← xx
                                                       |     | j ← j + 1
                                                       | Goodtest
```

The results of the simulations are shown below using the following inputs

$_{1992} := 800$ $\sigma_{input} := 65$ Inspections $:= 4$ Iterations $:= 100$

The simulation for 5 mils per year is input below $Target_{Rate} := 5.$

$\text{Runs}\left(Target_{Rate}, \mu_{1992}, \sigma_{input}, Inspections, Iterations\right) =$

	0
0	77
1	73
2	78
3	85
4	79
5	84
6	86
7	73
8	80
9	89

The simulation for 6 mils per year is input below $Target_{Rate} := 6.$

$\text{Runs}\left(Target_{Rate}, \mu_{1992}, \sigma_{input}, Inspections, Iterations\right) =$

	0
0	89
1	92
2	92
3	93
4	93
5	93
6	89
7	90
8	94
9	93

The simulation for 7 mils per year is input below $Target_{Rate} := 7.$

$\text{Runs}\left(Target_{Rate}, \mu_{1992}, \sigma_{input}, Inspections, Iterations\right) =$

	0
0	98
1	95
2	97
3	96
4	97
5	98
6	97
7	97
8	97
9	96

The simulation for 8 mils per year is input below $\mathrm{Target}_{\mathrm{Rate}} := 8.$

$$\mathrm{Runs}\left(\mathrm{Target}_{\mathrm{Rate}}, \mu_{1992}, \sigma_{\mathrm{input}}, \mathrm{Inspections}, \mathrm{Iterations}\right) =$$

	0
0	99
1	99
2	96
3	99
4	99
5	98
6	98
7	98
8	99
9	99

The simulation for 9 mils per year is input below $\mathrm{Target}_{\mathrm{Rate}} := 9.$

$$\mathrm{Runs}\left(\mathrm{Target}_{\mathrm{Rate}}, \mu_{1992}, \sigma_{\mathrm{input}}, \mathrm{Inspections}, \mathrm{Iterations}\right) =$$

	0
0	100
1	99
2	100
3	99
4	100
5	100
6	99
7	100
8	98
9	100

Therefore the observable rate that passes the corrosion test more that 95 times in 100 iterations approaches 7 mils per year. Defining a more precise rate of 6.9 mils per year satisfies the tests.

The simulation for 6.9 mils per year is input below $\mathrm{Target}_{\mathrm{Rate}} := 6.9$

$$\mathrm{Runs}\left(\mathrm{Target}_{\mathrm{Rate}}, \mu_{1992}, \sigma_{\mathrm{input}}, \mathrm{Inspections}, \mathrm{Iterations}\right) =$$

	0
0	95
1	97
2	100
3	96
4	96
5	96
6	95
7	94
8	96
9	97

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Rev 0

Appendix 23

Page 1 of ~~2~~ pr 3

MPR
ASSOCIATES INC.
ENGINEERS

December 12, 2006

Mr. Francis H. Ray
AmerGen Energy Company, LLC
Oyster Creek Nuclear Generating Station
U.S. Route #9
Forked River, New Jersey 08731-0388

Subject: Oyster Creek NGS Independent Technical Review of Drywall Thickness Monitoring Program Ultrasonic Test Results

References : (a) AmerGen Calculation C-1302-187-E310-041, "Statistical Analysis of Drywell Vessel Sandbed Thickness Data 1992, 1994, 1996 and 2006," Revision 0, December 8, 2006

(b) AmerGen Calculation C-1302-187-E310-037, "Statistical Analysis of Drywell Vessel Thickness Data," Revision 3, December 11, 2006

Dear Mr. Ray:

In accordance with your request, MPR has performed a detailed technical review of the reference calculations that cover the statistical evaluation of Oyster Creek drywell ultrasonic thickness measurements taken over the period from 1990 to 2006. The calculations report the current mean thickness and projected corrosion rate of ultrasonic test locations in the sandbed region and in areas at higher elevations.

Based on our review of the two calculations, we conclude the following:

- AmerGen has shown that all areas of the drywell monitored by ultrasonic test meet minimum wall thickness requirements with margin.
- In areas of the drywell demonstrating statistically significant corrosion rates, the observed rates are small, less than 1 mil per year.
- Methods used by AmerGen to estimate corrosion rates in areas with limited statistics and no observable corrosion (in a statistical sense) are very conservative, and the required inspection intervals based on these rates are conservative.
- All inputs to the calculations are accurate, assumptions are conservative, and results are used correctly.

320 KING STREET ALEXANDRIA, VA 22314-3230 703-519-0200 FAX: 703-519-0224 http://www.mpr.com

We note that the calculations could be made less conservative and observed corrosion rates could be estimated more accurately if individual locations in each grid array used for ultrasonic testing are tracked separately over time, rather than tracking the mean thickness over time for each array. Corrosion rates at individual locations could then be determined, and an average rate computed for the array of data. Upper bound rate data could also be determined. These refinements should be incorporated in future statistical evaluations of the ultrasonic test data.

Finally, we note that ultrasonic testing of wall thickness in the sandbed area above the concrete floor inside the drywell is probably not necessary, since the drywell can be examined both inside and outside for evidence of coating failure or corrosion. If no evidence of coating failure or corrosion is observed, ultrasonic tests are redundant.

Overall, we concur that the reference calculations are complete and conservative. Please call if you have any questions or comments on this letter.

Sincerely yours,

J E Nestell

J. E. Nestell

cc: Pete Tamburo, Oyster Creek

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Appendix 23

Page 3 of 5

D. Gary Harlow, Ph.D.
149 W. Langhorne Ave.
Bethlehem, PA 18017
610-758-4127 (office)
610-758-6224 (fax)
dgh0@lehigh.edu

December 15, 2006

Mr. Peter Tamburro
Exelon Corporation

Dear Pete:

I have reviewed the methodology described in section 6.5.9.4 and Appendix 12 of AmerGen Cal caution C-1302-187-E310-037 Rev.3. I find the methodology consistent with standard statistical methods. The conclusions based on the methodology are accurate and reasonable.

I have also reviewed the methodology described section 6.5.9.4, section 7.5, and Appendix 22 of AmerGen Cal caution C-1302-187-E310-041 Rev.0. I find the methodology consistent with standard statistical methods. The conclusions based on the methodology are accurate and reasonable.

Sincerely,

DGHarlow

D.G. Harlow
Professor of Mechanical Engineering and Mechanics

GPU Nuclear

C-1307-187-E310-041

ATTACHMENT 1

PAGE 2 OF __

Sketch Form

Oyster Creek - QC

Component: D/W LINER

Location: INSIDE CONTAINMENT

Data Sheet No.: 91-119-08

Drawing No.: N/A

Rev. N/A

DRAWING

ELEV. 13 BAY 9D

	A	B	C	D	E	F	G
1	1.010	1.052	0.998	1.165	1.163	1.141	1.106
2	0.966	0.960	0.992	1.024	0.979	1.063	1.075
3	0.763	0.883	0.978	1.053	1.033	1.112	1.125
4	0.914	1.003	0.992	0.985	01.00	1.023	1.042
5	1.034	0.969	0.921	0.940	0.897	0.927	1.010
6	0.955	0.872	0.980	1.017	0.972	0.966	0.948
7	1.103	1.011	0.978	0.991	0.975	0.897	0.975

ELEV. 13 BAY 11A

	A	B	C	D	E	F	G
1	0.930	0.824	0.831	0.809	0.807	0.817	0.751
2	0.816	0.827	0.834	0.823	0.851	0.787	0.799
3	0.733	0.762	0.866	0.762	0.771	0.677	0.764
4	0.745	0.253	0.147	0.809	0.767	0.805	0.846
5	0.841	1.082	1.111	0.886	0.881	0.901	0.778
6	0.755	0.896	0.804	0.805	0.898	0.844	0.823
7	0.847	0.900	0.902	0.924	0.923	0.828	0.884

ELEV. 13 BAY 11C

	A	B	C	D	E	F	G
1	0.941	0.839	0.806	0.917	0.776	0.860	0.926
2	1.105	1.044	0.997	0.975	1.076	1.120	1.045
3	1.091	1.175	1.018	0.942	0.940	0.874	0.896
4	0.847	0.845	0.794	0.833	0.838	0.838	0.870
5	0.845	0.829	0.863	0.870	0.850	0.850	0.827
6	0.941	0.817	0.858	0.839	0.876	0.879	0.854
7	0.603	0.893	0.905	0.901	0.913	0.877	0.845

ELEV. 13 BAY 13A

	A	B	C	D	E	F	G
1	0.885	0.979	0.857	0.886	1.013	1.041	1.069
2	0.814	0.856	0.778	0.829	0.898	0.871	0.794
3	0.762	0.903	0.813	0.827	0.761	0.771	0.826
4	0.860	0.884	0.872	0.923	0.790	0.798	0.876
5	0.869	0.807	0.854	0.892	0.805	0.858	0.840
6	0.827	0.813	0.878	0.925	0.828	0.784	0.868
7	0.815	0.840	0.770	0.842	0.914	0.879	0.879

Prepared by: STAN MCCAULLEY

Reviewed by:

Level: III

Date: 12/11/92

Title: NDE 1151

Date: 12-8-92

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NDE Request No.: 91-119

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Oyster Creek - QC

Sketch Form

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ATTACHMENT 1

PAGE 3 OF —

Component: D/W LINEAR

Location: INSIDE CONTAINMENT

Data Sheet No.: 91-119-08

Drawing No.: N/A

Rev. N/A

DRAWING

ELEV. 13 BAY 13D

	A	B	C	D	E	F	G
1	1.064	1.117	1.134	1.103	1.105	1.106	1.117
2	0.949	1.081	01.00	1.054	1.151	1.118	1.121
3	0.984	0.948	0.868	0.834	0.979	1.048	1.067
4	0.963	0.980	0.893	0.855	0.913	0.981	1.012
5	0.957	0.958	0.869	0.879	0.917	0.913	0.911
6	0.963	0.948	0.895	0.880	0.915	0.862	0.905
7	1.016	0.918	0.927	0.920	0.918	0.825	0.824

ELEV. 13 BAY 15D

	A	B	C	D	E	F	G
1	1.131	1.133	1.133	1.141	1.145	1.134	1.142
2	1.096	1.111	1.088	1.091	1.126	1.118	1.133
3	1.066	1.031	1.048	1.067	1.094	1.079	1.090
4	0.980	0.923	0.989	1.038	1.036	1.092	1.081
5	0.990	0.985	0.894	1.054	1.048	1.065	1.091
6	0.924	1.019	1.041	1.051	1.064	1.075	1.055
7	0.980	0.958	0.991	1.036	1.027	1.074	1.069

ELEV. 13 BAY 17A

	A	B	C	D	E	F	G
1	1.159	1.153	1.158	1.138	1.127	1.169	1.167
2	1.121	1.155	1.121	1.143	1.125	1.151	1.120
3	1.071	1.095	1.112	1.115	1.097	1.070	1.053
4	1.020	0.995	0.977	1.012	1.048	1.029	0.951
5	0.976	0.919	0.881	0.935	0.871	0.936	0.964
6	0.866	0.961	0.892	0.822	0.804	0.946	0.991
7	0.934	0.970	0.923	0.925	0.871	0.952	0.986

ELEV. 13 BAY 17D

	A	B	C	D	E	F	G
1	0.839	0.802	0.853	0.905	0.955	0.877	0.710
2	0.804	0.802	0.710	0.806	0.737	0.762	0.648
3	1.029	0.814	0.752	0.802	0.819	0.737	0.668
4	1.069	1.069	0.748	0.803	0.784	0.806	0.785
5	0.809	0.845	0.845	0.816	0.846	0.845	0.840
6	0.790	0.833	0.892	0.846	0.878	0.855	0.792
7	0.832	0.896	0.835	0.862	0.886	0.936	0.862

Prepared by: STAN MCCAULLEY

Title: NDE II51

Date: 12-8-92

Reviewed by: Reid Wadsmer

Level: III

Date: 12/11/92

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NDE Request No. 91-119

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Oyster Creek - QC

Sketch Form

C-1307-187-E310-041

ATTACHMENT 1

PAGE 2 OF

Component: D/W LINER

Location: INSIDE CONTAINMENT

Data Sheet No.: 91-119-08

Drawing No.: N/A

Rev. N/A

DRAWING

ELEV. 13 Bay 19 Cutout

	A	B	C	D	E	F	G
1	0.958	1.007	0.954	0.934	0.959	0.957	0.964
2	0.982	0.977	0.968	0.992	0.960	1.001	0.969
3	0.978	0.975	1.004	0.985	0.984	1.030	0.959
4	1.010	0.958	0.957	0.979	0.991	0.985	0.956
5	0.968	0.963	0.992	0.947	0.979	0.997	0.914
6	1.045	1.012	0.968	0.974	0.958	0.970	0.994
7	1.034	1.038	1.039	1.005	1.056	0.990	1.004

ELEV. 13 BAY 19A

	A	B	C	D	E	F	G
1	0.681	0.781	0.749	0.659	0.729	0.694	0.731
2	0.810	0.778	0.820	0.759	0.747	0.723	0.773
3	0.776	0.800	0.888	0.755	0.771	0.809	0.806
4	0.886	0.888	0.803	1.077	0.794	0.772	0.762
5	0.872	0.864	0.273	1.160	0.796	0.751	0.859
6	0.859	0.766	0.844	0.848	0.859	0.894	0.850
7	0.864	0.802	0.803	0.844	0.882	0.818	0.792

ELEV. 13 BAY 19B

	A	B	C	D	E	F	G
1	0.868	0.834	0.829	0.925	0.914	0.998	0.823
2	0.832	0.819	0.778	0.838	0.905	0.796	0.824
3	0.865	0.867	0.821	0.879	0.915	0.850	0.876
4	0.892	0.821	0.809	0.834	0.761	0.768	0.748
5	0.795	0.766	0.814	0.783	0.827	0.743	0.685
6	0.825	0.839	0.887	0.889	0.933	0.828	0.732
7	0.872	0.803	0.920	0.820	0.845	0.943	0.906

ELEV. 13 BAY 19C

	A	B	C	D	E	F	G
1	0.822	0.757	0.792	0.994	0.922	0.979	0.931
2	0.683	0.716	0.693	0.797	0.753	0.887	0.838
3	0.815	0.744	0.879	0.859	0.856	0.222	0.888
4	0.785	0.650	0.713	0.766	1.147	1.152	0.907
5	0.839	0.782	0.732	0.762	0.859	0.791	0.838
6	0.867	0.833	0.880	0.756	0.852	0.736	0.752
7	0.835	0.861	0.889	0.842	0.896	0.884	0.809

Prepared by: STAN MCCAULLEY

Title: NDE / ISI

Date: 12-8-92

Reviewed by:

Level: II

Date: 12/11/92

Page 4 of 5

NDE Request No.: 91-119

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Oyster Creek - QC

Sketch Form

C-1307-187-E310-041
ATTACHMENT 1
PAGE 5 **OF** 5

Component: D/W LINER
Location: INSIDE CONTAINMENT

Data Sheet No.: 91-119-08
Drawing No.: N/A **Rev.:** N/A

DRAWING

ELEV. 11
STRIP-1D

	A	B	C	D	E	F	G
1	0.889	1.136	1.112	1.144	1.132	1.103	1.126

ELEV. 11
STRIP-3D

	A	B	C	D	E	F	G
1	1.198	1.191	1.191	1.184	1.159	1.182	1.169

ELEV. 11
STRIP-5D

	A	B	C	D	E	F	G
1	1.164	1.220	1.167	1.185	1.183	1.174	1.178

ELEV. 11
STRIP-7D

	A	B	C	D	E	F	G
1	1.147	1.149	1.150	1.150	1.111	1.127	1.122

ELEV. 11
STRIP 9A

	A	B	C	D	E	F	G
1	1.162	1.161	1.164	1.162	1.161	1.157	1.133

ELEV. 11
STRIP 13C

	A	B	C	D	E	F	G
1	1.148	1.151	1.151	1.153	1.149	1.138	1.152

ELEV. 11
STRIP 15A

	A	B	C	D	E	F	G
1	1.139	1.145	1.166	1.162	1.136	1.102	1.083

Prepared by: STAN MCCAULLEY
Title: NDE/ISI
Date: 12-8-92
Reviewed by:
Level: III
Date: 12/11/92
Page 5 **of** 5
NDE Request No.: 91-119

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GP Nuclear

Oyster Creek - QC

C-1307-187-E310-041
ATTACHMENT 2
PAGE 2 OF 4

Sketch Form

: 91-119-12

N/A | Rev. N/A ✓

Component: D/W LINER

Location: ELEVATION 13' · INSIDE CONTAINMENT

DRAWING

BAY-9D ✓

	A	B	C	D	E	F	G
1-	1.005	1.053	0.995	1.132	1.095	1.141	1.112
2-	0.921	0.956	0.999	1.027	0.983	1.060	1.077
3-	0.770	0.884	0.986	1.086	1.049	1.119	1.112
4-	0.802	0.965	0.978	0.986	1.007	1.026	1.048
5-	0.969	0.967	0.980	0.940	0.894	0.929	0.977
6-	0.959	0.855	0.971	1.018	0.982	0.971	0.943
7-	0.943	0.968	0.945	0.991	0.977	0.899	0.932

BAY-13A ✓

	A	B	C	D	E	F	G
1-	0.869	0.842	0.856	0.845	1.019	0.987	0.926
2-	0.805	0.826	0.771	0.823	0.858	0.847	0.790
3-	0.745	0.896	0.803	0.764	0.752	0.764	0.819
4-	0.851	0.873	0.861	0.853	0.787	0.793	0.845
5-	0.868	0.793	0.849	0.877	0.799	0.847	0.830
6-	0.822	0.798	0.866	0.918	0.825	0.775	0.843
7-	0.840	0.834	0.762	0.793	0.879	0.865	0.862

BAY-11A ✓

	A	B	C	D	E	F	G
1-	0.924	0.822	0.828	0.804	0.802	0.813	0.749
2-	0.805	0.826	0.836	0.823	0.824	0.791	0.790
3-	0.728	0.758	0.866	0.738	0.773	0.677	0.760
4-	0.734	0.234	1.052	0.809	0.804	0.798	0.851
5-	0.811	1.091	1.106	0.888	0.881	0.878	0.790
6-	0.750	0.896	0.808	0.845	0.905	0.834	0.869
7-	0.839	0.868	0.906	0.881	0.874	0.815	0.846

PLUG

BAY-13D ✓

	A	B	C	D	E	F	G
1-	1.100	1.114	1.110	1.078	1.062	1.103	1.113
2-	0.944	1.075	0.995	1.015	1.003	1.112	1.125
3-	0.977	0.941	0.834	0.827	0.992	1.033	1.028
4-	0.943	0.973	0.879	0.847	0.915	0.974	0.986
5-	0.951	0.911	0.871	0.873	0.923	0.903	0.899
6-	0.938	0.942	0.894	0.875	0.915	0.859	0.877
7-	0.956	0.911	0.922	0.924	0.918	0.825	0.811

BAY-11C ✓

	A	B	C	D	E	F	G
1-	EMPTY	EMPTY	EMPTY	EMPTY	EMPTY	0.855	0.886
2-	EMPTY	EMPTY	1.042	1.095	1.036	1.093	1.032
3-	1.042	1.085	0.945	0.938	0.938	0.895	0.889
4-	0.836	0.846	0.795	0.828	0.833	0.843	0.869
5-	0.823	0.842	0.873	0.872	0.837	0.822	0.879
6-	0.855	0.836	0.862	0.824	0.872	0.857	0.823
7-	0.860	0.874	0.899	0.876	0.880	0.840	0.851

BAY-15D ✓

	A	B	C	D	E	F	G
1-	1.126	1.132	1.133	1.140	1.142	1.131	1.140
2-	1.097	1.106	1.089	1.141	1.129	1.119	1.129
3-	1.063	1.025	1.046	1.067	1.096	1.080	1.097
4-	0.979	0.947	0.966	1.018	1.035	1.097	1.068
5-	0.973	0.971	1.001	1.050	1.050	1.066	1.029
6-	0.920	0.972	1.030	1.049	1.009	1.058	1.036
7-	0.903	0.958	1.013	1.031	1.004	1.052	1.076

Prepared by: R.P. SPECHT

Title: L-II

Date: 9-14-94

Reviewed by:

Level: III

Date: 9/17/94

Page 2 of 4

NDE Request No. 91-119

FORM 6130-QAP-7200.06 (12-83)

A0001025 7-84

Nuclear

C-1307-187-E310-041
ATTACHMENT 2
PAGE 3 OF 4

ch Form (with grid)

☒ OC ☐ TMI ☐ OTHER ____________

91-119-12

Component: D/W LINER

Location: ELEVATION - 13' INSIDE CONTAINMENT

N/A **Rev.:** N/A

Drawing

BAY-17A ✓

	A	B	C	D	E	F	G
1-	1.163	1.146	1.158	1.141	1.136	1.168	1.172
2-	1.122	1.155	1.122	1.144	1.128	1.157	1.133
3-	1.121	1.088	1.108	1.116	1.102	1.071	1.055
4-	0.977	0.993	0.981	0.989	1.046	1.001	0.956
5-	0.962	0.914	0.869	0.942	0.877	0.938	0.962
6-	0.861	0.963	0.894	0.820	0.809	0.947	0.984
7-	0.927	0.970	0.866	0.895	0.893	0.956	0.953

BAY-19A ✓

	A	B	C	D	E	F	G
1-	0.679	0.808	0.748	0.650	0.722	0.696	0.727
2-	0.778	0.767	0.820	0.739	0.743	0.723	0.766
3-	0.770	0.794	0.885	0.756	0.796	0.833	0.785
4-	0.889	0.900	0.266	1.143	0.795	0.771	0.759
5-	0.868	0.862	0.253	1.161	0.793	0.763	0.861
6-	0.945	0.767	0.814	0.870	0.852	0.880	0.857
7-	0.888	0.799	0.808	0.847	0.880	0.854	0.975

PLUG

BAY-17D ✓

	A	B	C	D	E	F	G
1-	0.797	0.815	0.853	0.887	0.925	0.878	0.696
2-	0.807	0.806	0.698	0.802	0.729	0.734	0.646
3-	1.008	0.243	0.749	0.741	0.816	0.735	0.662
4-	1.068	1.066	0.739	0.812	0.772	0.793	0.785
5-	0.804	0.836	0.838	0.794	0.853	0.828	0.842
6-	0.790	0.825	0.885	0.847	0.872	0.853	0.795
7-	0.827	0.899	0.826	0.863	0.922	0.934	0.835

PLUG

BAY-19B

	A	B	C	D	E	F	G
1-	0.864	0.831	0.831	0.918	0.897	0.868	0.796
2-	0.829	0.816	0.775	0.834	0.857	0.770	0.827
3-	0.866	0.866	0.819	0.850	0.914	0.847	0.801
4-	0.811	0.815	0.750	0.845	0.752	0.769	0.754
5-	0.782	0.764	0.783	0.778	0.807	0.716	0.689
6-	0.825	0.785	0.883	0.888	0.931	0.818	0.745
7-	0.863	0.817	0.930	0.821	0.853	0.893	0.843

17-19 CUTOUT ✓

	A	B	C	D	E	F	G
1-	0.921	0.957	0.955	0.967	0.960	0.952	0.922
2-	0.955	0.970	0.955	1.001	0.945	0.957	0.970
3-	0.982	0.977	0.991	0.993	0.969	0.995	0.933
4-	1.039	0.965	0.973	0.979	0.997	0.985	0.953
5-	0.959	1.002	0.953	0.942	0.943	0.975	0.906
6-	0.998	0.995	0.967	0.938	0.834	0.960	0.980
7-	1.027	1.008	1.011	0.992	1.038	0.993	0.983

✓ BAY-19C

	A	B	C	D	E	F	G
1-	0.816	0.757	0.820	0.979	0.904	0.952	0.917
2-	0.677	0.738	0.694	0.798	0.762	0.897	0.831
3-	0.813	0.736	0.876	0.855	0.838	0.221	0.884
4-	0.787	0.666	0.718	0.762	1.153	1.149	0.906
5-	0.841	0.782	0.734	0.764	0.856	0.787	0.834
6-	0.871	0.832	0.886	0.766	0.867	0.735	0.748
7-	0.836	0.853	0.892	0.851	0.900	0.902	0.831

Prepared by: R.P. SPECHT

Title: L-II

Date: 9-14-94

Reviewed by:

Level: III

Date: 9/17/94

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NDE Request No.: 91-119

M6130-QAP-7200.06 (12-83)

N5454 (05-90)

Nuclear

☒ OC ☐ TMI ☐ OTHER ______________

Sketch Form (with grid)

Component:	D/W LINER	Data Sheet No.:	91-119-12
Location:	ELEVATION 11' INSIDE CONTAINMENT	Drawing No.: N/A	Rev.: N/A

Drawing

STRIP-1D ✓

	A	B	C	D	E	F	G
4-	0.879	1.054	1.105	1.119	1.124	1.088	1.118

STRIP-3D ✓

	A	B	C	D	E	F	G
4-	1.194	1.194	1.191	1.194	1.164	1.184	1.168

STRIP-5D ✓

	A	B	C	D	E	F	G
4-	1.163	1.172	1.155	1.174	1.171	1.171	1.173

STRIP-7D ✓

	A	B	C	D	E	F	G
4-	1.143	1.146	1.137	1.146	1.135	1.134	1.113

STRIP-9A

	A	B	C	D	E	F	G
4-	1.162	1:164	1.168	1.163	1.157	1.155	1.132

STRIP-13C

	A	B	C	D	E	F	G
4-	1.147	1.147	1.146	1.147	1.128	1.123	1.139

STRIP-15A ✓

	A	B	C	D	E	F	G
4-	1.142	1.142	1.140	1.134	1.138	1.064	1.040

C-1307-187-E310-041
ATTACHMENT 2
PAGE 4 **OF** 4

Prepared by: R.P. SPECHT			Title: L-II		Date: 9-14-94
Reviewed by:	Level:	Date:-	Page 4 of 4	NDE Request No.: 91-119	

RM6130-QAP-7200.06 (12-83)

N5454 (05-90)

REPORT # 1R21LR-001 Pg 1 of 5

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/18/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 5		Specification:	IS-328227-004

Examiner: Matt Wilson	Level: II	Instrument Type:	Panametrics 37DL Plus
Examiner: Leslie Richter	Level: II	Instrument No:	031125409

Transducer Type: DV 506	Serial #: 072561	Size: 0.438"	Freq: 5 Mhz	Angle: 0°
Transducer Cable Type: Panametrics Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-088			

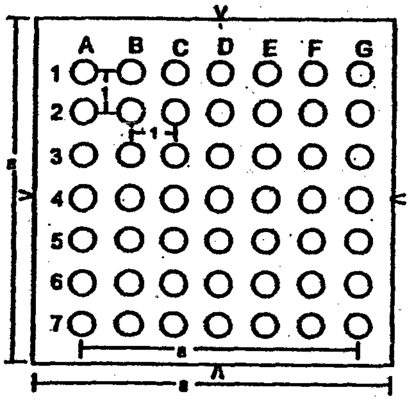
SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	2.0"	10:00	See Data	See Data	14:32	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.300"	Inches to	1.500"	Inches	
Delay Calib:	N/A	Thermometer:	246647	Comp. Temp: 72°	Block Temp:	81°
Range Calib:	N/A	W/O Number:	R2090917			
Instrument Freq.	N/A	Total Crew Dose	Drywell Containment Vessel Thickness Examination. Internal UT Inspections.			
Gain:	67 db	[redacted] mr				

'emplate aligned to V Stamps.

'ickness readings taken at holes located in template.

C-1307-187-E310-041
ATTACHMENT 4
PAGE 1 OF 5



Location ID	9D		Bay	9	Elev.	11' 3"
	A	B	C	D	E	F	G
1	1.005	1.056	0.985	1.133	1.132	1.136	1.101
2	0.896	0.927	1.067	1.037	0.974	1.077	1.069
3	0.751	0.883	0.975	1.071	1.033	1.105	1.123
4	0.885	0.993	0.949	0.984	0.995	1.022	1.041
6	0.980	0.968	0.936	0.942	0.880	0.927	0.998
6	0.960	0.869	0.976	0.987	0.967	0.965	0.949
7	0.968	0.967	0.963	1.004	0.947	0.892	0.943

Calibration Check: 10:15	
Tscr.	AVG.
.628	0.988

Location ID	11A		Bay	11	Elev.	11' 3"	
	A	B	C	D	E	F	G
1	0.905	0.832	0.829	0.803	0.830	0.812	0.737
2	0.797	0.825	0.834	0.822	0.858	0.783	0.795
3	0.720	0.766	0.858	0.731	0.762	0.669	0.764
4	0.739	1.047	1.057	0.806	0.761	0.821	0.849
5	0.843	1.090	1.104	0.879	0.879	0.854	0.817
6	0.741	0.897	0.818	0.890	0.907	0.833	0.826
7	0.875	0.869	0.923	0.886	0.871	0.810	0.842

COMMENTS:
Core Plug located at C04, C05, B04, B05.

Calibration Check: 10:32	
Tscr.	AVG.
.628	0.846

COMMENTS: File Specific Comments located to right of readings.

Location ID 11C: The following template holes were painted onto the plate using the template. The readings were then taken with the template removed. This was done due to the Drywell Vent Attachment weld obstructing the template. Row 1 A through G, Row 2 A through C, Row 7 C through D.

Exam'd L III 10-20-06

Reviewed by: Lee Stone Level II Date 10/18/2006

1R21LR-001 Pg 2 of 5

General Electric		File Name:	N/A
Oyster Creek		Date:	10/18/2006
Refueling Outage -	1R21	UT Procedure:	ER-AA-335-004
Page 2 of	5	Grid Procedure:	IS-328227-004

Ultrasonic Thickness Measurement Data Sheet

Location ID		11C		Bay	11	Elev.	11' 3"
	A	B	C	D	E	F	G
1	OBST.	0.771	0.803	0.912	0.767	0.858	0.886
2	1.056	1.046	0.984	1.094	1.036	1.118	1.029
3	1.073	1.113	1.002	0.935	0.942	0.888	0.853
4	0.837	0.836	0.790	0.874	0.834	0.846	0.838
5	0.850	0.825	0.869	0.889	0.833	0.866	0.876
6	0.856	0.840	0.864	0.829	0.872	0.876	0.844
7	0.861	0.877	0.879	0.885	0.880	0.849	0.876

Calibration Check: 10:46

COMMENTS: A01 obstructed due to D.W Vent attachment weld. B01 reading taken adjacent to D.W. attachment weld.
See Comments above.

Tscr.	AVG.
.628	0.898

Location ID		13A		Bay	13	Elev.	11' 3"
	A	B	C	D	E	F	G
1	0.887	0.833	0.887	0.906	1.046	0.951	0.922
2	0.823	0.883	0.774	0.826	0.897	0.870	0.783
3	0.760	0.913	0.798	0.823	0.746	0.759	0.768
4	0.845	0.895	0.875	0.848	0.788	0.799	0.852
5	0.880	0.811	0.861	0.869	0.798	0.846	0.840
6	0.816	0.813	0.869	0.924	0.824	0.785	0.870
7	0.801	0.834	0.763	0.838	0.895	0.885	0.863

Calibration Check: 11:02

Tscr.	AVG.
.628	0.846

Location ID		13D		Bay	13	Elev.	11' 3"
	A	B	C	D	E	F	G
1	1.114	1.117	1.132	1.083	1.068	1.106	1.119
2	0.950	1.041	0.999	1.061	1.007	1.117	1.100
3	0.986	0.950	0.837	0.833	0.949	1.088	1.085
4	1.005	0.877	0.878	0.851	0.911	0.958	0.997
5	0.960	0.907	0.874	0.874	0.915	0.916	0.905
6	0.944	0.947	0.897	0.887	0.920	0.865	0.892
7	0.996	0.939	0.929	0.958	0.944	0.832	0.821

Calibration Check: 11:16

Tscr.	AVG.
.628	0.968

Location ID		15D		Bay	15	Elev.	11' 3"
	A	B	C	D	E	F	G
1	1.133	1.133	1.133	1.141	1.145	1.145	1.144
2	1.094	1.109	1.087	1.142	1.129	1.119	1.131
3	1.040	1.026	1.043	1.081	1.095	1.085	1.096
4	0.978	0.948	0.975	1.029	1.030	1.096	1.068
5	0.976	0.969	0.977	1.069	1.013	1.067	1.041
6	0.930	0.979	1.031	1.037	1.017	1.059	1.051
7	0.922	0.972	0.996	1.031	1.005	1.033	1.052

Calibration Check: 11:30

Tscr.	AVG.
.628	1.054

Location ID		17A		Bay	17	Elev.	11' 3"
	A	B	C	D	E	F	G
1	1.110	1.149	1.164	1.138	1.130	1.170	1.169
2	1.121	1.159	1.114	1.144	1.134	1.148	1.123
3	1.068	1.073	1.111	1.114	1.094	1.053	1.053
4	0.976	0.991	0.980	1.030	1.046	0.994	0.950
5	0.962	0.926	0.909	0.950	0.869	0.938	0.967
6	0.903	0.956	0.891	0.835	0.802	0.950	0.963
7	0.954	0.972	0.677	0.890	0.875	0.891	0.945

Calibration Check: 11:43

Tscr.	AVG.
.628	1.015

MM' 10-20-06

Examined by Matt Wilson Matt Wilson Level II Date 10/18/2006
Examined by Leslie Richter Level II Date 10/18/2006
Reviewed by: Lee Stone Level II Date 10/18/2006

C-1307-187-E310-041
ATTACHMENT 4
PAGE 2 OF

1R21LR-001 Pg 3 of 5

General Electric		**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek			Date:	10/18/2006
Refueling Outage -	1R21		UT Procedure:	ER-AA-335-004
Page 3 of	5		Specification:	IS-328227-004

Location ID	17D		Bay	17	Elev.	11' 3"
	A	B	C	D	E	F	G
1	0.849	0.828	0.861	0.894	0.930	0.888	0.702
2	0.806	0.802	0.717	0.806	0.736	0.756	0.648
3	0.998	0.823	0.752	0.733	0.822	0.730	0.667
4	1.072	1.074	0.742	0.812	0.812	0.803	0.791
5	0.814	0.841	0.850	0.816	0.852	0.856	0.869
6	0.792	0.829	0.888	0.846	0.888	0.855	0.800
7	0.824	0.897	0.837	0.887	0.891	0.935	0.886

Calibration Check: 11:59

COMMENTS:
Core Plug located at A03, A04 and B03, B04.

Tscr.	AVG.

Location ID	17/19		Bay	17	Elev.	11' 3"	Call
	A	B	C	D	E	F	G
1	0.969	0.962	0.945	0.931	0.965	0.960	0.928
2	0.972	0.977	0.959	0.991	0.967	0.956	0.937
3	0.968	0.974	1.004	0.987	0.982	0.996	0.924
4	1.022	0.959	0.963	0.974	0.993	0.985	0.952
5	0.960	0.962	0.951	0.950	0.943	0.982	0.901
6	1.001	0.994	0.952	0.929	0.917	0.962	1.001
7	0.995	1.019	1.012	0.995	1.009	0.946	1.000

Tscr.	AVG.
.628	0.969

C-1307-187-E310-041
ATTACHMENT 4
PAGE 3 OF __

Location ID	19A		Bay	19	Elev.	11' 3"
	A	B	C	D	E	F	G
1	0.692	0.788	0.743	0.648	0.699	0.702	0.735
2	0.807	0.774	0.845	0.736	0.747	0.724	0.773
3	0.813	0.812	0.892	0.885	0.861	0.792	0.806
4	0.916	0.883	0.805	1.179	0.808	0.777	0.766
5	0.873	0.904	0.842	1.160	0.801	0.752	0.878
6	0.844	0.768	0.834	0.858	0.851	0.834	0.867
7	0.865	0.803	0.793	0.844	0.878	0.817	0.808

Calibration Check: 12:26

COMMENTS:
Core Plug located at D04, D05, and C04, C05.

Tscr.	AVG.
.628	0.822

Location ID	19B		Bay	19	Elev.	11' 3"
	A	B	C	D	E	F	G
1	0.865	0.862	0.872	0.932	0.947	0.992	0.802
2	0.842	0.883	0.780	0.840	0.916	0.778	0.866
3	0.861	0.906	0.838	0.898	0.974	0.930	0.834
4	0.869	0.883	0.807	0.801	0.766	0.834	0.774
5	0.811	0.770	0.785	0.788	0.799	0.731	0.778
6	0.828	0.787	0.885	0.891	0.934	0.834	0.738
7	0.872	0.822	0.904	0.828	0.843	0.876	0.871

Calibration Check: 12:39

Tscr.	AVG.
.628	0.847

Location ID	19C		Bay	19	Elev.	11' 3"
	A	B	C	D	E	F	G
1	0.809	0.768	0.862	1.059	0.968	0.961	0.920
2	0.679	0.745	0.695	0.814	0.766	0.865	0.845
3	0.816	0.776	0.870	0.871	0.863	Obst.	0.898
4	0.791	0.660	0.716	0.793	1.151	1.164	0.918
5	0.851	0.781	0.733	0.762	0.862	0.787	0.796
6	0.866	0.830	0.880	0.757	0.867	0.760	0.753
7	0.801	0.794	0.852	0.841	0.901	0.906	0.840

Calibration Check: 12:53

COMMENTS:
Core Plug located at F03, F04, G03, G04. F03 obstructed due to surface condition.
A01-A07 taken on Vertical Weld.

Tscr.	AVG.
.628	0.839

MW 10-20-06

Examined by Matt Wilson MattWil Level II Date 10/18/2006
Examined by Leslie Richter Level II Date 10/18/2006
Reviewed by: Lee Stone Level II Date 10/18/2006

1R21LR-001 - Pg 4 of 5

General Electric		File Name:	N/A
Oyster Creek		Date:	10/18/2006
Refueling Outage -	1R21	UT Procedure:	ER-AA-335-004
Page 4 of	5	Specification:	IS-328227-004

Ultrasonic Thickness Measurement Data Sheet

Location ID	1D		Bay	1	Elev.	11' 3"	
	A	B	C	D	E	F	G
1	0.881	1.156	1.104	1.124	1.134	1.093	1.122

Calibration Check: 13:05

Tscr.	AVG.
.628	1.088

Location ID	3D		Bay	3	Elev.	11' 3"	
	A	B	C	D	E	F	G
1	1.199	1.169	1.187	1.173	1.156	1.187	1.166

Calibration Check: 13:14

Tscr.	AVG.
.628	1.180

Location ID	5D		Bay		Elev.	11' 3"	
	A	B	C	D	E	F	G
1	1.174	1.191	1.186	1.187	1.187	1.184	1.184

Calibration Check: 13:23

Tscr.	AVG.
.628	1.185

Location ID	7D		Bay	7	Elev.	11' 3"	
	A	B	C	D	E	F	G
1	1.144	1.147	1.147	1.138	1.102	1.135	1.116

Calibration Check: 13:31

Tscr.	AVG.
.628	1.133

Location ID	9A		Bay	9	Elev.	11' 3"	
	A	B	C	D	E	F	G
1	1.158	1.159	1.162	1.159	1.159	1.153	1.130

Calibration Check: 13:40

Tscr.	AVG.
.628	1.154

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[illegible] 10-20-06

Examined by Matt Wilson	Matt Wilson	Level II	Date 10/18/2006
Examined by Leslie Richter		Level II	Date 10/18/2006
Reviewed by: Lee Stone		Level II	Date 10/18/2006

1R21LR-001 Pg 5 of 5

General Electric		**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek			Date:	10/18/2006
Refueling Outage -	1R21		UT Procedure:	ER-AA-335-004
Page 5 of	5		Specification:	IS-328227-004

Location ID	13C		Bay	13	Elev.	11' 3"	Calibration Check: 13:48
	A	B	C	D	E	F	G
1	1.146	1.148	1.148	1.149	1.144	1.128	1.134

Tscr.	AVG.
.628	1.142

Location ID	16A		Bay	16	Elev.		Calibration Check: 14:00
	A	B	C	D	E	F	G
1	1.180	1.129	1.136	1.129	1.146	1.077	1.049

Tscr.	AVG.
.628	1.121

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MW 10-20-06

Examined by Matt Wilson Level II Date 10/18/2006
Examined by Leslie Richter Level II Date 10/18/2006
Reviewed by: Lee Stone Level II Date 10/18/2006

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Pg 1 of 2

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/22/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Leslie Richter		Level:	II	Instrument Type:	Panametrics 37DL Plus
Examiner: N/A		Level:	N/A	Instrument No:	031124909

Transducer Type:	D795	Serial #:	104012	Size:	0.200"	Freq:	5 Mhz	Angle: 0°
Transducer Cable Type:	Panametrics	Length:	5'	Couplant:	Soundsafe	Batch No:	19620	
Calibration Block Type:	C/S Step Wedge	Block Number:	CAL-STEP-080					

SYSTEM CALIBRATION

INSTRUMENT SETTINGS						
Coarse Range:	5.0"	Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Delay:	N/A	11:59	13:00	13:30	14:30	
Delay Calib:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches				
Range Calib:	N/A	Thermometer: 246647		Comp. Temp: 82°	Block Temp: 79°	
Instrument Freq.	N/A	W/O Number:	~~R2088926~~			
Gain:	74 db	Total Crew Dose [redacted] mr	C 2013477 Drywell Containment Vessel Thickness Examination. 10-22-06 External UT Inspections.			
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 1

BAY	Point Number		Vertical Location			Horizontal Location			Thi

See Attached for Locations and Thickness Readings

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ATTACHMENT 5
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COMMENTS: Coated surface is rough at all reading points. Unable to slide off of best measurement spot. Plot measurement numbers are more accurate if measuring tape is placed 13" to the right from the center of the weld on the zzle, then follow down passing through point # 8.

L III 10-22-06

Reviewed by: Lee Stone Level II Date 10/22/2006

DAY 1

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D16	R27	0.720	0.710	
	2	D22	R17	0.716	0.690	
	3	D23	L3	0.705	0.665	
	4	D24	L33	0.760	0.738	Very Rough Surface
	5	D24	L45	0.710	0.680	
	6	D48	R19	0.760	0.731	
	7	D39	R7	0.700	0.669	
	8	D48	R0	0.805	0.783	
	9	D36	L38	0.805	0.754	
	10	D16	R23	0.839	0.824	
	11	D23	R12	0.714	0.711	
	12	D24	L5	0.724	0.722	
	13	D24	L40	0.792	0.719	
	14	D2	R35	1.147	1.157	
	15	D8	L51	1.156	1.160	
	16	D50	R40	0.796	0.795	
	17	D40	R16	0.860	0.846	
	18	D38	L2	0.917	0.899	
	19	D38	L24	0.890	0.865	
	20	D18	R13	0.965	0.912	
	21	D24	R15	0.726	0.712	
	22	D32	R13	0.852	0.854	
	23	D48	R15	0.850	0.828	

Data obtained from
NDE Data Sheets 92-072-12 page 1 of 1
NDE Data Sheets 92-072-18 page 1 of 1
NDE Data Sheets 92-072-19 page 1 of 1
All horizonal measurements taken 13" to the right of the centerline of the reinforcement ring (Boss).
All vertical measurements taken from bottom of vent nozzle at the 13" reference line.
Surface roughness prohibited characterization of all readings.

Note: Per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

10-22-06

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ATTACHMENT 5
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IC-OILR-U44
Pg 2 of 2
[illegible] III 10-22-06

1R21 LR-012 Pg 1 of 2

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/20/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Scott Erickson Scott R. Erickson	Level: II	Instrument Type:	Panametrics 37DL Plus
Examiner: N/A	Level: N/A	Instrument No:	031120708

Transducer Type: D7908	Serial #: 338302	Size: 0.200"	Freq: 7.5 Mhz	Angle: 0°
Transducer Cable Type: Panametrics Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-136			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	2.0"	22:05	N/A	N/A	23:50	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500"	Inches to	1.500" Inches		
Delay Calib:	N/A	Thermometer:	246647	Comp. Temp: 78°	Block Temp:	75°
Range Calib:	N/A	W/O Number:	C2013477			
Instrument Freq.	N/A	Total Crew Dose	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	54 db	[redacted] mr				
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 3

BAY	Point Number	▨	Vertical Location		▨	Horizonal Location		▨	Thickness Reading

See Attached for Locations and Thickness Readings

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COMMENTS: N/A

L III 10-22-06

Reviewed by: Lee Stone   Level II   Date 10/19/2006

BAY 3

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D16	R63	0.795	0.795	N/A
	2	D18	R48	1	0.999	
	3	D17	R33	0.857	0.850	
	4	D13	L5	0.898	0.903	
	5	D25	L8	0.823	0.819	
	6	D15	L56	0.968	0.972	
	7	D29	R4	0.826	0.816	
	8	D34	L4	0.78	0.764	

Data obtained from
NDE Data Sheets 92-072-14 page 1 of 1
Note: Per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

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REPORT # 1R21LR-019
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General Electric
Oyster Creek
Refueling Outage - 1R21
Page 1 of 2

Ultrasonic Thickness Measurement Data Sheet

File Name: N/A
Date: 10/20/2006
UT Procedure: ER-AA-335-004
Specification: IS-328227-004

Examiner: Leslie Richter | Level: II | Instrument Type: Panametrics 37DL Plus
Examiner: N/A | Level: N/A | Instrument No: 031124909
Transducer Type: D795 | Serial #: 104012 | Size: 0.200" | Freq: 5 Mhz | Angle: 0°
Transducer Cable Type: Panametrics Length: 5' | Couplant: Soundsafe | Batch No: 19620
Calibration Block Type: C/S Step Wedge | Block Number: CAL-STEP-136

SYSTEM CALIBRATION

INSTRUMENT SETTINGS	
Coarse Range:	5.0"
Coarse Delay:	N/A
Delay Calib:	N/A
Range Calib:	N/A
Instrument Freq.	N/A
Gain:	72 db
Damping:	N/A
Reject:	N/A
Filter:	N/A

Initial Cal. Time	Calibration Checks		Final Cal. Time
15:38	15:51	16:45	17:28

Calibrated Sweep Range = 0.500" Inches to 1.500" Inches
Thermometer: 246647 | Comp. Temp: 82° | Block Temp: 76°
W/O Number: C2013477
Total Crew Dose [redacted] mr
Drywell Containment Vessel Thickness Examination. External UT Inspections.

Bay - 5

BAY	Point Number		Vertical Location		Horizonal Location		Thickness Reading

See Attached for Locations and Thickness Readings

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COMMENTS: N/A

LIII 10-22-06

Reviewed by: Scott Erickson Scott R. Erickson Level II Date 10/19/2006

1R21LR-019 Pg 2 of 2
[illegible] 10-22-06

BAY 5

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
*	1	D38	R12	0.97	0.948	up .97 dn .97
*	2	D38	R7	1.04	0.955	Rough surface - up .99 dn .99
*	3	D42	R10	1.02	0.989	up 1.0 dn 1.04
*	4	D41	L7	0.97	0.948	Rough surface, also dished
*	5	D42	L11	0.89	0.88	Rough surface
**	6	D47	R5	1.06	0.981	up 1.018 dn 1.014
**	7	D48	L18	0.99	0.974	Rough surface left .99 right N/A
**	8	D46	L31	1.01	1.007	Rough surface

Note: up, dn, left & right readings were taken 1/8" from recorded 2006 value reading.
Rough surface limited taking additional readings. Reference above.
* =Vertical and horizontal measurements taken from top of coating on long seam 62" to right
** =Vertical and horizontal measurements taken from bottom of nozzle at 6 o'clock position
Reference NDE Data Sheets 92-072-16 page 1 of 1

1 - Reference off the weld 62" to the right of the centerline of the bay.
2 The original data sheet is not clear as to whether this point is to the right or left of the weld. Therefore NDE shall verify this dimension.

Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

10-20-06

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1R21LR-005 · Pg 1 of 2

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/19/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004-*

Examiner: Lee Stone		Level:	II	Instrument Type:	Panametrics 37DL Plus
Examiner: N/A		Level:	N/A	Instrument No:	031124909
Transducer Type: D795	Serial #: 1103007	Size: 0.200"	Freq: 5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant	Soundsafe	Batch No:	19620
Calibration Block Type: C/S Step Wedge	Block Number:	CAL-STEP-109			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS						
Coarse Range:	5.0"	Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Delay:	N/A	14:20	N/A	N/A	15:10	
Delay Calib:	N/A	Calibrated Sweep Range = 0.500"	Inches to	1.500"	Inches	
Range Calib:	N/A	Thermometer: 246737	Comp. Temp:	72°	Block Temp: 74°	
Instrument Freq.	N/A	W/O Number: C2013477				
Gain:	67 db	Total Crew Dose [redacted]mr	Drywell Containment Vessel Thickness Examination. External UT inspections.			
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 7

BAY	Point Number		Vertical Location			Horizonal Location	

See Attached for Locations and Thickness Readings

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ATTACHMENT 5
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COMMENTS: ~~N/A~~
* INSPECTION PERFORMED IAW ENGINEERING DIRECTION
REF. REV 14 DRAFT. 10-22-06

LIII 10-22-06

Reviewed by: Kimberly Wert Kimberly Wert Level II Date 10/19/2006

BAY 7

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D21	R39	0.92	N/A	Could not locate area
	2	D21	R32	1.016	N/A	Could not locate area
	3	D10	R20	0.984	0.964	up/dn ranged from 0.956 to 0.980
	4	D10	R10	1.04	1.04	N/A
	5	D21	L6	1.03	1.003	up/dn ranged from 1.000 to 1.049
	6	D10	L23	1.045	1.023	up/dn ranged from 1.020 to 1.052
	7	D21	L12	1	1.003	up/dn ranged from 1.002 to 1.026

Data obtained from
NDE Data Sheets 92-072-20 page 1 of 1
Note: up, dn readings were taken 1/8" from recorded 2006 value reading.

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General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/19/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Scott Erickson Scott R. Erickson		Level:	II	Instrument Type:	Panametrics 37DL Plus		
Examiner: N/A		Level:	N/A	Instrument No:	031120708		
Transducer Type: D7908	Serial #: 338302	Size:	0.200"	Freq:	7.5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics Length: 5'		Couplant:	Soundsafe	Batch No:	19620		
Calibration Block Type: C/S Step Wedge		Block Number:	CAL-STEP-080				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	2.0"	22:05	N/A	N/A	23:50	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches				
Delay Calib:	N/A	Thermometer: 246737		Comp. Temp: 74°	Block Temp: 72°	
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose [redacted] mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	61 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 9

BAY	Point Number		Vertical Location			Horizonal Location	

See Attached for Locations and Thickness Readings

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ATTACHMENT 5
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COMMENTS: N/A

L III 10-22-06

Reviewed by: Lee Stone Lee Stone Level II Date 10/19/2006

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BAY 9

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D29	R32	0.96	0.968	N/A
	2	D18	R17	0.94	0.934	
	3	D20	R8	0.994	0.989	
	4	D27	R15	1.02	1.016	
	5	D35	L5	0.985	0.964	
	6	D13	L30	0.82	0.802	
	7	D16	L35	0.825	0.82	
	8	D21	L38	0.791	0.781	
	9	D20	L53	0.832	0.823	
	10	D30	L8	0.98	0.955	

Data obtained from
NDE Data Sheets 92-072-22 page 1 of 1

Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

1R21LR-006 Pg. 2 of 2

MK'L III
10-22-06

1R21CR-008 . Pg 1 of 2
10-22-06

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/20/2006
'efueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Graham McNabb	Level: II	Instrument Type:	Panametrics 37DL Plus
Examiner: N/A	Level: N/A	Instrument No:	031124909

Transducer Type: D795	Serial #: 104010	Size: 0.200"	Freq: 5 Mhz	Angle: 0°
Transducer Cable Type: Panametrics Length: 5'	Couplant: Soundsafe		Batch No:	19620
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-080			

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time
Coarse Range:	5.0"	2:15	N/A	N/A	5:15
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches			
Delay Calib:	N/A	Thermometer: 246534	Comp. Temp: 74°		Block Temp: 72°
Range Calib:	N/A	W/O Number: C2013477			
Instrument Freq.	N/A	Total Crew Dose [redacted]mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.		
Gain:	58 db				
Damping:	N/A				
Reject:	N/A				
Filter:	N/A				

Bay - 11

BAY	Point Number		Vertical Location			Horizonal Location	

See Attached for Locations and Thickness Readings

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ATTACHMENT 1
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COMMENTS: N/A

L III 10-22-06

Reviewed by: Scott Erickson Scott R. Erickson Level II Date 10/20/2006

BAY 11

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D20	R29	0.705	0.700	N/A
	2	D25	R32	0.77	0.760	
	3	D21	L4	0.832	0.830	
	4	D24	L6	0.755	0.751	
	5	D32	L14	0.831	0.823	
	6	D27	L22	0.8	0.756	
	7	D31	R20	0.831	0.817	
	8	D40	R13	0.85	0.825	

Data obtained from
NDE Data Sheets 92-072-10 page 1 of 1
Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

MMc L III 10-22-06

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1R21LR-010 Pg 1 of 2

General Electric	# Ultrasonic Thickness Measurement Data Sheet	File Name:	N/A
Oyster Creek		Date:	10/19/2006
Refueling Outage -	1R21	UT Procedure:	ER-AA-335-004
Page 1 of	2	Specification	IS-328227-004

Examiner: Scott Erickson Scott R. Erickson	Level: II	Instrument Type:	Panametrics 37DL Plus
Examiner: N/A	Level: N/A	Instrument No:	031120708

Transducer Type: D799	Serial #: 104044	Size: 0.312"	Freq: 5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe	Batch No: 04120B		
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-109				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	3:00	N/A	N/A	4:15	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches				
Delay Calib:	N/A	Thermometer: 246737		Comp. Temp: 72°	Block Temp: 70°	
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose [redacted] mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	51 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 13

BAY	Point Number		Vertical Location			Horizontal Location	

See Attached for Locations and Thickness Readings

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ATTACHMENT 5
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COMMENTS: N/A

III 10-22-06

Reviewed by: Lee Stone Level II Date 10/19/2006

BAY 13

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	U1	R45	0.672	N/A	Could not locate area
	2	U1	R38	0.729	N/A	Could not locate area
	3	D21	R48	0.941	0.923	
	4	D12	R36	0.915	0.873	
	5	D21	R6	0.718	0.708	
	6	D24	L8	0.655	0.658	
	7	D17	L23	0.618	0.602	
	8	D24	L20	0.718	0.704	
	9	D28	R41	0.924	0.915	
	10	D28	R12	0.728	0.741	
	11	D28	L15	0.685	0.669	
	12	D28	L23	0.885	0.886	
	13	D18	D40	0.932	0.814	
	14	D18	R8	0.868	0.870	
	15	D20	L9	0.683	0.666	
	16	D20	L29	0.829	0.814	
	17	D9	R38	0.807	N/A	Could not locate area
	18	D22	R38	0.825	N/A	Could not locate area
	19	D37	R38	0.912	0.916	

Data obtained from
NDE Data Sheets 92-072-24 page 1 of 2
Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

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ATTACHMENT 5
PAGE 4 OF ___

L III-10-22-06

1R21LR-06-Pg 2 of 2

1R21CR-015 Pg 1 of 2

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/20/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Matt Wilson Matt Wilson	Level: II	Instrument Type:	Panametrics 37DL Plus
Examiner: N/A	Level: N/A	Instrument No:	031124709

Transducer Type: D795	Serial #: 1103008	Size: 0.200"	Freq: 5 Mhz
Angle: 0°			
Transducer Cable Type: Panametrics Length: 5'	Couplant: Soundsafe	Batch No:	19620
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-088		

SYSTEM CALIBRATION

INSTRUMENT SETTINGS		Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Range:	5.0"	10:30	12:10	12:33	13:05	
Coarse Delay:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches				
Delay Calib:	N/A	Thermometer: 246484		Comp. Temp: 82°	Block Temp: 76°	
Range Calib:	N/A	W/O Number: C2013477				
Instrument Freq.	N/A	Total Crew Dose [redacted] mr	Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Gain:	67 db					
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 15

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ATTACHMENT 1
PAGE 15 OF

BAY	Point Number		Vertical Location			Horizonal Location	

See Attached for Locations and Thickness Readings

COMMENTS: N/A

L III 10-22-06

Reviewed by: Lee Stone Lee Stone Level II Date 10/20/2006

BAY 15

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D12	R26	0.786	0.779	0.711 to 0.779
	2	D22	R21	0.829	0.798	0.777 to 0.798
	3	D33	R17	0.932	0.935	
	4	D30	R7	0.795	0.791	
	5	D26	L3	0.85	0.855	0.817 to 0.855
	6	D6	L8	0.794	0.787	0.715 to 0.787
	7	D26	L18	0.808	0.805	
	8	D20	L36	0.77	0.760	
	9	D36	L44	0.722	0.749	0.720 to 0.749
	10	D24	L48	0.86	0.852	0.837 to 0.852
	11	D24	L65	0.825	0.843	0.798 to 0.843

Data obtained from
NDE Data Sheets 92-072-21 page 1 of 1
Note: scanned 0.25" area around recorded 2006 value number - see comments for ranges.

C-1307-187-E310-041
ATTACHMENT 5
PAGE 6 OF —

1R21LR-015 Pg 2 of 2

Pg. 1 of 2 021

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name: N/A
Oyster Creek		Date: 10/19/2006
Refueling Outage - 1R21		UT Procedure: ER-AA-335-004
Page 1 of 2		Specification IS-328227-004

Examiner: Matt Wilson	Matt Wilson	Level: II	Instrument Type: Panametrics 37DL Plus		
Examiner: N/A		Level: N/A	Instrument No: 031124709		
Transducer Type: D795	Serial #: 104010	Size: 0.200"	Freq: 5 Mhz	Angle: 0°	
Transducer Cable Type: Panametrics	Length: 5'	Couplant: Soundsafe		Batch No: 19620	
Calibration Block Type: C/S Step Wedge	Block Number: CAL-STEP-088				

SYSTEM CALIBRATION

INSTRUMENT SETTINGS							
Coarse Range:	5.0"	Initial Cal. Time	Calibration Checks		Final Cal. Time		
Coarse Delay:	N/A	15:36	N/A	N/A	17:18		
Delay Calib:	N/A	Calibrated Sweep Range =	0.500"	Inches to	1.500"	Inches	
Range Calib:	N/A	Thermometer:	246534	Comp. Temp:	82°	Block Temp:	78°
Instrument Freq.	N/A	W/O Number:	C2013477				
Gain:	67 db	Total Crew Dose	Drywell Containment Vessel Thickness Examination. External UT Inspections.				
Damping:	N/A	▨mr					
Reject:	N/A						
Filter:	N/A						

Bay - 17

BAY	Point Number	▨	Vertical Location		▨	Horizon Locatio
		▨			▨	

See Attached for Locations and Thickness Readings

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ATTACHMENT 5
PAGE 12 **OF** —

COMMENTS: N/A

10-22-06

Reviewed by: Scott Erickson Scott R Erickson	Level II	Date	10/19/2006

Report 1R21LR-014
Page 2 of 2 021
10-22-06

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ATTACHMENT 5
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BAY 17

Note: measurement from vent pipe CL to floor 60"

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D12	R50	0.916	0.909	
	2	D9	R40	1.150	0.681	up .705 dn .663
	3	D16	R26	0.898	0.894	
	4	D34	R24	0.951	0.963	
	5	D6	R20	0.913	0.822	
	6	D17	R7	0.992	0.909	
	7	D18	L14	0.970	0.970	
	8	D34	L46	0.990	0.960	
	9	D21	L29	0.720	0.970	
	10	D3	L2	0.830	0.844	
	11	N/A	N/A	N/A	N/A	

Note: Down measurements taken from bottom of boss which is 18" below vent line.
Locations 8,9, & 3 look to be un-prepped flat areas of the original surface.
All left, right measurements taken from 8" left of liner long seam
Data obtained from
NDE Data Sheets 92-072-08 page 1 of 1

Note: Per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

Matthew E. Watson 10-19-2006

Repair #1R21LR-018
-020

Page 1 of 2

General Electric	**Ultrasonic Thickness Measurement Data Sheet**	File Name:	N/A
Oyster Creek		Date:	10/22/2006
Refueling Outage - 1R21		UT Procedure:	ER-AA-335-004
Page 1 of 2		Specification	IS-328227-004

Examiner: Matt Wilson	Level: II	Instrument Type: Panametrics 37DL Plus
Examiner: N/A	Level: N/A	Instrument No: 031124709

Transducer Type: D795 | Serial #: 104010 | Size: 0.200" | Freq: 5 Mhz | Angle: 0°

Transducer Cable Type: Panametrics Length: 5' | Couplant: Soundsafe | Batch No: 19620

Calibration Block Type: C/S Step Wedge | Block Number: CAL-STEP-088

SYSTEM CALIBRATION

INSTRUMENT SETTINGS						
Coarse Range:	5.0"	Initial Cal. Time	Calibration Checks		Final Cal. Time	
Coarse Delay:	N/A	14:26	15:36	N/A	16:09	
Delay Calib:	N/A	Calibrated Sweep Range = 0.500" Inches to 1.500" Inches				
Range Calib:	N/A	Thermometer: 246534	Comp. Temp: 82°		Block Temp: 82°	
Instrument Freq.	N/A	W/O Number:	~~R2088926~~ SRW			
Gain:	67 db	Total Crew Dose mr	C2013477 Drywell Containment Vessel Thickness Examination. External UT Inspections.			
Damping:	N/A					
Reject:	N/A					
Filter:	N/A					

Bay - 19

BAY	Point Number		Vertical Location			Horizo Locati

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ATTACHMENT 5
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See Attached for Locations and Thickness Readings

COMMENTS: N/A

10-22-06

Reviewed by: Lee Stone Level II Date 10/22/2006

Report - 1R21L2-018 020
Pg. 2 of 2
10-22-06

BAY 19

	Point	Vertical	Horizontal	1992 value	2006 Value	Comments
	1	D30	R60	0.932	0.904	up .897 dn .867
	2	D52	R58	0.924	0.921	up .850 dn .907
	3	D33	R40	0.955	0.932	up .894 dn .905
	4	D32	R11	0.94	N/A	Could not locate area
	5	D31	R3	0.95	0.932	up .883 dn .897
	6	D52	L65	0.86	N/A	Could not locate area
	7	D54	L10	0.969	0.891	up .821 dn .912
	8	D16	R64	0.793/0.953 ***	0.745	up .721 dn .747
	9	D18	R12	0.776	0.780	up .728 dn .745
	10	D19	R0	0.79	0.791	up .736 dn .846
	11	20D	L18	N/A	0.738	up .738 dn .712

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ATTACHMENT 5
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Data obtained from
NDE Data Sheets 92-072-05 page 1 of 1
NDE Data Sheets 92-072-07 page 1 of 1
Note: Per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.
*** - This value is not clear form the original datasheet -NDE to verify this value.
Note: per discussion with Engineering, single point readings were taken in lieu of 6, based on surface curvature.

Matthew E Watson 10/22/06

APPLICANT'S EXH. 21

Official Transcript of Proceedings ACRS-3378

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
Subcommittee on Plant License Renewal

Docket Number: (not applicable)

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005
SUNSI REVIEW COMPLETE

Location: Rockville, Maryland

Date: Thursday, January 18, 2007

Work Order No.: NRC-1398

Pages 1-371

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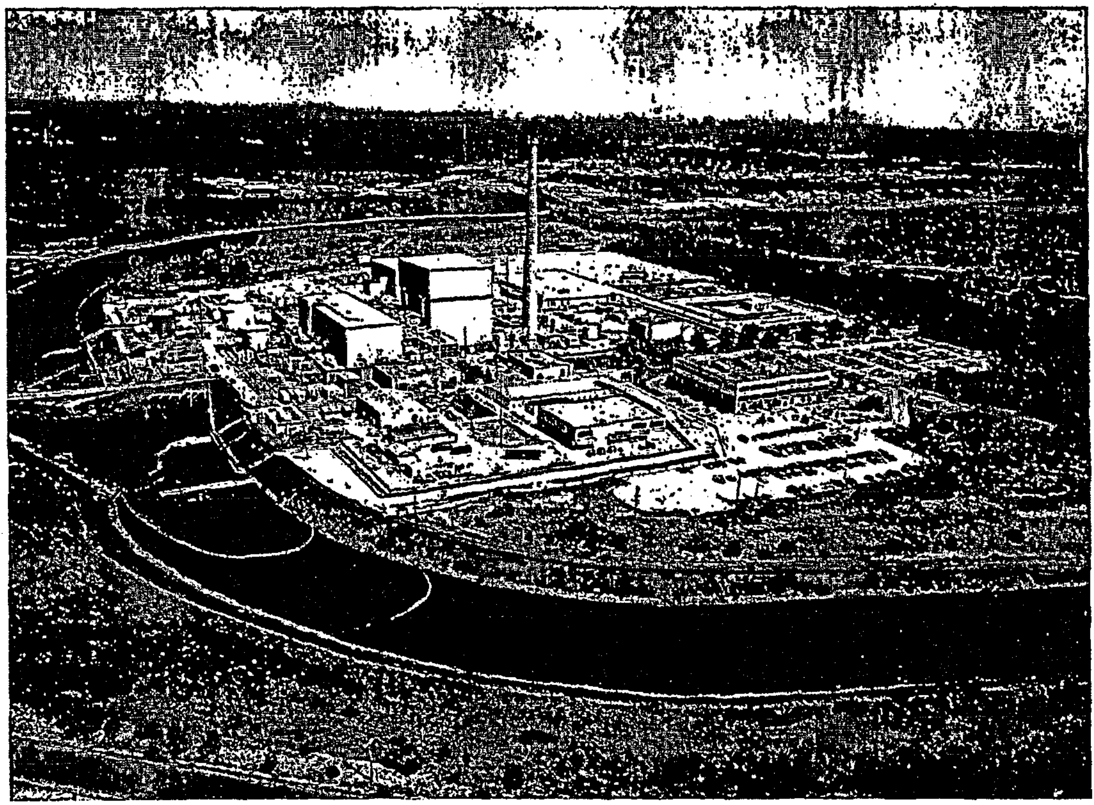
Oyster Creek Generating Station

License Renewal

ACRS Presentation - January 18, 2007



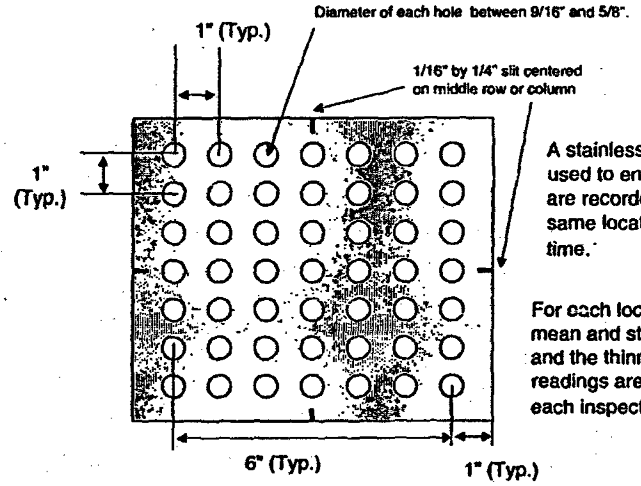
ACRS
Presentation

AmerGen
An Exelon Company

Statistical Methodology

AmerGen.
An Exelon Company

49 UT readings are recorded over a 6" by 6" area.



A stainless steel template is used to ensure that the readings are recorded consistently and in same location (+/- 1/16") every time.

For each location, the mean and standard error and the thinnest of the 49 readings are calculated after each inspection.

AmerGen.
An Exelon Company

Statistical Methodology

- Because of roughness of the exterior surface of the drywell shell in the sand bed, there is uncertainty in the mean thickness calculated for each grid location
- The major contributor to the uncertainty in the means is the variance from point to point due to the rough surface and not inaccuracy or repeatability of the UT Instrumentation

APPLICANT'S EXH. 22

GPU Nuclear Calculation Sheet

Subject	Calc No	Rev No	Sheet No
STATISTICAL ANALYSIS OF DRYWELL THICKNESS DATA THRU 12-31-88	C-1302-187-5300-005	0	1 of 98

Originator	Date	Reviewed by	Date
JH Moore Jr	1-31-89	S. D. Leshnoff Fred P. Barbieri	2/1/89 2/2/89

1.0 PROBLEM STATEMENT

1.1 Background

The design of the carbon steel drywell includes a sand bed which is located around the outside circumference between elevations 8'-11-1/4" and 12'-3". Leakage was observed from the sand bed drains during the 1980, 1983 and 1986 refueling outages indicating that water had intruded into the annular region between the drywell shell and the concrete shield wall.

The drywell shell was inspected in 1986 during the 10R outage to determine if corrosion was occurring. The inspection methods, results and conclusions are documented in Ref. 3.1, 3.2, and 3.3. As a result of these inspections it was concluded that a long term monitoring program would be established. This program includes repetitive Ultrasonic Thickness (UT) measurements in the sand bed region at a nominal elevation of 11'-3" in bays 11A, 11C, 17D, 19A, 19B, and 19C.

The continued presence of water in the sand bed raised concerns of potential corrosion at higher elevations. Therefore, UT measurements were taken at the 51' and 87' elevations in November 1987 during the 11R outage. As a result of these inspections, repetitive measurements in Bay 5 at elevation 51' and in Bays 9, 13 and 15 at the 87' elevation were added to the long term monitoring program to confirm that corrosion is not occurring at these higher elevations.

A cathodic protection system is being installed in selected regions of the sand bed during the 12R outage to minimize corrosion of the drywell. The long term monitoring program was also expanded during the 12R outage to include measurements in the sand bed region of Bays 1D, 3D, 5D, 7D, 9A, 13A, 13C, 13D, 15A, 15D and 17A which are not covered by the cathodic protection system. It also includes measurements in the sand bed region between Bays 17 and 19 which is covered by the cathodic protection system, but does not have a reference electrode to monitor its effectiveness in this region.

Some measurements in the long term monitoring program are to be taken at each outage of opportunity, while others are taken during each refueling outage. The functional requirements for these inspections are documented in Ref. 3.4. The primary purpose of the UT measurements in the sand bed region is to determine the corrosion rate and monitor it over time. When the cathodic protection system is installed and operating, these data will be used to monitor its effectiveness. The purpose of the measurements at other locations is to confirm that corrosion is not occurring in those regions.

1.2 Purpose

The purpose of this calculation is to:

(1) Statistically analyze the thickness measurements for Bays 11A, 11C, 17D, 19A, 19B and 19C in the sand bed region to determine the mean thickness and corrosion rate.

(2) Statistically analyze the thickness measurements for Bay 5 at elevation 51' and Bays 9, 13 and 15 at elevation 87' to determine the mean thickness corrosion rate.

(3) To the extent possible, statistically analyze the limited data for the 6" x 6" grids in the sand bed region of Bays 9D, 13A, 15D and 17A to calculate the mean thickness and determine if there is ongoing corrosion.

(4) To the extent possible, statistically analyze the limited data for the 6" x 1" horizontal strips in the sand bed region of Bays 1D, 3D, 5D, 7D, 9A, 13C and 15A to calculate the mean thickness and determine if there is ongoing corrosion.

Statistically compare the thickness data from December 1986 and December 1988 for the trench in Bay 17D to calculate the mean thickness at various elevations in the trench and determine if there is ongoing corrosion.

(5) Statistically analyze the thickness data from December 1988 for the Frame Cutout between Bays 17 and 19 to calculate the mean thickness.

2.0 SUMMARY OF RESULTS

Bay & Area	Location	Corrosion Rate**	Mean Thickness***
2.1	**6"x6" Grids in Sand Bed Region at Original Locations**		
11A	Sand Bed	Not significant	908.6 ±5.0 mils
11C	Sand Bed	Indeterminable	916.6 ±10.4 mils
17D	Sand Bed	-27.6 ±6.1 mpy	864.8 ±6.8 mils
19A	Sand Bed	-23.7 ±4.3 mpy	837.9 ±4.8 mils
19B	Sand Bed	-29.2 ±0.5 mpy	856.5 ±0.5 mils
19C	Sand Bed	-25.9 ±4.1 mpy	860.9 ±4.0 mils
2.2	**6"x6" Grids in Sand Bed Region at New Locations**		
9D	Sand Bed	Indeterminable*	1021.4 ±9.7 mils
13A	Sand Bed	Not significant*	905.3 ±10.1 mils
15D	Sand Bed	Possible*	1056.0 ±9.1 mils
17A	Sand Bed	Indeterminable*	957.4 ±9.2 mils
2.3	**6"x6" Grids at Upper Elevations**		
5	51' Elev.	-4.3 ±0.03 mpy	750.0 ±0.02 mils
9	87' Elev.	Not significant	620.3 ±1.0 mils
13	87' Elev.	Not significant	635.6 ±0.7 mils
15	87' Elev.	Not significant	634.8 ±0.7 mils
2.4	**Multiple 6"x6" Grids in Trench**		
17D	Trench	Not significant*	981.2 ±6.7 mils
17/19	Frame Cutout	Indeterminable*	981.7 ±4.4 mils
2.5	**6" Strips in Sand Bed Region**		
1D	Sand Bed	Indeterminable*	1114.7 ±30.6 mils
3D	Sand Bed	Not significant*	1177.7 ±5.6 mils
5D	Sand Bed	Not significant*	1174.0 ±2.2 mils
7D	Sand Bed	Possible*	1135.1 ±4.9 mils
9A	Sand Bed	Indeterminable*	1154.6 ±4.8 mils
13C	Sand Bed	Not significant*	1147.4 ±3.7 mils
13D	Sand Bed	Not significant*	962.1 ±22.3 mils
15A	Sand Bed	Not significant*	1120.0 ±12.6 mils

2.6 Evaluation of Individual Measurements Below 800 Mils

One data point in Bay 19A and one data point in Bay 5 Elev. 51' fell outside the 99% confidence interval and thus are statistically different from the mean thickness.

*Based on limited data. See text for interpretation.
**Mean corrosion rate in mils per year ± standard error of the mean
***Current mean thickness in mils ± standard error of the mean

3.0 REFERENCES

3.1 GPUN Safety Evaluation SE-000243-002, Rev. 0, "Drywell Steel Shell Plate Thickness Reduction at the Base Sand Cushion Entrenchment Region"

3.2 GPUN TDR 854, Rev. 0, "Drywell Corrosion Assessment"

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

3.4 GPUN Installation Specification IS-328227-004, Rev. 3, "Functional Requirements for Drywell Containment Vessel Thickness Examination"

3.5 Applied Regression Analysis, 2nd Edition, N.R. Draper & H. Smith, John Wiley & Sons, 1981

3.6 Statistical Concepts and Methods G.K. Bhattacharyya & R.A. Johnson, John Wiley & sons, 1977

APPLICANT'S EXH. 23

Superseded by Rev 1

2.0 SUMMARY OF RESULTS

Bay & Area	Corrosion Rate **	Mean Thickness ***	F-Ratio
2.1 Sand Bed Region With Cathodic Protection - All Data			
11A	-15.6 ±2.9 mpy	870.4 ± 5.7 mils	5.4
11C Top	-35.2 ±6.8 mpy	977.0 ±12.5 mils	4.6
11C Bottom	-22.4 ±4.3 mpy	865.0 ± 7.8 mils	4.9
17D	-25.0 ±2.0 mpy	829.5 ± 4.0 mils	29.4
19A	-21.4 ±1.5 mpy	807.6 ± 3.0 mils	39.5
19B	-19.0 ±1.7 mpy	836.9 ± 3.2 mils	21.3
19C	-24.3 ±1.3 mpy	825.1 ± 2.3 mils	66.2
2.2 Sand Bed Region With Cathodic Protection - Since October 1988			
11A	Not Significant*	878.0 ± 5.9 mils	
11C Top	Not Significant*	996.6 ± 8.3 mils	
11C Bottom	Not Significant*	878.1 ± 5.6 mils	
17D	-23.7 ±4.6 mpy	830.1 ± 3.8 mils	2.7
19A	-20.6 ±3.9 mpy	808.2 ± 3.2 mils	2.8
19B	-11.8 ±3.9 mpy	841.2 ± 3.3 mils	0.9
19C	-21.5 ±3.5 mpy	826.3 ± 2.9 mils	3.7
2.3 Sand Bed Region Frame Cutout			
17/19 Top	Not Significant*	986.0 ± 4.7 mils	
17/19 Bottom	Not Significant*	1008.4 ± 3.9 mils	
2.4 Sand Bed Region Without Cathodic Protection			
9D	Not Significant*	1021.7 ± 8.9 mils	
13A	-39.1 ± 3.4 mpy	853.1 ± 2.4 mils	16.9
13D	Indeterminate	931.9 ±22.6 mils	
15D	Not Significant*	1056.5 ± 2.3 mils	
17A Top	Not Significant*	1128.3 ± 2.2 mils	
17A Bottom	Not Significant*	745.2 ± 2.1 mils	1.3

* Not statistically significant compared to random variations in measurements
** Mean corrosion rate in mils per year ± standard error of estimate
***Best estimate of current mean thickness in mils ± standard error of the mean

2.0 SUMMARY OF RESULTS

Bay & Area	Corrosion Rate (mpy) Best Estimate*	Corrosion Rate (mpy) 95% Conf.**	Mean Thickness ***	F-Ratio	N	Yrs	
2.1 Sand Bed Region With Cathodic Protection - All Data							
11A	-15.6 ±2.9 mpy	-21.0	870.4 ± 5.7 mils	5.4	9	3.0	
11C Top	-35.2 ±6.8 mpy	-48.2	977.0 ±12.5 mils	4.6	9	3.0	
11C Bottom	-22.4 ±4.3 mpy	-30.5	865.0 ± 7.8 mils	4.9	9	3.0	
17D	-25.0 ±2.0 mpy	-28.7	829.5 ± 4.0 mils	29.4	10	3.2	
19A	-21.4 ±1.5 mpy	-24.1	807.6 ± 3.0 mils	39.5	10	3.2	
19B	-19.0 ±1.7 mpy	-22.3	836.9 ± 3.2 mils	21.3	9	3.0	
19C	-24.3 ±1.3 mpy	-26.7	825.1 ± 2.3 mils	66.2	9	3.0	
2.2 Sand Bed Region With Cathodic Protection - Since October 1988							
11A	Not Significant****		878.0 ± 5.9 mils		5	1.5	
11C Top	Not Significant****		996.6 ± 8.3 mils		5	1.5	
11C Bottom	Not Significant****		878.1 ± 5.6 mils		5	1.5	
17D	-23.7 ±4.6 mpy	-34.2	830.1 ± 3.8 mils	2.7	5	1.5	
19A	-20.6 ±3.9 mpy	-29.7	808.2 ± 3.2 mils	2.8	5	1.5	
19B	-11.8 ±3.9 mpy	-21.1	841.2 ± 3.3 mils	0.9	5	1.5	
19C	-21.5 ±3.5 mpy	-29.5	826.3 ± 2.9 mils	3.7	5	1.5	
2.3 Sand Bed Region Frame Cutout							
17/19 Top	Not Significant****		986.0 ± 4.7 mils		5	1.3	
17/19 Bottom	Not Significant****		1005.7 ± 5.6 mils		5	1.3	1
2.4 Sand Bed Region Without Cathodic Protection							
9D	Not Significant****		1021.7 ± 8.9 mils		5	1.3	
13A	-39.1 ± 3.4 mpy	-46.4	853.1 ± 2.4 mils	16.9	6	1.4	
13D	Indeterminate		931.9 ±22.6 mils		1	0	
15D	Not Significant****		1056.5 ± 2.3 mils		5	1.5	
17A Top	Not Significant****		1128.3 ± 2.2 mils		5	1.4	
17A Bottom	Not Significant****		950.8 ± 5.3 mils		5	1.4	1

* Mean corrosion rate in mils per year ± standard error of estimate
** Upper bound of the one-sided 95% confidence interval
*** Best estimate of current mean thickness in mils ± standard error of the mean
****Not statistically significant compared to random variations in measurements

N = Number of data sets
Yrs = Years from first to last data set

GPU Nuclear	DOCUMENT NO. C-1302-187-5300-011
TITLE STATISTICAL ANALYSIS OF DRYWELL THICKNESS THRU 4-24-90	

REV	SUMMARY OF CHANGE	APPROVAL	DATE
1	Computed 95% upper bound of the corrosion rate in each bay where regression model is appropriate. Computed maximum potential corrosion rate at 95% confidence for each bay where mean model is appropriate. Deleted Summary of Apparent Corrosion Rates and added Summary of Maximum Potential Corrosion Rates at 95% Confidence. Revised paragraphs 2.0, 4.5.2, and 4.10 to reflect these changes. Corrected typos on Summary Sheets (pg. 2 & 3) & Pgs 4, 21	JD Moore Verification V-1302-187-005 Rev. 4 Fred P Barbieri	1-22-91 1/22/91 4/12/91

Superseded [illegible]

Bay & Area	Corrosion Rate **	Mean Thickness ***	F-Ratio
2.5 Elevation 51'			
5/D-12	- 4.6 ± 1.6	745.2 ± 2.1 mils	1.3
5/5	Indeterminate	745.1 ± 3.2 mils	
13/31	Indeterminate	750.8 ±11.5 mils	
15/23	Indeterminate	751.2 ± 3.8 mils	
2.6 Elevation 52'			
7/25	Indeterminate	715.5 ± 2.9	
13/6	Indeterminate	724.9 ± 2.9	
13/32	Indeterminate	698.3 ± 5.0	
19/13	Indeterminate	712.5 ± 3.1	
2.7 Elevation 87'			
9	Not Significant*	619.9 ± 0.6	
13	Not Significant*	636.5 ± 0.8	
15	Not Significant*	636.2 ± 1.1	

2.5 Apparent Corrosion Rates

These estimates of the corrosion rate are based on a least squares fit of the data. In those cases where the F-Ratio is less than 1.0 they should not be used to make future projections. For bays with cathodic protection, these apparent rates are for the period from October 1988 to April 1990. For the other bays, it is for all data.

Bay	Apparent Corrosion Rate (mpy)	F-Ratio	Bay	Apparent Corrosion Rate (mpy)	F-Ratio
11A	-16.2 ± 8.6	0.2	9D	-21.0 ±18.1	0.1
11C Top	-25.0 ±10.6	0.6	13A	-39.1 ± 3.4	16.9
11C Bottom	-16.7 ± 7.1	0.6	15D	- 4.6 ± 4.8	0.1
17D	-23.7 ± 4.6	2.7	17A Top	- 6.8 ± 3.7	0.3
19A	-20.6 ± 3.9	2.8	17A Bottom	-17.7 ± 7.6	0.01
19B	-11.8 ± 3.9	0.9	5 EL 51'	- 4.6 ± 1.6	1.3
19C	-21.5 ± 3.5	3.7	9 EL 87'	- 0.2 ± 0.9	zero
17/19 Top	- 8.2 ±10.7	0.1	13 EL 87'	zero	
17/19 Bottom	-13.1 ±11.6	0.1	15 EL 87'	zero	

Bay & Area	Corrosion Rate (mpy) Best Estimate*	 95% Conf.**	Mean Thickness ***	F-Ratio	N	Yrs
2.5	Elevation 51'					
5/D-12	- 4.6 ± 1.6 mpy	-2.2	745.2 ± 2.1 mils	1.3	8	2.5
5/5	Indeterminate		745.1 ± 3.2 mils		2	1.1
13/31	Indeterminate		750.8 ±11.5 mils		2	1.1
15/23	Indeterminate		751.2 ± 3.8 mils		2	1.1
2.6	Elevation 52'					
7/25	Indeterminate		715.5 ± 2.9 mils		1	0
13/6	Indeterminate		724.9 ± 2.9 mils		1	0
13/32	Indeterminate		698.3 ± 5.0 mils		1	0
19/13	Indeterminate		712.5 ± 3.1 mils		1	0
2.7	Elevation 87'					
9	Not Significant****		619.9 ± 0.6 mils		5	2.4
13	Not Significant****		636.5 ± 0.8 mils		5	2.4
15	Not Significant****		636.2 ± 1.1 mils		5	2.4

2.8 Potential Corrosion Rates at 95% Confidence

For those locations where the corrosion rate is not statistically significant, the possibility does exist that the variability in the data may be masking an actual corrosion rate. The potentially masked corrosion rate at 95% confidence is bounded by the upper bound of the 95% one-sided confidence interval about the slope computed in the regression analysis (see Paragraph 4.10.1).

Bay	Elevation	95% Upper Bound Corrosion Rate (mpy)	N	Yrs
11A (Since 10/88)	Sand Bed	-36.4	5	1.5
11C Top (Since 10/88)	Sand Bed	-49.9	5	1.5
11C Bottom (Since 10/88)	Sand Bed	-33.3	5	1.5
17/19 Top	Frame Cutout	-33.4	5	1.3
17/19 Bottom	Frame Cutout	-40.5	5	1.3
9D	Sand Bed	-63.4	5	1.3
15D	Sand Bed	-16.0	5	1.4
17A Top	Sand Bed	-15.5	5	1.4
17A Bottom	Sand Bed	-35.6	5	1.4
9	87'	-2.2	5	2.4
13	87'	-2.1	5	2.4
15	87'	-0.6	5	2.4

NOTE: The high value for Bay 9D results from one extremely high mean value on 6/26/89. Without this data point, the 95% upper bound is -29.2 mpy.

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2.~~8~~9 Evaluation of Individual Measurements Exceeding 99%/99% Tolerance Interval

One data point in Bay 5 Elev. 51' fell outside the 99%/99% tolerance interval and thus is statistically different from the mean thickness.

Based on a linear regression analysis for this point, it is concluded that the corrosion rate in this pit is essentially the same as the overall grid.

3.0 REFERENCES

3.1 GPUN Safety Evaluation SE-000243-002, Rev. 0, "Drywell Steel Shell Plate Thickness Reduction at the Base Sand Cushion Entrenchment Region"

3.2 GPUN TDR 854, Rev. 0, "Drywell Corrosion Assessment"

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

3.4 GPUN Installation Specification IS-328227-004, Rev. 3, "Functional Requirements for Drywell Containment Vessel Thickness Examination"

3.5 Applied Regression Analysis, 2nd Edition, N.R. Draper & H. Smith, John Wiley & Sons, 1981

3.6 Statistical Concepts and Methods, G.K. Bhattacharyya & R.A. Johnson, John Wiley & sons, 1977

3.7 GPUN Calculation C-1302-187-5300-005, Rev. 0, "Statistical Analysis of Drywell Thickness Data Thru 12-31-88"

3.8 GPUN TDR 948, Rev. 1, "Statistical Analysis of Drywell Thickness Data"

3.9 Experimental Statistics, Mary Gibbons Natrella, John Wiley & Sons, 1966 Reprint. (National Bureau of Standards Handbook 91)

3.10 Fundamental Concepts in the Design of Experiments, Charles C. Hicks, Saunders College Publishing, Fort Worth, 1982

3.11 GPUN Calculation C-1302-187-5300-008, Rev. 0, "Statistical Analysis of Drywell Thickness Data thru 2-8-90"

4.0 ASSUMPTIONS & BASIC DATA

4.1 Background

The design of the carbon steel drywell includes a sand bed which is located around the outside circumference between elevations 8'-11-1/4" and 12'-3". Leakage was observed from the sand bed drains during the 1980, 1983 and 1986 refueling outages indicating that water had intruded into the annular region between the drywell shell and the concrete shield wall.

The drywell shell was inspected in 1986 during the 10R outage to determine if corrosion was occurring. The inspection methods, results and conclusions are documented in Ref. 3.1, 3.2, and 3.3. As a result of these inspections it was concluded that a long term monitoring program would be established. This program includes repetitive Ultrasonic Thickness (UT) measurements in the sand bed region at a nominal elevation of 11'-3" in bays 11A, 11C, 17D, 19A, 19B, and 19C.

The continued presence of water in the sand bed raised concerns of potential corrosion at higher elevations. Therefore, UT measurements were taken at the 51' and 87' elevations in November 1987 during the 11R outage. As a result of these inspections, repetitive measurements in Bay 5 at elevation 51' and in Bays 9, 13 and 15 at the 87' elevation were added to the long term monitoring program to confirm that corrosion is not occurring at these higher elevations.

A cathodic protection system was installed in selected regions of the sand bed during the 12R outage to minimize corrosion of the drywell. The cathodic protection system was placed in service on January 31, 1989. The long term monitoring program was also expanded during the 12R outage to include measurements in the sand bed region of Bays 1D, 3D, 5D, 7D, 9A, 13A, 13C, 13D, 15A, 15D and 17A which are not covered by the cathodic protection system. It also includes measurements in the sand bed region between Bays 17 and 19 which is covered by the cathodic protection system, but does not have a reference electrode to monitor its effectiveness in this region.

The high corrosion rate computed for Bay 13A in the sand bed region through February 1990 (Ref. 3.11) raised concerns about the corrosion rate in the sand bed region of Bay 13D. Therefore, the monitoring of this location using a 6"x6" grid was added to the long term monitoring program. In addition, a 2-inch core sample was removed in March 1990 from a location adjacent to the 6"x6" monitored grid in Bay 13A.

Measurements taken in Bay 5 Area D-12 at elevation 51' through March 1990 indicated that corrosion is occurring at his location. Therefore, survey measurements were taken to determine the thinnest locations at elevation 51'. As a result, three new locations were added to the long term monitoring program (Bay 5 Area 5, Bay 13 Area 31, and Bay 15 Area 2/3).

The indication of ongoing corrosion at elevation 51' raised concerns about potential corrosion of the plates immediately above which have a smaller nominal thickness. Therefore, survey measurements were taken in April 1990 at the 52' elevation in all bays to determine the thinnest locations. As a result of this survey, four new locations were added to the long term monitoring plan at elevation 52' (Bay 7 area 25, Bay 13 Area 6, Bay 13 Area 32, and Bay 19 Area 13).

Some measurements in the long term monitoring program are to be taken at each outage of opportunity, while others are taken during each refueling outage. The functional requirements for these inspections are documented in Ref. 3.4. The purpose of the UT measurements is to determine the corrosion rate and monitor it over time, and to monitor the effectiveness of the cathodic protection system.

4.2 Selection of Areas to be Monitored

A program was initiated during the 11R outage to characterize the corrosion and to determine its extent. The details of this inspection program are documented in Ref. 3.3. The greatest corrosion was found via UT measurements in the sand bed region at the lowest accessible locations. Where thinning was detected, additional measurements were made in a cross pattern at the thinnest section to determine the extent in the vertical and horizontal directions. Having found the thinnest locations, measurements were made over a 6"x6" grid.

To determine the vertical profile of the thinning, a trench was excavated into the floor in Bay 17 and Bay 5. Bay 17 was selected since the extent of thinning at the floor level was greatest in that area. It was determined that the thinning below the top of the curb was no more severe than above the curb, and became less severe at the lower portions of the sand cushion. Bay 5 was excavated to determine if the thinning line was lower than the floor level in areas where no thinning was detected above the floor. There were no significant indications of thinning in Bay 5.

It was on the basis of these findings that the 6"x6" grids in Bays 11A, 11C, 17D, 19A, 19B and 19C were selected as representative locations for longer term monitoring. The initial measurements at these locations were taken in December 1986 without a template or markings to identify the location of each measurement. Subsequently, the location of the 6"x6" grids were permanently marked on the drywell shell and a template is used in conjunction with these markings to locate the UT probe for successive measurements. Analyses have shown that including the non-template data in the data base creates a significant variability in the thickness data. Therefore, to minimize the effects of probe location, only those data sets taken with the template are included in the analyses.

The presence of water in the sand bed also raised concern of potential corrosion at higher elevations. Therefore, UT measurements were taken at the 51' and 87' elevations in 1987 during the 11M outage. The measurements were taken in a band on 6-inch centers at all accessible regions at these elevations. Where these measurements indicated potential corrosion, the measurements spacing was reduced to 1-inch on centers. If these additional readings indicated potential corrosion, measurements were taken on a 6"x6" grid using the template. It was on the basis of these inspections that the 6"x6" grids in Bay 5 at elevation 51' and in bays 9, 13 and 15 at the 87' elevation were selected as representative locations for long term monitoring.

A cathodic protection system was installed in the sand bed region of Bays 11A, 11C, 17D, 19A, 19B, 19C, and at the frame between Bays 17 and 19 during the 12R outage. The system was placed in service on January 31, 1989.

The long term monitoring program was expanded as follows during the 12R outage:

(1) Measurements on 6"x6" grids in the sand bed region of Bays 9D, 13A, 15D and 17A. The basis for selecting these locations is that they were originally considered for cathodic protection but are not included in the system being installed.

(2) Measurements on 1-inch centers along a 6-inch horizontal strip in the sand bed region of Bays 1D, 3D, 5D, 7D, 9A, 13C, and 15A. These locations were selected on the basis that they are representative of regions which have experienced nominal corrosion and are not within the scope of the cathodic protection system.

(3). A 6"x6" grid in the curb cutout between Bays 17 and 19. The purpose of these measurements is to monitor corrosion in this region which is covered by the cathodic protection system but does not have a reference electrode to monitor its performance.

The long term monitoring program was expanded in March 1990 as follows:

(1) Measurements in the sand bed region of Bay 13D: This location was added due to the high indicated corrosion rate in the sand bed region of Bay 13A. The measurements taken in March 1990 were taken on a 1"x6" grid. All subsequent measurements are to be taken on a 6"x6" grid.

(2) Measurements on 6"x6" grids at the following locations at elevation 51': Bay 5 Area 5, Bay 13 Area 31, and Bay 15 Area 2/3. These locations were added due to the indication of ongoing corrosion at elevation 51', Bay 5 Area D-1.

The long term monitoring program was expanded in April 1990 by adding the following locations at elevation 52': Bay 7 Area 25, Bay 13 Area 6, Bay 13 Area 32, and Bay 19 Area 13. All measurements are taken on 6"x6" grids. These locations were added due to the indication of ongoing corrosion at elevation 51' and the fact that the nominal plate thickness at elevation 52' is less than at elevation 51'..

4.3 UT Measurements

The UT measurements within the scope of the long term monitoring program are performed in accordance with Ref. 3.4. This involves taking UT measurements using a template with 49 holes laid out on a 6"x6" grid with 1" between centers on both axes. The center row is used in those bays where only 7 measurements are made along a 6-inch horizontal strip.

The first set of measurements were made in December 1986 without the use of a template. Ref. 3.4 specifies that for all subsequent readings, QA shall verify that locations of UT measurements performed are within ± 1/4" of the location of the 1986 UT measurements. It also specifies that all subsequent measurements are to be within ± 1/8" of the designated locations.

4.4 Data at Plug Locations

Seven core samples, each approximately two inches in diameter were removed from the drywell vessel shell. These samples were evaluated in Ref. 3.2. Five of these samples were removed within the 6"x6" grids for Bays 11A, 17D, 19A, 19C and Bay 5 at elevation 51'. These locations were repaired by welding a plug in each hole. Since these plugs are not representative of the drywell shell, UT measurements at these locations on the 6"x6" grid must be dropped from each data set.

The following specific grid points have been deleted:

Bay Area	Points
11A	23, 24, 30, 31
17D	15, 16, 22, 23
19A	24, 25, 31, 32
19C	20, 26, 27, 33,
5 EL 51'	13, 20, 25, 26, 27, 28, 33, 34, 35

The core sample removed in the sand bed region of Bay 13A was not within the monitored 6"x6" grid.

4.5 Bases for Statistical Analysis of 6"x6" Grid Data

4.5.1 Assumptions

The statistical evaluation of the UT measurement data to determine the corrosion rate at each location is based on the following assumptions:

(1) Characterization of the scattering of data over each 6"x6" grid is such that the thickness measurements are normally distributed.

(2) Once the distribution of data for each 6"x6" grid is found to be normal, then the mean value of the thickness is the appropriate representation of the average condition.

(3) A decrease in the mean value of the thickness with time is representative of the corrosion occurring within the 6"x6" grid.

(4) If corrosion has ceased, the mean value of the thickness will not vary with time except for random errors in the UT measurements.

(5) If corrosion is continuing at a constant rate, the mean thickness will decrease linearly with time. In this case, linear regression analysis can be used to fit the mean thickness values for a given zone to a straight line as a function of time. The corrosion rate is equal to the slope of the line.

The validity of these assumptions is assured by:

(a) Using more than 30 data points per 6"x6" grid

(b) Testing the data for normality at each 6"x6" grid location.

(c) Testing the regression equation as an appropriate model to describe the corrosion rate.

These tests are discussed in the following section. In cases where one or more of these assumptions proves to be invalid, non-parametric analytical techniques can be used to evaluate the data.

4.5.2 Statistical Approach

The following steps are performed to test and evaluate the UT measurement data for those locations where 6"x6" grid data has been taken at least three times:

(1) Edit each 49-point data set by setting all invalid points to zero. Invalid points are those which are declared invalid by the UT operator or are at a plug location. (The computer programs used in the following steps ignore all zero thickness data points.)

(2) Perform a Chi-squared goodness of fit test of each 49 point data set to ensure that the assumption of normality is valid at the 5% and 1% level of significance.

(3) Calculate the mean thickness and variance of each 49 point data set.

(4) Perform an Analysis of Variance (ANOVA) F-test to determine if there is a significant difference between the means of the data sets.

(5) Using the mean thickness values for each 6"x6" grid, perform linear regression analysis over time at each location.

(a) Perform F-test for significance of regression at the 5% level of significance. The result of this test indicates whether or not the regression model is more appropriate than the mean model. In other words, it tests to see if the variation of the regression model is statistically significant over that of a mean model.

(b) Calculate the ratio of the observed F value to the critical F value at 5% level of significance. For data sets where the Residual Degress of Freedom in ANOVA is 4 to 9, this F-Ratio should be at least 8 for the regression to be considered ~~"useful"~~ "reliable" as opposed to simply "significant." ~~(Ref. 3.5 pp. 92-93, 129-133)~~ (See Paragraph 10.2)

(c) Calculate the coefficient of determination (R^2) to assess how well the regression model explains the percentage of total error and thus how useful the regression line will be as a predictor.

(d) Determine if the residual values for the regression equations are normally distributed.

(e) If the regression model is found to be appropriate, calculate the y-intercept, the slope and their respective standard errors. The y-intercept represents the fitted mean thickness at time zero, the slope represents the corrosion rate, and the standard errors represent the uncertainty or random error of these two parameters. Calculate the upper bound of the 95% one-sided confidence interval about the computed slope to provide an estimate of the maximum probable corrosion rate at 95% confidence. This is explained in greater detail in paragraph 4.10.2.

(f) If the mean model is found to be more appropriate than the regression model, the corrosion rate is not statistically significant compared to random variations in the mean thickness. Although the mean model is deemed more appropriate than the regression model, the upper bound of the 95% one-sided confidence interval about the slope computed in the regression analysis provides an estimate at 95% confidence of the maximum corrosion rate which could be masked by the random variations. This is explained in greater detail in paragraph 4.10.1.

(6) Use a K factor from Table A-7 of Reference 3.9 and the standard deviation to establish a one-sided 99%/99% tolerance limit about the mean thickness values for each 6"x6" grid location to determine whether low thickness measurements or "outliers" are statistically significant. If the data points are greater than the 99%/99% lower tolerance limit, then the difference between the value and the mean is deemed to be due to expected random error. However, if the data point is less than the lower 99%/99% tolerance limit, this implies that the difference is statistically significant and is probably not due to chance.

4.6 Analysis of Two 6"x6" Grid Data Sets

Regression analysis is inappropriate when data is available at only two points in time. However, the t-test can be used to determine if the means of the two data sets are statistically different.

4.6.1 Assumptions

This analysis is based upon the following assumptions:

(1) The data in each data set is normally distributed.

(2) The variances of the two data sets are equal.

4.6.2 Statistical Approach

The evaluation takes place in three steps:

(1) Perform a chi-squared test of each data set at 5% and 1% levels of significance to ensure that the assumption of normality is valid.

(2) Perform an F-test at 5% and 1% level of significance of the two data sets being compared to ensure that the assumption of equal variances is valid.

(3) Perform a two-tailed t-test for two independent samples at the 5% and 1% levels of significance to determine if the means of the two data sets are statistically different.

A conclusion that the means are <u>not</u> statistically different is interpreted to mean that significant corrosion did not occur over the time period represented by the data. However, if equality of the means is rejected, this implies that the difference is statistically significant and could be due to corrosion.

4.7 Analysis of Single 6"x6" Grid Data Set

In those cases where a 6"x6" data set is taken at a given location for the first time during the current outage, the only other data to which they can be compared are the UT survey measurements taken at an earlier time. For the most part, these are single point measurements which were taken in the vicinity of the 49-point data set, but not at the exact location. Therefore, rigorous statistical analysis of these single data sets is impossible. However, by making certain assumptions, they can be compared with the previous data points. If more extensive data is available at the location of the 49-point data set, the t-test can be used to compare the means of the two data sets as described in paragraph 4.5.

When additional measurements are made at these exact locations during future outages, more rigorous statistical analyses can be employed.

4.7.1 Assumptions

The comparison of a single 49-point data sets with previous data from the same vicinity is based on the following assumptions:

(1) Characterization of the scattering of data over the 6"x6" grid is such that the thickness measurements are normally distributed.

(2) Once the distribution of data for the 6"x6" grid is found to be normal, then the mean value of the thickness is the appropriate representation of the average condition.

(3) The prior data is representative of the condition at this location at the earlier date.

4.7.2 Statistical Approach

The evaluation takes place in four steps:

(1) Perform a chi-squared test of each data set to ensure that the assumption of normality is valid at the 95% and 99% confidence levels.

(2) Calculate the mean and the standard error of the mean of the 49-point data set.

(3) Determine the two-tailed t value from a t distribution table at levels of significance of 0.05 and 0.01 for n-1 degrees of freedom.

(4) Use the t value and the standard error of the mean to calculate the 95% and 99% confidence intervals about the mean of the 49-point data set.

(5) Compare the prior data point(s) with these confidence intervals about the mean of the 49-point data sets.

If the prior data falls within the 95% confidence intervals, it provides some assurance that significant corrosion has not occurred in this region in the period of time covered by the data. If it falls within the 99% confidence limits but not within the 95% confidence limits, this implication is not as strong. In either case, the corrosion rate will be interpreted to be "Not Significant".

If the prior data falls above the upper 99% confidence limit, it could mean either of two things: (1) significant corrosion has occurred over the time period covered by the data, or (2) the prior data point was not representative of the condition of the location of the 49-point data set in 1986. There is no way to differentiate between the two. In this case, the corrosion rate will be interpreted to be "Possible".

If the prior data falls below the lower 99% confidence limit, it means that it is not representative of the condition at this location at the earlier date. In this case, the corrosion rate will be interpreted to be "Indeterminable".

4.8 Analysis of Single 7-Point Data Set

In those cases where a 7-point data set is taken at a given location for the first time during the current outage, the only other data to which they can be compared are the UT survey measurements taken at an earlier time to identify the thinnest regions of the drywell shell in the sand bed region. For the most part, these are single point measurements which were taken in the vicinity of the 7-point data sets, but not at the exact locations. However, by making certain assumptions, they can be compared with the previous data points. If more extensive data is available at the location of the 7-point data set, the t-test can be used to compare the means of the two data sets as described in paragraph 4.5.

When additional measurements are made at these exact locations during future outages, more rigorous statistical analyses can be employed.

4.8.1 Assumptions

The comparison of a single 7-point data sets with previous data from the same vicinity is based on the following assumptions:

(1) The corrosion in the region of each 7-point data set is normally distributed.

(2) The prior data is representative of the condition at this location at the earlier date.

The validity of these assumptions cannot be verified.

4.8.2. Statistical Approach

The evaluation takes place in four steps:

(1) Calculate the mean and the standard error of the mean of the 7-point data set.

(2) Determine the two-tailed t value using the t distribution tables at levels of significance of 0.05 and 0.01 for n-1 degrees of freedom.

(3) Use the t value and the standard error of the mean to calculate the 95% and 99% confidence intervals about the mean of the 7-point data set.

(4) Compare the prior data point(s) with these confidence intervals about the mean of the 7-point data sets.

If the prior data falls within the 95% confidence intervals, it provides some assurance that significant corrosion has not occurred in this region in the period of time covered by the data. If it falls within the 99% confidence limits but not within the 95% confidence limits, this implication is not as strong. In either case, the corrosion rate will be interpreted to be "Not Significant".

If the prior data falls above the upper 99% confidence interval, it could mean either of two things: (1) significant corrosion has occurred over the time period covered by the data, or (2) the prior data point was not representative of the condition of the location of the 7-point data set in 1986. There is no way to differentiate between the two. In this case, the corrosion rate will be interpreted to be "Possible".

If the prior data falls below the lower 99% confidence limit, it means that it is not representative of the condition at this location at the earlier date. In this case, the corrosion rate will be interpreted to be "Indeterminable".

4.9 Evaluation of Drywell Mean Thickness

This section defines the methods used to evaluate the drywell thickness at each location within the scope of the long term monitoring program.

4.9.1 Evaluation of Mean Thickness Using Regression Analysis

The following procedure is used to evaluate the drywell mean thickness at those locations where regression analysis has been deemed to be more appropriate than the mean model.

(1) The best estimate of the mean thickness at these locations is the point on the regression line corresponding to the time when the most recent set of measurements was taken. In the SAS Regression Analysis output (App. 6.2), this is the last value in the column labeled "PREDICT VALUE".

(2) The best estimate of the standard error of the mean thickness is the standard error of the predicted value used above. In the SAS Regression Analysis output, this is the last value in the column labeled "STD ERR PREDICT".

(3) The two-sided 95% confidence interval about the mean thickness is equal to the mean thickness plus or minus t times the estimated standard error of the mean. This is the interval for which we have 95% confidence that the true mean thickness will fall within. The value of t is obtained from a t distribution table for equal tails at n-2 degrees of freedom and 0.05 level of significance, where n is the number of sets of measurements used in the regression analysis. The degrees of freedom is equal to n-2 because two parameters (the y-intercept and the slope) are calculated in the regression analysis with n mean thicknesses as input.

(4) The one-sided 95% lower limit of the mean thickness is equal to the estimated mean thickness minus t times the estimated standard error of the mean. This is the mean thickness for which we have 95% confidence that the true mean thickness does not fall below. In this case, the value of t is obtained from a t distribution table for one tail at n-2 degrees of freedom and 0.05 level of significance.

4.9.2 Evaluation of Mean Thickness Using Mean Model

The following procedure is used to evaluate the drywell mean thickness at those locations where the mean model is deemed to be more appropriate than the linear regression model. This method is consistent with that used to evaluate the mean thickness using the regression model.

(1) Calculate the mean of each set of UT thickness measurements.

(2) Sum the means of the sets and divide by the number of sets to calculate the grand mean. This is the best estimate of the mean thickness. In the SAS Regression Analysis output, this is the value labelled "DEP MEAN".

(3) Using the means of the sets from (1) as input, calculate the <u>standard error about the mean</u>. This is the best estimate of the standard error of the mean thickness.

(4) The two-sided 95% confidence interval about the mean thickness is equal to the mean thickness plus or minus t times the estimated standard error of the mean. This is the interval for which we have 95% confidence that the true mean thickness will fall within. The value of t is obtained from a t distribution table for <u>equal tails</u> at n-1 degrees of freedom and 0.05 level of significance.

(5) The one-sided 95% lower limit of the mean thickness is equal to the estimated mean thickness minus t times the estimated standard error of the mean. This is the mean thickness for which we have 95% confidence that the true mean thickness does not fall below. In this case, the value of t is obtained from a t distribution table for <u>one tail</u> at n-1 degrees of freedom and 0.05 level of significance.

4.9.3 Evaluation of Mean Thickness Using Single Data Set

The following procedure is used to evaluate the drywell thickness at those locations where only one set of measurements is available.

(1) Calculate the mean of the set of UT thickness measurements. This is the best estimate of the mean thickness.

(2) Calculate the standard error of the mean for the set of UT measurements. This is the best estimate of the standard error of the mean thickness.

Confidence intervals about the mean thickness cannot be calculated with only one data set available.

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4.10 Evaluation of Drywell Corrosion Rate

4.10.1 Mean Model

If the ratio of the observed F value to the critical F value is less than 1 for the F-test for the significance of regression, it indicates that the mean model is more appropriate than the regression model at the 5% level of significance. In other words, the variation in mean thickness with time can be explained solely by the random variations in the measurements. This means that the corrosion rate is not significant compared to the random variations.

~~In this case, an F-test is performed to compare the variability of the data set means between data sets with the variability of individual measurements within the data sets. If the observed F value is less than the critical F value, it confirms that the mean model is appropriate.~~

Superseded

~~If the F-test indicates that the variability of the means is significant, the Least Significant Difference (LSD) is computed. This is the maximum difference between data set mean thicknesses that can be attributed to random variation in the measurements. If the difference between the means of data sets exceeds LSD, it indicates that difference is significant. The difference between means is subtracted from LSD and the result is divided by the time between measurements to estimate the "Significant Corrosion Rate" in mils per year (mpy). If the difference between the means does not exceed LSD, then it is concluded that no significant corrosion occurred during that period of time.~~

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4.10.2 Regression Model

If the ratio of the observed F value to the critical F value is 1 or greater, it indicates that the regression model is more appropriate than the mean model at the 5% level of significance. In other words, the variation in mean thickness with time cannot be explained solely by the random variations in the measurements. This means that the corrosion rate is significant compared to the random variations.

Although a ratio of 1 or greater indicates that regression is significant, it does not mean that the slope of the regression line is an accurate prediction of the corrosion rate. The ratio should be at least 4 or 5 to consider the slope to be a useful predictor of the corrosion rate (Ref.

4.19 The possibility does exist that the variability in the data may be masking an actual corrosion rate. Although the mean model is deemed more appropriate than the regression model, the results of the regression analysis can be used to estimate the potentially masked corrosion rate. We can state with 95% confidence that the potential corrosion rate cannot exceed the upper bound of the 95% one-sided confidence interval of the slope computed in the regression analysis. The 95% upper bound is equal to the computed slope plus the one-sided t-table value times the standard error of the slope. The value of t is determined for n-2 degrees of freedom.

3.5, pp. 93, 129-133). A ratio of 4 or 5 means that the variation from the mean due to regression is approximately twice the standard deviation of the residuals of the regression.

To have a high degree of confidence in the predicted corrosion rate, the ratio should be at least 8 or 9 (Ref. 3.5, pp. 129-133).

4.~~10.3~~ 4 ~~Best Estimate of Recent Corrosion Rate~~

Superseded

~~In most instances, four sets of measurements over a period of about one year do not provide a significant regression model which can be used to predict future thicknesses. However, a least squares fit of the four data points does provide a reasonable estimate of the recent corrosion rate. This information is particularly valuable for assessing the effectiveness of cathodic protection and the draining of the sand bed region. Since a linear regression analysis performs a linear least squares fit of the data, the best estimate of the recent corrosion rate is the slope from the regression analysis for the period of interest.~~ 1

~~These values are tabulated as the "Apparent Corrosion Rate" in paragraph 2.5.~~

The upper bound of the 95% one-sided confidence interval about the computed slope is an estimate of the maximum probable corrosion rate at 95% confidence. The 95% upper bound is equal to the computed slope plus the one-sided t-table value times the standard error of the slope. The value of t is determined for n-2 degrees of freedom. 1

5.0 CALCULATIONS

5.1 6"x6" Grids in Sand Bed Region With Cathodic Protection

5.1.1 Bay 11A

5.1.1.1 Bay 11A: 5/1/87 to ~~2/8/90~~ 4/24/90 1

Nine 49-point data sets were available for this bay covering 4/24/90 period. Since a plug lies within this region, four of the points were voided in each data set. The data were analyzed as described in paragraphs 4.4, 4.5.1 and 4.6.1.

(1) The data are normally distributed.

(2) The regression model is appropriate.

(3) The regression model explains 78.3% of the variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 870.4 ± 5.7 mils.

(6) The corrosion rate ± standard error is -15.6 ± 2.9 mils per year.

(7) F/F critical = 5.4.

(8) The measurement below 800 mils was tested and determined not to be statistically different from the mean thickness.

5.1.1.2 Bay 11A: 10/8/88 to 4/24/90

Five 49-point data sets were available for this bay covering this period.

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) The F-test for the significant of the difference between the means shows that the difference between the mean thickness are not significant.

(4) The t-test of the last two data sets shows that the difference between the mean thickness is not significant.

(5) The current thickness based on the mean model is 878.9 ± 5.9 mils.

(6) These analyses indicate that the corrosion rate with cathodic protection is not significant compared to random variations in the measurements.

(7) The best estimate of the corrosion rate during the period based on a least squares fit is -16.2 ± 8.6 mils per year.

5.1.2 Bay 11C

5.1.2.1 Bay 11C: 5/1/87 to 4/24/90

Nine 49-point data sets were available for this bay covering this period. The initial analysis of this data indicated that the data are not normally distributed. The lack of normality was tentatively attributed to minimal corrosion in the upper half of the 6"x6" grid with more extensive corrosion in the lower half of the grid. To test this hypothesis, each data set was divided into two subsets, with one containing the top three rows and the other containing the bottom four rows.

Top 3 Rows

(1) The data are normally distributed.

(2) The regression model is appropriate.

(3) The regression model explains 79% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 977.0 ± 12.5 mils.

(6) The corrosion rate is -35.2 ± 6.8 mils per year.

(7) F/F critical = 4.6.

Bottom 4 Rows

(1) Seven of the nine data sets are normally distributed. The other two are skewed toward the thinner side of the mean. The Chi-square test shows that they are close to being normally distributed at the 1% level of significance.

(2) The regression model is appropriate.

(3) The regression model explains 80% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 865.0 ± 7.8 mils.

(6) The corrosion rate ± standard error is -22.4 ± 4.3 mils per year.

(7) F/F critical = 4.9

5.1.2.2 Bay 11C: 10/8/88 to 4/24/90

Five 49-point data sets were available for this period. These data were divided into two subsets as described above.

Top 3 Rows

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) The F-test for the significance of the difference between the means shows that the differences between the mean thicknesses are not significant.

(4) The t-test of the last two data sets shows that there is no statistical difference between their means.

(5) These analyses indicate that the current corrosion rate with cathodic protection is not significant compared to random variations in the measurements.

(6) Based on the mean model, the current thickness ± standard error is 996.6 ± 8.3 mils.

(7) The best estimate of corrosion rate during this period based on a least squares fit is -25.0 ± 10.6 mils per year.

Bottom 4 Rows

(1) Four of the five data sets are normally distributed. (See 5.1.2.1 above).

(2) The mean model is more appropriate than the regression model.

(3) The F-test for the significance of the difference between the means shows that the differences between the mean thicknesses are significant.

(4) The t-test of the last two data sets shows that there is no significant statistical difference between their means.

(5) Based on the mean model, the current thickness ± standard error is 878.1 ± 5.6 mils.

(6) Based upon examination of the distribution of the five data set mean values, it is concluded that the current corrosion rate is not significant compared to random variations in the measurements. The measurements alternated as follows: 897, 877, 891, 869, 863. Therefore the difference must be due to variations other than corrosion.

(7) The best estimate of the corrosion rate during this period based on a least squares fit is -16.7 ± 7.1 mils per year.

5.1.3 Bay 17D

5.1.3.1 Bay 17D: 2/17/87 to 4/24/90

Ten 49-point data sets were available for this period. Since a plug lies within this region, four of the points were voided in each data set. Point 24 in the 2/8/90 data was voided since it is characteristic of the plug thickness.

(1) The data are normally distributed.

(2) The regression model is appropriate.

(3) The regression model explains 95% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 829.5 ± 4.0 mils.

(6) The corrosion rate ± standard error is -25.0 ± 2.0 mils per year.

(7) F/F critical = 29.4

(8) The measurements below 800 mils were tested and determined not to be statistically different from the mean thickness.

5.1.3.2 Bay 17D: 10/8/88 to 4/24/90

Five 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The regression model is more appropriate than the mean model.

(3) The regression model explains 90% of the variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 830.1 ± 3.8 mils.

(6) The corrosion rate ± standard error is -23.7 ± 4.6 mpy.

(7) F/F critical = 2.7

5.1.4 Bay 19A

5.1.4.1 Bay 19A: 2/17/87 to 4/24/90

Ten 49-point data sets were available for this period. Since a plug lies within this region, four of the points were voided in each data set.

(1) The data are normally distributed at the 1% level of significance.

(2) The regression model is appropriate

(3) The regression model explains 96% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 807.6 ± 3.0 mils.

(6) The corrosion rate ± standard error is -21.4 ± 1.5 mpy.

(7) F/F critical = 39.5

(8) The data points that were below 800 mils were tested and determined not to be statistically different from the mean thickness.

5.1.4.2 Bay 19A: 10/8/88 to 4/24/90

Five 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The regression model is more appropriate than the mean model.

(3) The regression model explains 90% of the variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 808.2 ± 3.2 mils.

(6) The corrosion rate ± standard error is -20.6 ± 3.9 mpy.

(7) F/F critical = 2.8

5.1.5 Bay 19B

5.1.5.1 Bay 19B: 5/1/87 to 4/24/90

Nine 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The regression model is appropriate.

(3) The regression model explains 94% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 836.9 ± 3.2 mils.

(6) The corrosion rate ± standard error is -19.0 ± 1.7 mpy.

(7) F/F critical = 21.3

(8) The measurements below 800 mils were tested and determined not to be statistically different from the mean thickness.

5.1.5.2 Bay 19B: 10/8/88 to 4/24/90

Five 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The regression model is more appropriate than the mean model.

(3) The regression model explains 75% of the variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 841.2 ± 3.3 mils.

(6) The corrosion rate ± standard error is -11.8 ± 3.9 mpy.

(7) F/F critical = 0.9

5.1.6 Bay 19C

5.1.6.1 Bay 19C: 5/1/87 to 4/24/90

Nine 49-point data sets were available for this period. Since a plug lies within this region, four of the points were voided in each data set.

(1) The data are normally distributed at the 1% level of significance, but appears to be developing two peaks.

(2) The regression model is appropriate.

(3) The regression model explains 98% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 825.1 ± 2.3 mils.

(6) The corrosion rate ± standard error is -24.3 ± 1.3 mpy.

(7) F/F critical = 66.2

(8) The measurements below 800 mils were tested and determined not to be statistically different from the mean thickness.

5.1.6.2 <u>Bay 19C: 10/8/88 to 4/24/90</u>

Five 49-point data sets were available for this period.

(1) The data are normally distributed at the 1% level of significance.

(2) The F-test for significance of regression indicates that the regression model is appropriate.

(3) The regression model explains 93% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 826.3 ± 2.9 mils.

(6) The corrosion rate ± standard error is -21.5 ± 3.5 mpy.

(6) F/F critical = 3.7.

5.1.7 <u>Bays 17/19 Frame Cutout: 12/30/88 to 4/24/90</u>

Two sets of 6"x6" grid measurements were taken in December 1988. The upper one is located 25" below the top of the high curb and the other below the floor. There is no previous data. The upper location was added to the long term monitoring program.

Five 49-point data sets were available for this period. These data were analyzed as described in 4.4, 4.5.2 and 4.6.1. The initial analysis of this data indicated that the first and last data sets are not normally distributed. The lack of normality was tentatively attributed to more extensive corrosion in the upper half of the grid than the bottom half. To test this hypothesis, each data set was divided into two subsets, with one containing the top three rows and the other containing the bottom four rows.

Top 3 Rows

(1) Four of the five subsets are normally distributed at the 1% level of significance but one is not.

(2) The mean model is appropriate.

(3) The F-test for the significance of the difference between the means shows that the differences between the mean thicknesses are not significant at 1% level of significance.

(4) These analyses indicate that the corrosion rate is not significant compared to the random variations in the measurements.

(5) Based on the mean model, the current thickness ± standard error is 986.0 ± 4.7 mils.

(6) The best estimate of the corrosion rate during this period based on a least squares fit is -8.2 ± 10.7 mils per year.

Bottom 4 Rows

(1) Four of the five subsets are normally distributed at the 5% level of significance, and one at the 1% level of significance.

(2) The mean model is appropriate.

(3) The F-test for the significance of the difference between the means shows that the differences between the mean thicknesses are not significant at 1% level of significance.

(4) These analyses indicate that the corrosion rate is not significant compared to the random variations i the measurements.

(5) Based on the mean model, the current thickness ± standard error is 1005.7 ± 5.6 mils.

(6) The best estimate of the corrosion rate during this period based on a least squares fit is -13.1 ± 11.6 mils per year.

5.2 6"x6" Grids in Sand Bed Region Without Cathodic Protection

5.2.1 Bay 9D: 12/19/88 to 4/24/90

Five 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) The current mean thickness is 1021.7 ± 8.9 mils.

(4) The F-test for the significance of the difference between the mean thicknesses indicates that the differences between the means are significant. The LSD analysis shows that this is due to the second measurement on 6/26/89 which is 33 to 52.3 mils higher than the other four.

(5) The t-test of the last two data sets shows that the difference between the mean thicknesses is not significant.

(6) The overall analysis indicates that there was no significant corrosion from December 19, 1988 to April 24, 1990.

(7) The best estimate of the corrosion rate during this period based on a least squares fit is -21.0 ± 18.1 mils per year.

5.2.2 Bay 13A: 12/17/88 to 4/24/90

Seven 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The regression model is appropriate.

(3) The regression model explains 97% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 853.1 ± 2.4 mils.

(6) The indicated corrosion rate ± standard error is -39.1 ± 3.4 mils per year.

(7) F/F critical = 16.9

(8) The measurements below 800 mils were tested and determined not to be statistically different from the mean thickness.

5.2.3 Bay 13D: 3/28/90 to 4/25/90

One 7-point data set and one 49-point data set are available for this bay covering this period.

(1) The 7-point data set is normally distributed at 5% level of significance. The 49-point data set is normally distributed at 1% level of significance. However, there is a diagonal line of demarcation separating a zone of minimal corrosion at the top from a corroded zone at the bottom. Thus, corrosion has occurred at this location.

(2) The mean of the 7-point data set is not significantly different from the mean of the corresponding 7 points in the 49-point data set.

(3) The current means thickness is 931.9 ± 22.6 mils.

It is concluded that corrosion has occurred at this location. However, with minimal data over a one-month period, it is impossible to determine the current corrosion rate.

5.2.4 Bay 15D: 12/17/88 to 4/24/90

Five 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) The current mean thickness ± standard error is 1056.5 ± 2.3 mils.

(4) The F-test for the significance of the difference between the mean thicknesses indicates that the differences between the means are not significant.

(5) The t-test of the last two data sets shows that the difference between the mean thicknesses is not significant.

(6) There was no significant corrosion from December 17, 1988 to April 24, 1990.

(7) The best estimate of the corrosion rate during this period based on a least squares fit is -4.6 mils per year.

5.2.5 Bay 17A: 12/17/88 to 4/24/90

Five 49-point data sets were available for this period.

The initial analysis of this data indicated that the data are not normally distributed. The lack of normality was tentatively attributed to minimal corrosion in the upper half of the 6"x6" grid with more extensive corrosion in the lower half of the grid. To test this hypothesis, each data set was divided into two subsets, with one containing the top three rows and the other containing the bottom four rows.

Top 3 Rows

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) The current mean thickness ± standard error is 1128.3 ± 2.2 mils.

(4) The F-test for the significance of the difference between the mean thicknesses indicates the differences between the means are not significant.

(5) The t-test of the last two data sets indicates that the difference between the mean thicknesses is not significant.

(6) There was no significant corrosion during this period.

(7) The best estimate of the corrosion rate during this period based on a least squares fit is -6.8 ± 3.7 mils per year.

Bottom 4 Rows

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) The current mean thickness ± standard error 950.83 ± 5.3 mils.

(4) The F-test for the significance of the difference between the mean thicknesses indicates that the differences between the means are not significant.

(5) The t-test of the last two data sets indicates that the difference between the mean thicknesses is not significant.

(6) There was no significant corrosion during this period.

(7) The best estimate of the corrosion rate during this period based on a least squares fit is -17.7 ± 7.6 mils per year.

5.3 6"x6" Grids at 51' Elevation

5.3.1 Bay 5 Area D-1 2 51' Elevation: 11/1/87 to 4/24/90

Eight 49-point data sets were available for this period.

The initial analysis of this data indicated that the data are not normally distributed. These data sets names start with E. The following adjustments were made to the data:

(1) Point 29 in the 9/13/89 data is much greater than the preceding or succeeding measurements. Therefore, this reading was dropped from the analysis.

(2) Point 9 is a significant pit. Therefore, it was dropped from the overall analysis and is evaluated separately.

(3) Points 13 and 25 are extremely variable and are located adjacent to the plug which was removed from this grid. They were also dropped from the analysis.

(4) Point 43 in the 11/01/87 data is much less than any succeeding measurement. Therefore, this reading was dropped from the analysis.

With these adjustments, the first and last data sets are normally distributed at the 1% level of significance and the other five at 5%. These data set names start with F.

It was noted that the D-Meter calibration at 0.750" yielded readings which ranged from -1 mil for one set of measurements to + 4 mils for another. The data was adjusted to eliminate these biases. These data set names start with G. The final analyses are based on these adjusted data sets.

(1) The data are normally distributed.

(2) The regression model is appropriate.

(3) The regression model explains 57% of the total variation about the mean.

(4) The residuals are normally distributed.

(5) The current mean thickness ± standard error is 745.2 ± 2.1 mils.

(6) The indicated corrosion rate ± standard error is -4.6 ± 1.6 mils per year.

(7) F/F critical = 1.3. Thus, the regression is just barely significant.

(8) The F-test for significance of the difference between the mean thickness indicates that the differences are significant.

(9) The t-test of the last two data sets shows that the difference between the mean thickness is not significant.

(10) The measurements of the pit at point 9 were 706, 746, 696, 694, 700, 688, 699 and 689 mils. The mean value of these measurements is 702.3 ± 6.5 mils. A least squares fit shows that the best estimate of the corrosion rate during this period is -11.5 mils per year with R^2=31%. The second measurement is much higher than the others. Dropping this point, the mean of the remaining measurements is 696.0 ± 2.4 mils, and the best estimate of the corrosion rate is -4.9 mils per year with R^2 = 49%. Recognizing that the variability of single measurements will be about 6 times the variability of the mean of 40 measurements, it is concluded that the corrosion rate in the pit is essentially the same as the overall grid.

5.3.2 Bay 5 Area 51-5 at 51' Elevation: 3/31/90 to 4/25/90

Two 49-point data sets are available for this time period.

(1) The data are not normally distributed. This is due to a large corroded patch near the center of the grid, and several small patches on the periphery.

When the data less than the grand mean were segregated, it was found that these subsets are normally distributed.

(2) The t-tests of the two complete data sets and the two subsets indicate that the difference between the mean thicknesses are not significant.

(3) The current mean thickness ± standard error is 745.1 ± 3.2 mils.

It is concluded that corrosion has occurred at this location. However, with minimal data over such a brief period, it is impossible to determine the current corrosion rate.

5.3.3 Bay 13 Area 31 Elevation 51': 3/31/90 to 4/25/90

Two 49-point data sets are available for this time period.

(1) The data are to normally distributed. This is due to a large corroded patch at the left edge of the grid.

When the data less than the grand mean were segregated, it was found that these subsets are normally distributed..

(2) The t-test of the two complete data sets indicate that the difference between the means is statistically significant. However, the difference between the means of the two subsets is not statistically significant.

(3) The current mean thickness is ± standard error is 750.8 ± 11.5 mils.

It is concluded that corrosion has occurred at this location. However, with minimal data over such a brief period, it is impossible to determine the current corrosion rate.

5.3.4 Bay 15 Area 23 Elevation 51': 3/31/90 to 4/25/90

Two 49-point data sets are available for this time period.

(1) The data are not normally distributed. This is due to a large corroded patch.

When the data less than the grand mean were segregated, it was found that these two subsets are normally distributed.

(2) The t-tests of the two complete data sets and the two subsets indicate that the differences between the mean thicknesses are not significant.

(3) The current mean thickness ± standard error is 751.2 ± 3.8 mils.

It is concluded that corrosion has occurred at this location. However, with minimal data over such a brief period, it is impossible to determine the current corrosion rate.

5.4 6" x 6" Grids at 52' Elevation

5.4.1 Bay 7 Area 25 Elevation 52': 4/26/90

One 49-point data set is available.

(1) The data are not normally distributed.

The subset of the data less than the mean thickness is not normally distributed.

When four points below 700 mils were dropped from the data set, the remaining data was found to be normally distributed. Therefore, the lack of normality of the complete data set is attributed to these thinner points. Three of these could be considered to be pits (626, 657 and 676 mils) since they deviate from the mean by more than 3 sigma.

(2) The current mean thickness ± standard is 715.5 ± 2.9 mils.

It is concluded that corrosion has occurred at this location.

5.4.2 Bay 13 Area 6 Elevation 52': 4/26/90

One 49-point data set is available.

(1) The data are not normally distributed.

The subset of the data less than the mean thickness is normally distributed. Thus, the lack of normality of the complete data set is attributed to a large corroded patch at the left side of the grid.

(2) The current mean thickness ± standard error is 724.9 ± 2.9 mils.

(3) It is concluded that corrosion has occurred at this location.

5.4.3 Bay 13 Area 32 Elevation 52': 4/26/90

One 49-point data set is available.

(1) The data are not normally distributed.

The subset of the data less than the mean thickness is normally distributed. Thus, the lack of normality of the complete data set is attributed to these corrosion patches.

(2) The current mean thickness ± standard error is 698.3 ± 5.0 mils.

It is concluded that corrosion has occurred at this location.

5.4.4 Bay 19 Area 13 Elevation 52': 4/26/90

One 49-point data set is available.

(1) The data are normally distributed. However, two adjacent points differ from the mean by 3 sigma and 5 sigma. Thus, there is a pit.

(2) The current means thickness ± standard error is 712.5 ± 3.1 mils.

It is concluded that some corrosion has occurred at this location.

5.5 6" x 6" Grids at 87' Elevation

5.5.1 Bay 9 87' Elevation: 11/6/87 to 3/28/90

Five 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) There was no significant corrosion during this period.

(4) The current mean thickness ± standard error is 619.9 ± 0.6 mils.

(5) The best estimate of the corrosion rate during this period based on a least squares fit is -0.2 ± 0.9 mils per year.

5.5.2 Bay 13 87' Elevation: 11/10/87 to 3/28/90

Five 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) There was no significant corrosion during this period.

(4) The current mean thickness ± standard error is 636.5 ± 0.8 mils.

(5) The best estimate of the corrosion rate during this period based on a least squares fit is zero mils per year.

5.5.3 Bay 15 87' Elevation: 11/10/87 to 3/28/90

Five 49-point data sets were available for this period.

(1) The data are normally distributed.

(2) The mean model is more appropriate than the regression model.

(3) There was no significant corrosion during this period.

(4) The current mean thickness ± standard error is 636.2 ± 1.1 mils.

(5) The best estimate of the corrosion rate during this period based on a least squares fit is zero mils per year.

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APPLICANT'S EXH. 24

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: Exam Date: 10-19-06

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2088903-06

Location: Building: RX Elev.: 15' Col.: N/A Row: N/A Azimuth/Radius: 0°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: C/S

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-19-06 Time: 2130

Special / Specific Instructions:

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY #1 CONTAINMENT SURFACE REFERENCE SPEC. IS-328227-004 REV. 13	X			N/A

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☒ Yes ~~☒ No~~ 10-22-06 JZA ☐ Sketch ☐ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: Scott R. Erickson LEVEL II DATE: 10-19-06

NDE LEVEL III SIGNATURE: L III DATE: 10-22-06

RESP. INDIVIDUAL SIGNATURE: DATE:

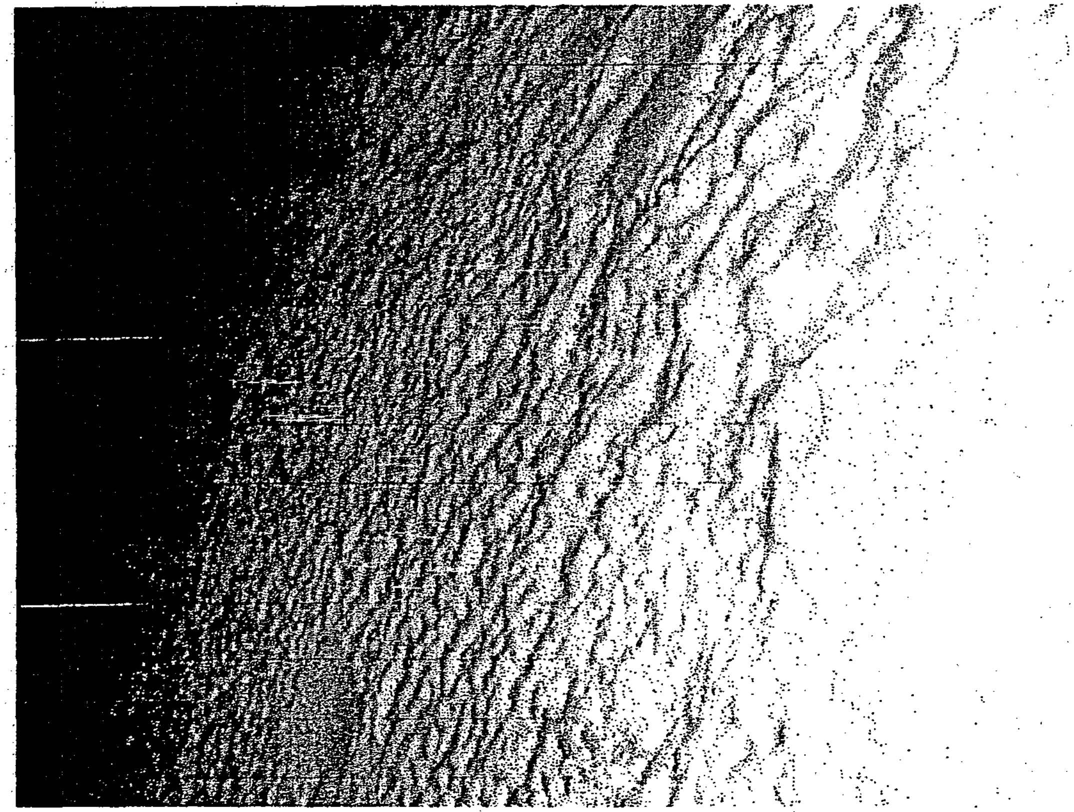
FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments:

ANII REVIEW SIGNATURE: DATE:

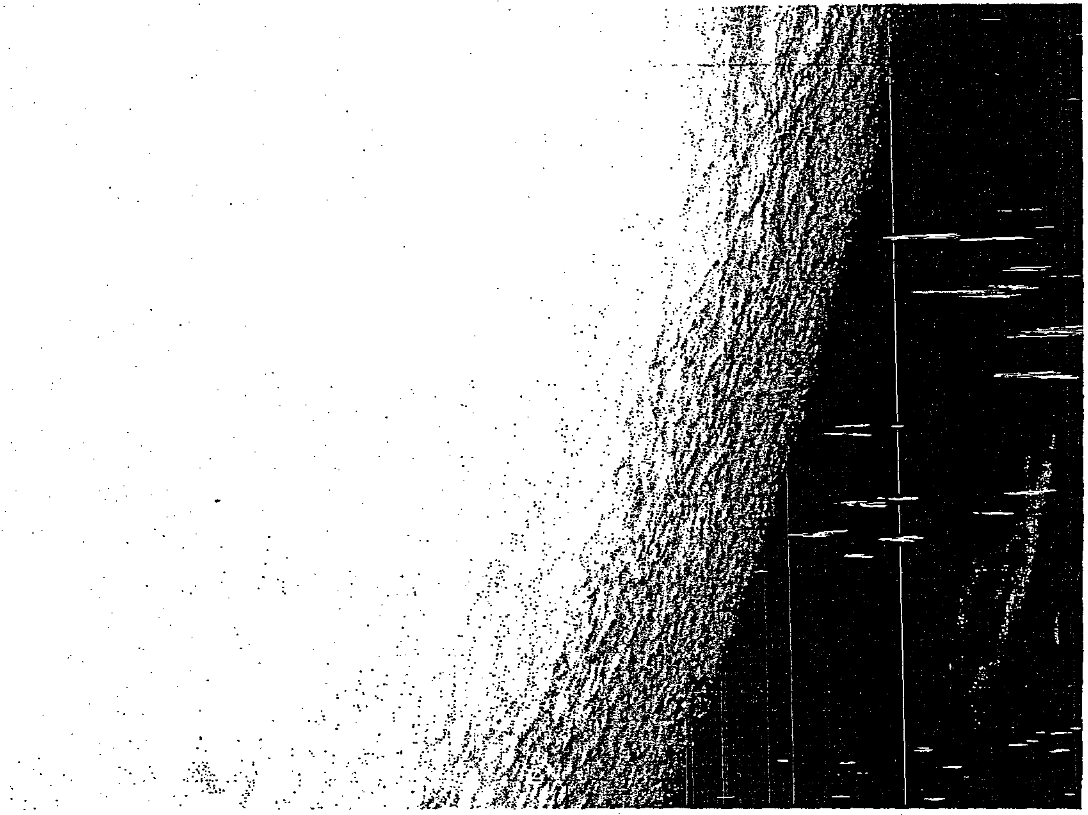
1R21LR-017 Pg 2 of 4

MHC L III 10-~~28~~06
22
MHC



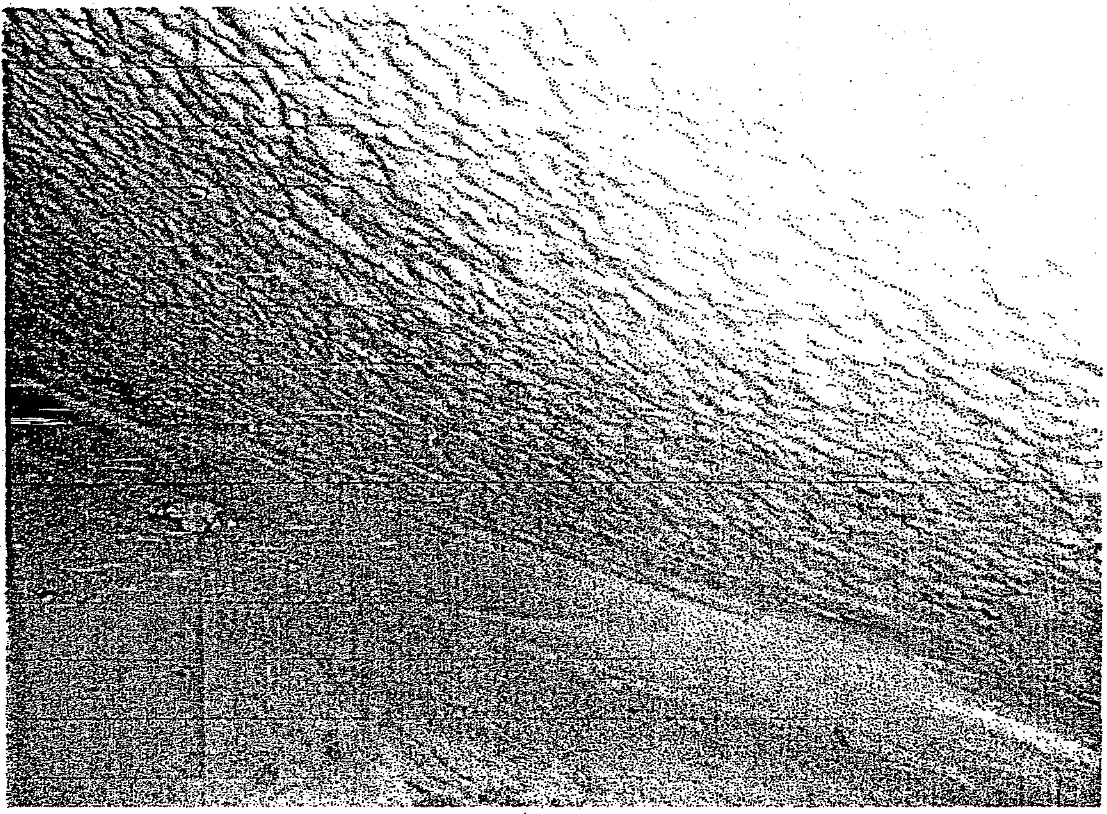
Bay 1 left side

1R21LR-017 Pg 3 of 4
L III 10-22-06



Bay 1 right side

1R21CR-017 Pg 4 OF 4
L III 10-22-06



Bay 1 caulking

1R21LR-013 Pg 1 of 6

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: Exam Date: 10-20-06

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2092867-06

Location: Building: RX Elev.: 15' Col.: N/A Row: N/A Azimuth/Radius: 30°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: C/S

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-20-06 Time: 2140

Special / Specific Instructions:

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY #3 CONTAINMENT SURFACE REFERENCE SPEC. IS-328227-004 REV. 13	X			NOTE: FLOOR COATING SEPARATION ON LEFT SIDE

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☒ Yes ☐ No ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: Scott R. Erickson LEVEL II DATE: 10-20-06

NDE LEVEL III SIGNATURE: L III 10-22-06 DATE:

RESP. INDIVIDUAL SIGNATURE: DATE:

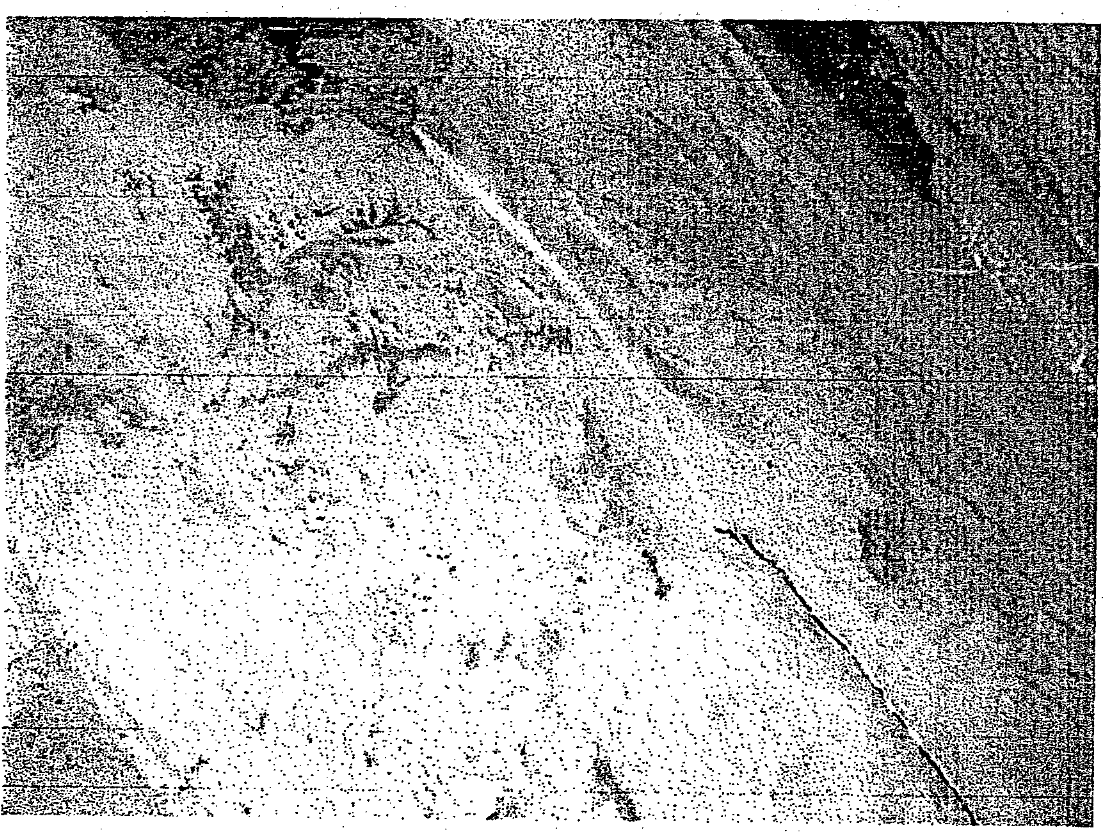
FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments:

ANII REVIEW SIGNATURE: DATE:

1R21LR-013 Pg 2 of 6

MMC L III 10-22-06



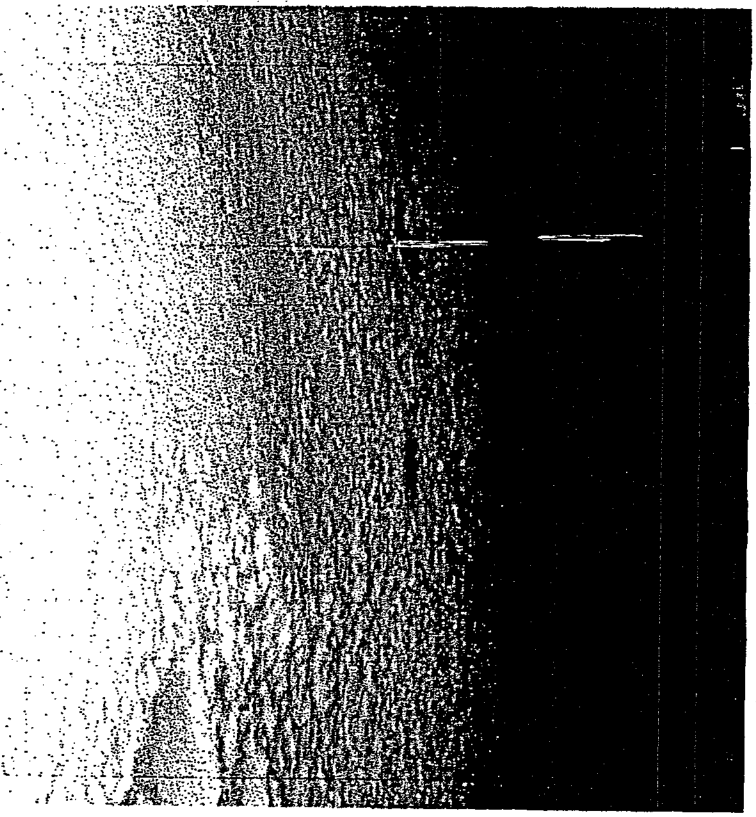
Bay 3 left floor separation

1R21LR-013 Pg 3 of 6

III 10-22-06

Bay 3 left floor separation

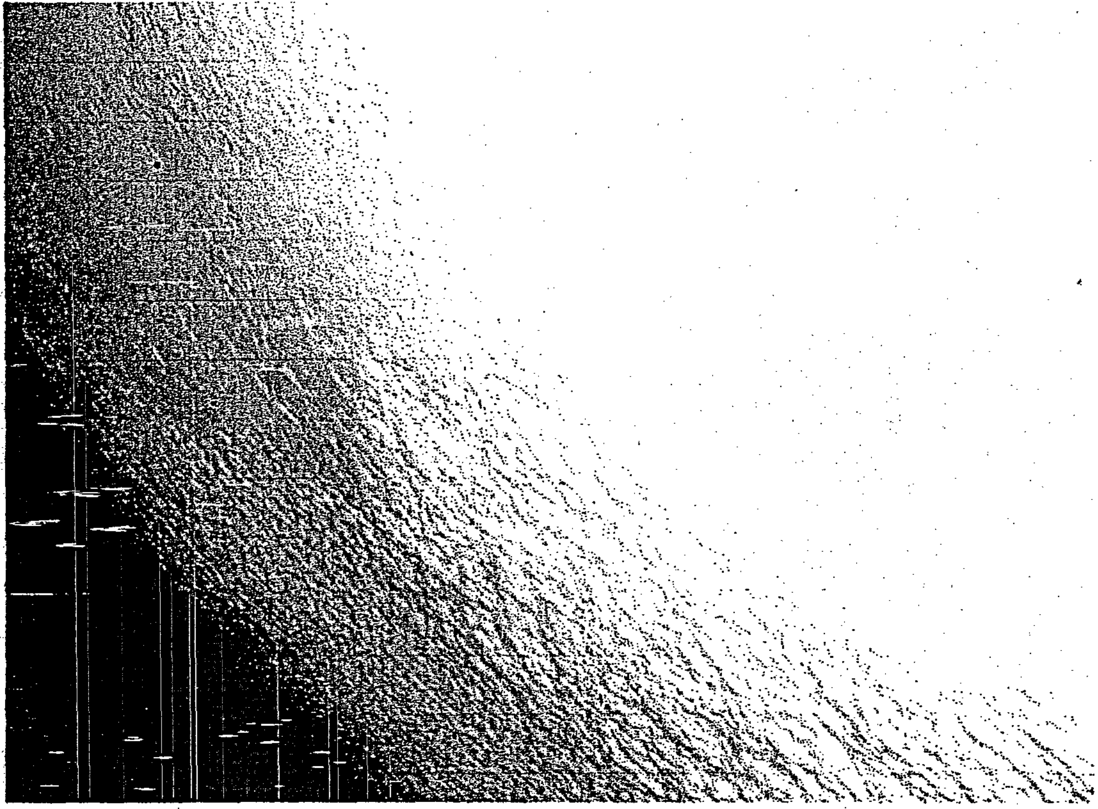
1R21LR-013 Pg 4 of 6
10-22-06



Bay 3 right side

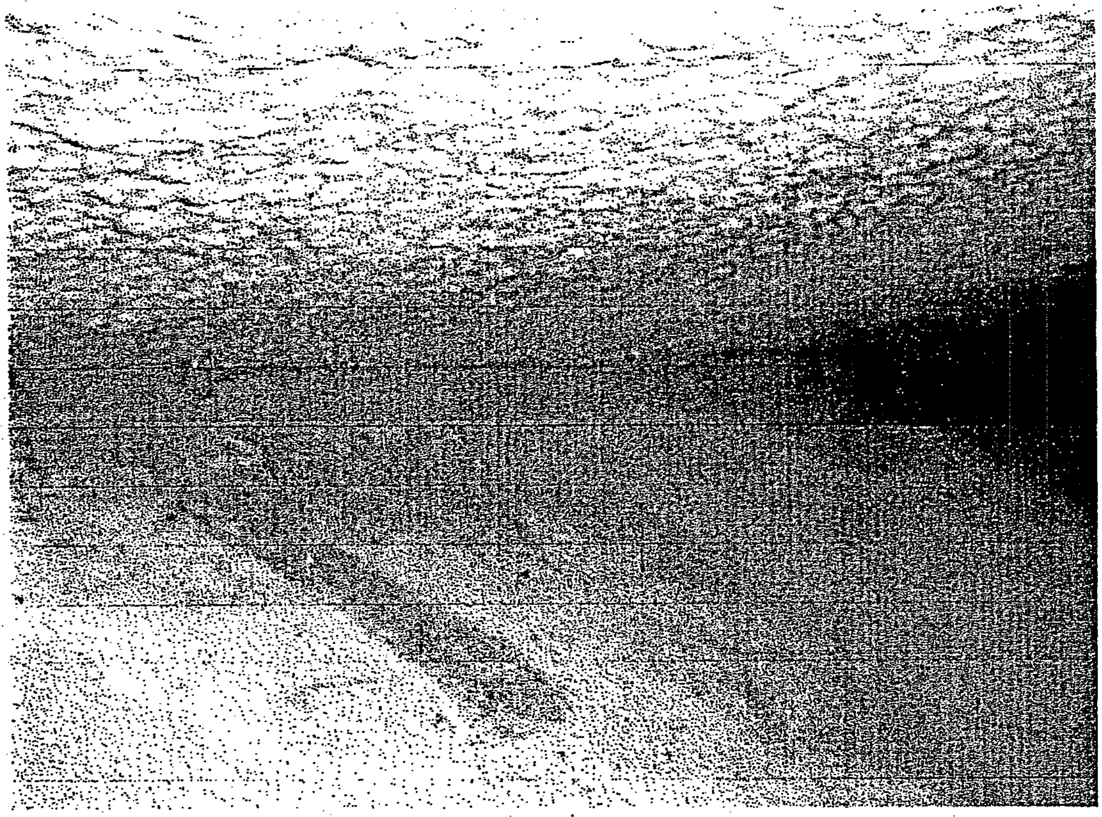
1R21CR-013 Pg 5 of 6

10-22-06
L III



Bay 3 left side

IR21CR-013 Pg 6 of 6
MMc 10-22-06
L III



Bay 3 caulking

1R21LR-014 Pg 1 of 4
L III 10-22-06

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: Oyster Creek Unit: 1 Exam Data Sheet. No.: Exam Date: 10-20-06 1600

System: 187 Examination Procedure ER-AA-335- Rev. Work Order No(s). R2088905-06

Location: Building: Rx Elev.: Col.: Row: Azimuth/Radius: 85°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: CS

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-20-06 Time: 1600

Special / Specific Instructions:

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS NI	RI TYPE	I.N.	Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
BAY #5 EXTERIOR LINER IN SAND BED AREA.	X	N/A	N/A	NOTE: FLOOR COATING SEPARATION ≈ 60" SEE ATTACHED PHOTO.

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A. Wear
B. Corrosion / Pitting
C. Mech. Damage
D. Erosion
E. Cracks
F. Flaking
G. Blistering
H. Peeling
I. Discoloration
J. Pitting
K. Nicks / Gouges
L. Dents
M. Missing Components
N. Loose Components
O. Tears
P. Coating Damaged
Q. Leakage / Moisture
R. Dislodged Seal, Gasket, or Moisture Barrier
S. Deviation From Design Drawing
T. Missing Paint Or Coating
U. Bulges / Deformation
V. Missing / Incomplete Welds
W. Arc Strikes
Z. Other (Provide Explanation)

Supplemental Information : ☒ Yes ☐ No ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: LEVEL III DATE: 10-20-06

NDE LEVEL III SIGNATURE: L III 10-22-06 DATE:

RESP. INDIVIDUAL SIGNATURE: DATE:

FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments:

ANII REVIEW SIGNATURE: DATE:

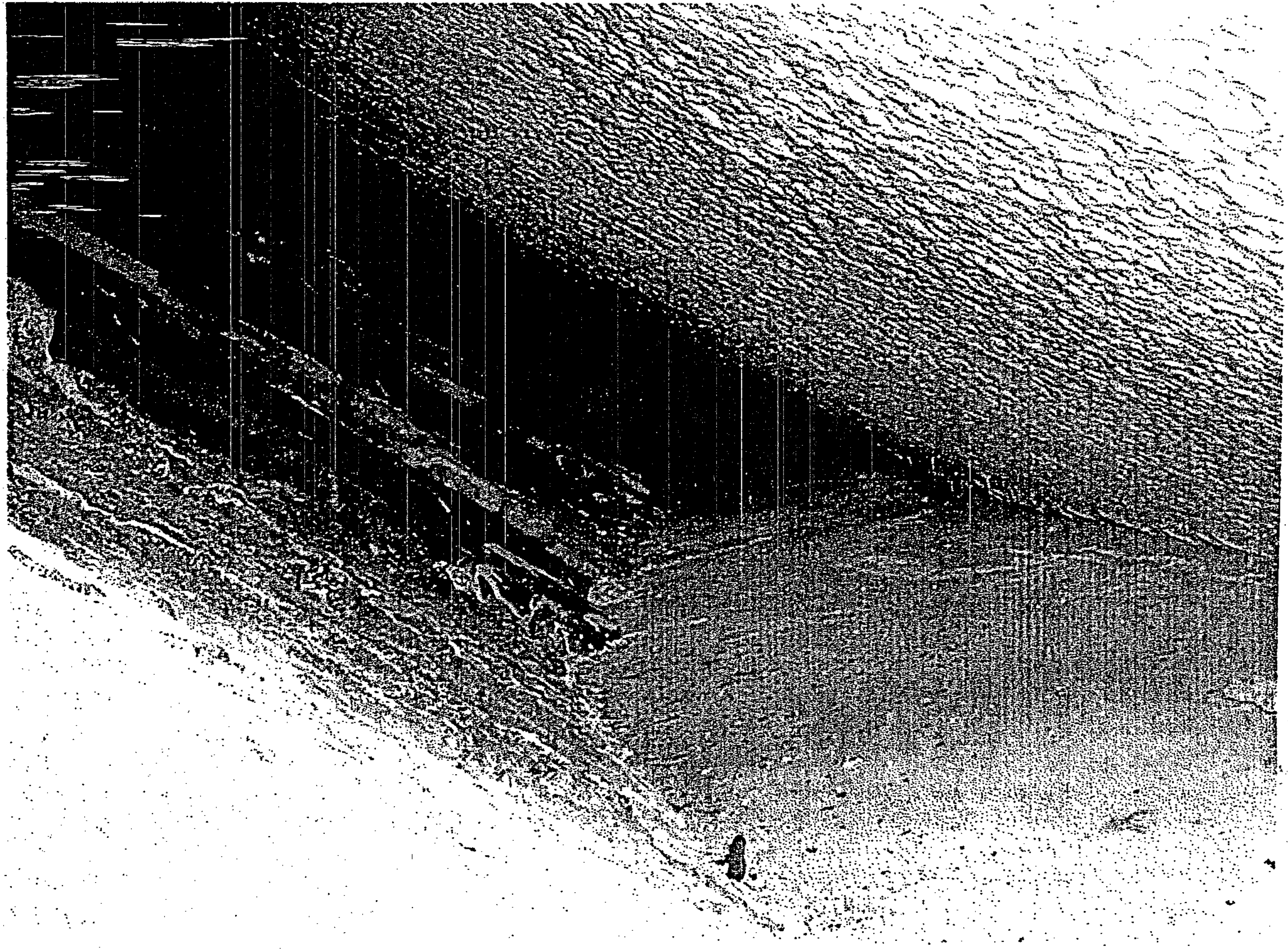
BAY #5

1R21LR-014 Pg 2 of 4
III 10-22-06

VIEW FROM BAY #5 ACCESS TUNNEL LOOKING RIGHT.

BAY #5

1R21LR-014 Pg 3 of 4
L III 10-22-06

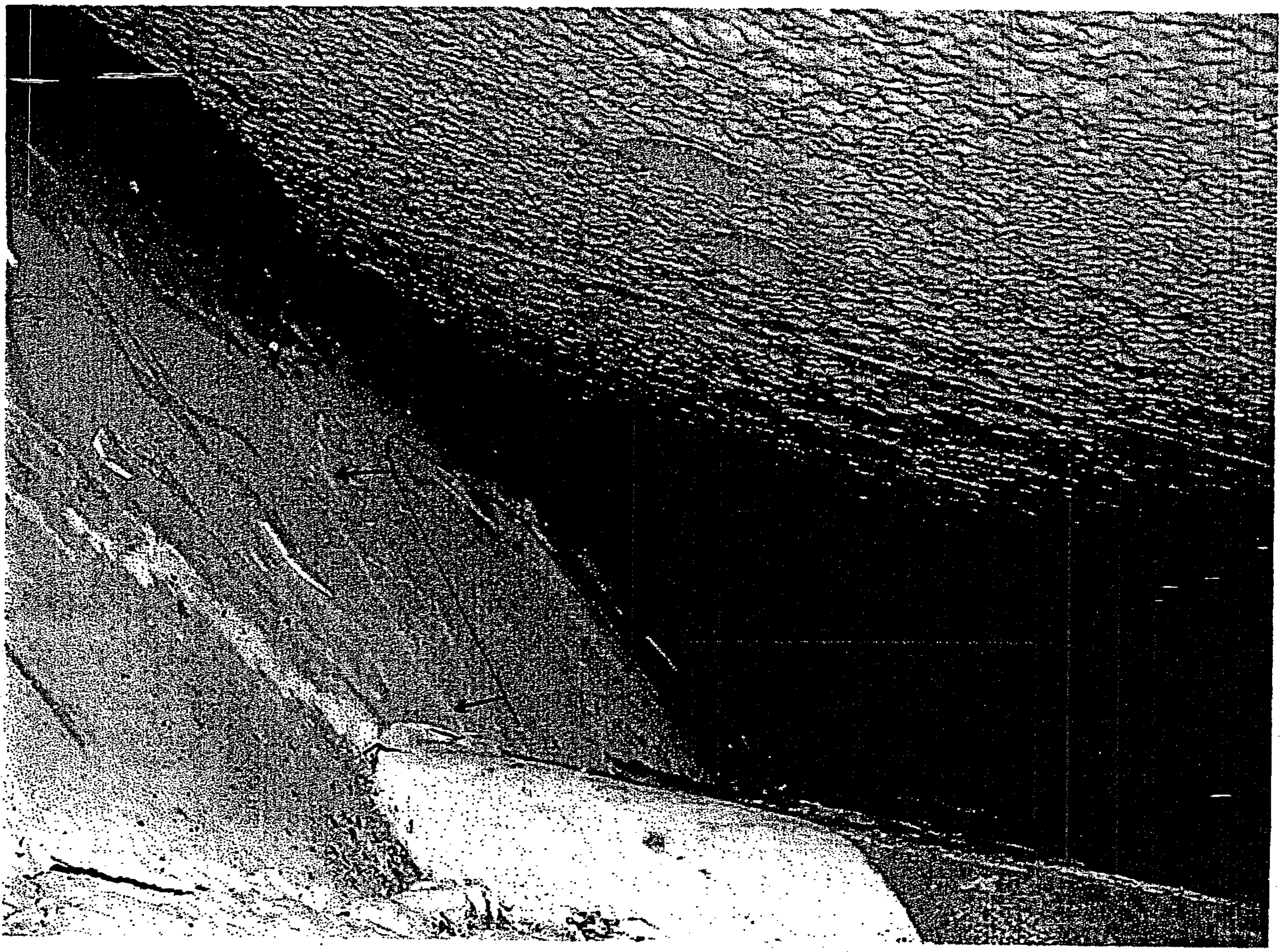


VIEW FROM BAY #5 ACCESS TUNNEL LOOKING LEFT.

BAY #5

IR21LR-014 Pg 4 of 4

C III 10-22-06



FLOOR COATING SEPARATION ≈ 60"

1R21LR-004 Pg 1 of 6

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: Exam Date: 10-19-06 1330

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2088906-06

Location: Building: Rx Elev.: 15' Col.: N/A Row: N/A Azimuth/Radius: ≈120°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: C/S

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-19-06 Time: 1320

Special / Specific Instructions:

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY # 7 CONTAINMENT SURFACE REFERENCE SPEC. IS-328227-004 REV. 13	X			NOTE: BY FLOOR HAS (2) AREAS THAT HAVE DAMAGE. 1) 72" LONG FLOOR COATING SEPARATION, of WHICH 10" is RAISED. Right of OPENING. 2) 42" LONG AREA of FLOOR COATING THAT IS CRUSHED INWARD. LEFT OF OPENING.

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☒ Yes ☐ No ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: LEVEL III DATE: 10-19-06

NDE LEVEL III SIGNATURE: DATE: 10-20-06

RESP. INDIVIDUAL SIGNATURE: DATE:

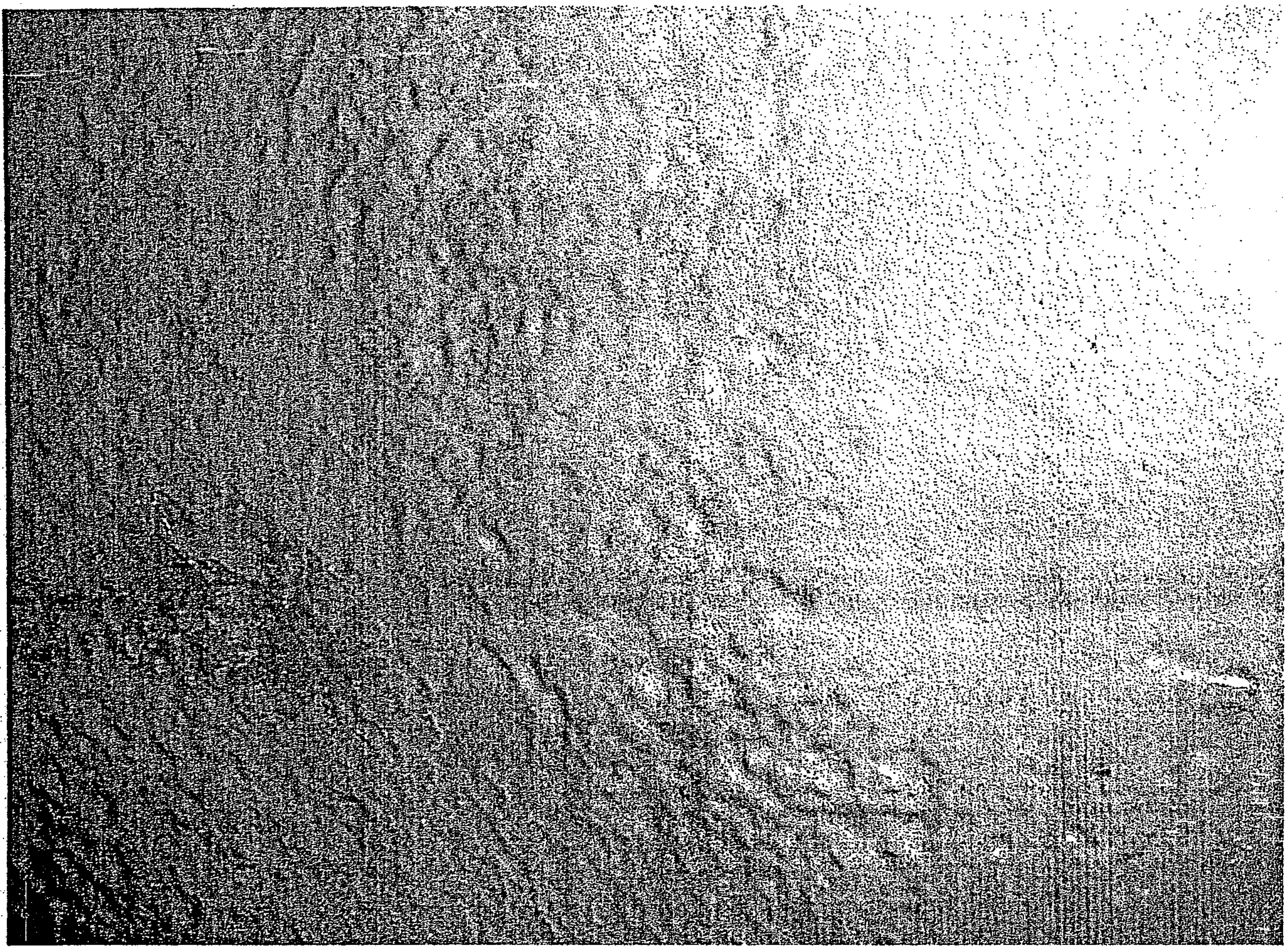
FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments: NOTE: (1) AREA ABOVE 12'3" EL. HAD BARE SURFACE (NO COATING SIZE 8½" X 14") AREA is LOCATED ON RIGHT SIDE of VENT LINE. DRAIN HAS CONCRETE PARTICLES, PARTLY BLOCKING DRAIN.

ANII REVIEW SIGNATURE: DATE:

BAY #7 LINER COATING GENERAL AREA.

1R21LR-004 Pg 2 of 6



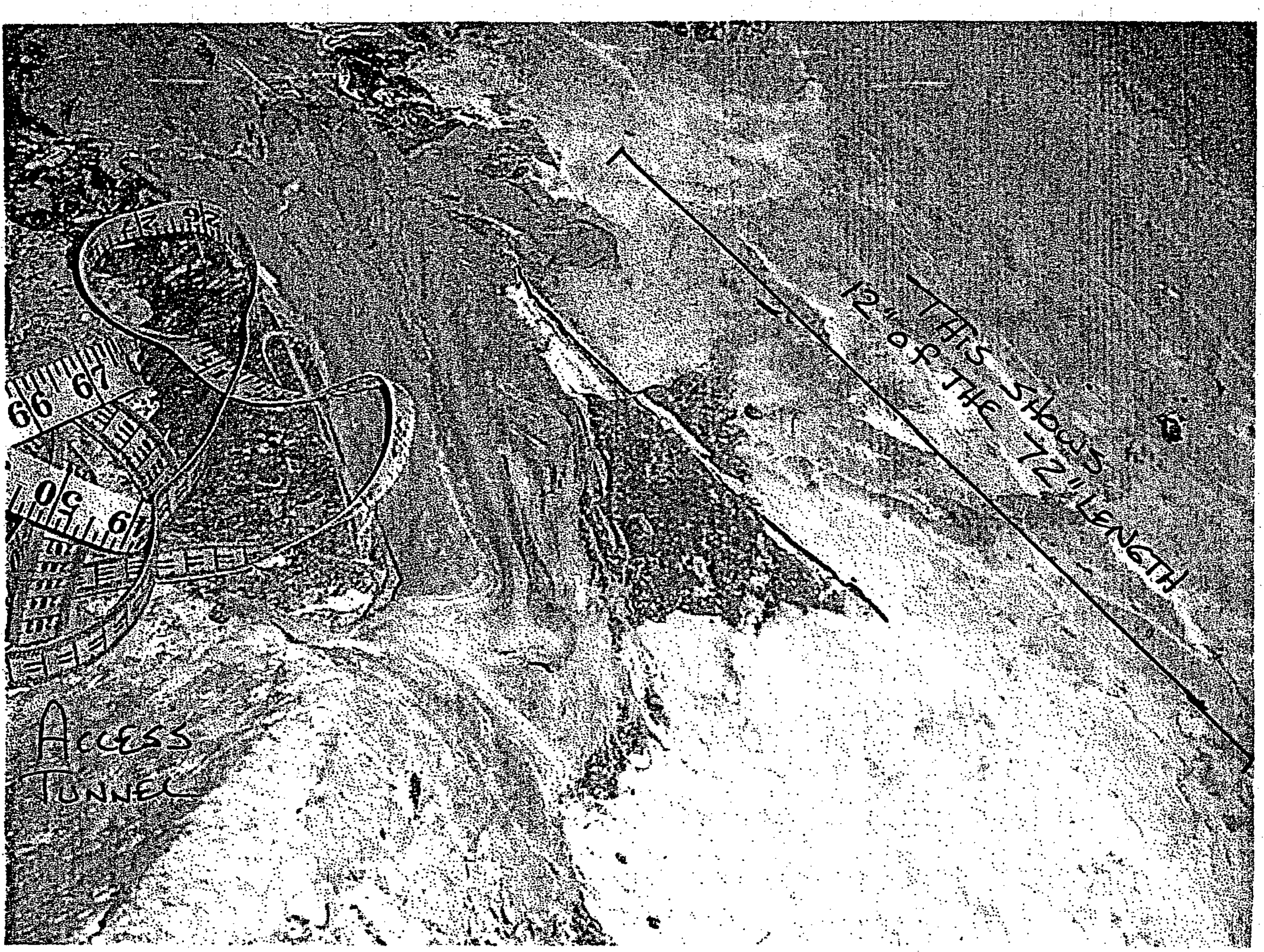
10-19-06

BAY # 7

~~IRLR~~ IR21LR-004 Pg 3 of 6

10-20-06

REFERENCE NOTE # 1 ON DATA SHEET



10-19-06

BAY #7

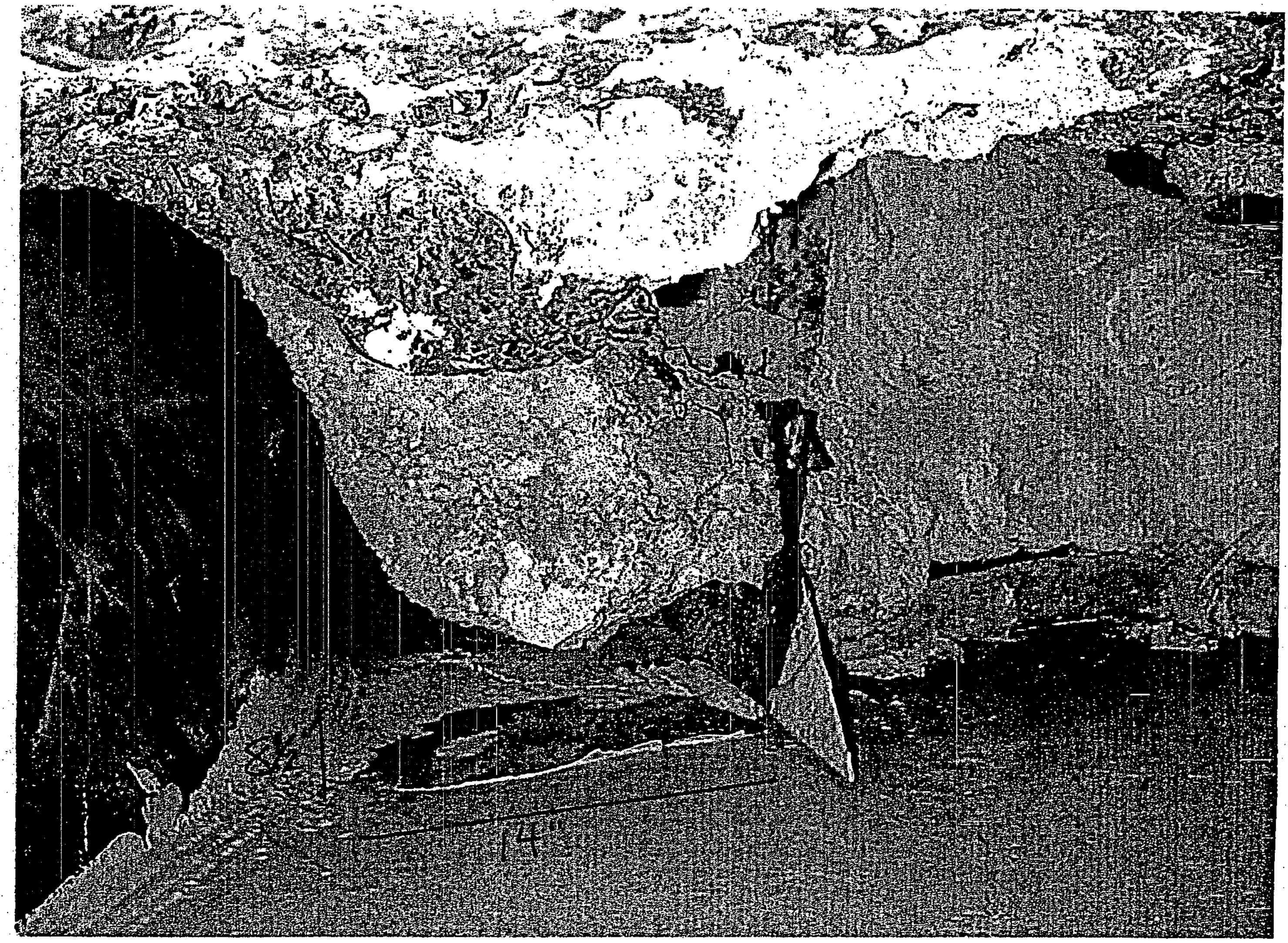
1R21LR-004 Pg 4 of 6

REFERENCE NOTE #2 ON DATA SHEET.
(LEFT of BAY 7 ACCESS TUNNEL)

10-19-06

BAY # 7

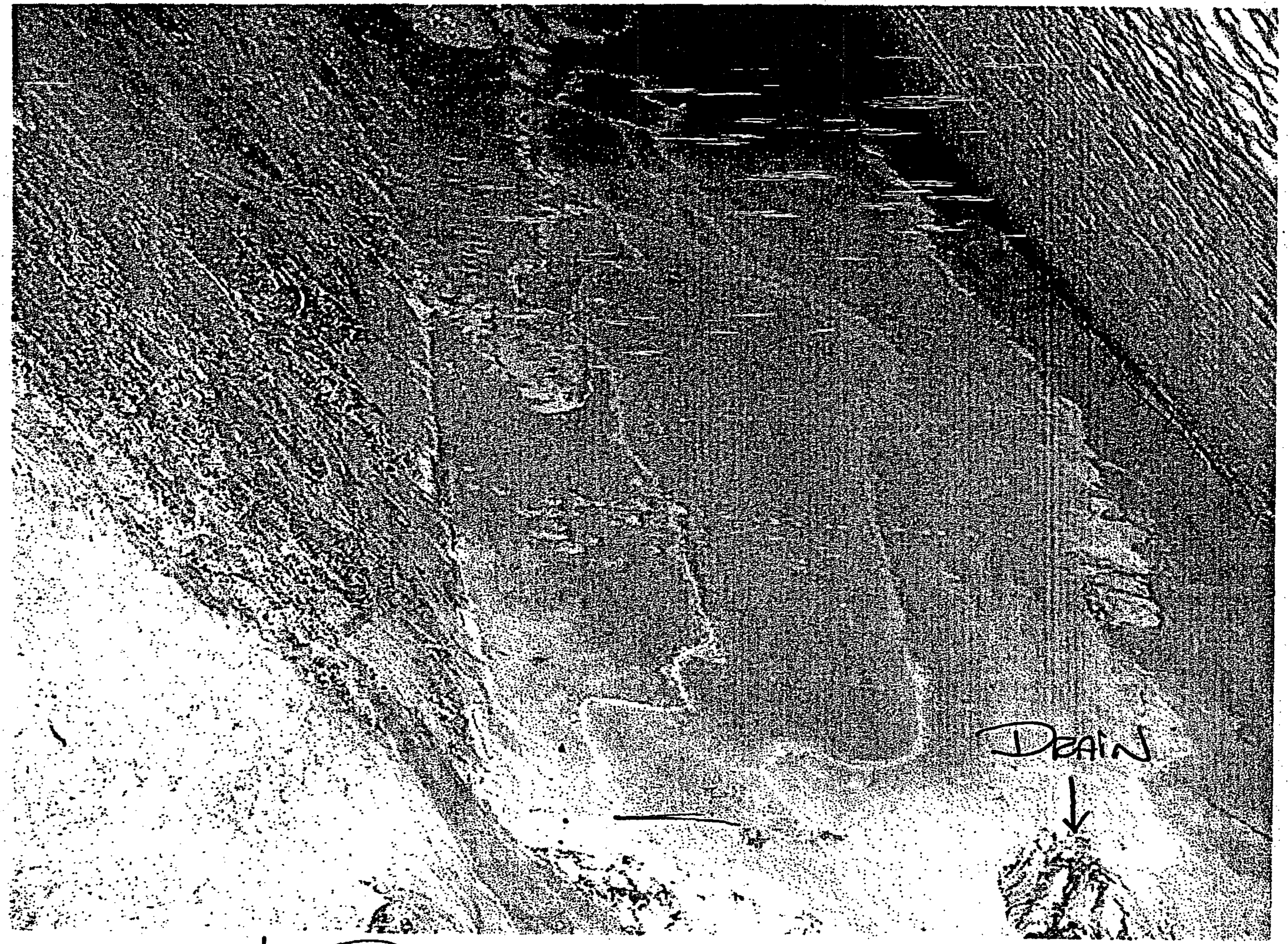
REFERENCE NOTE IN COMMENTS SECTION



L/III
10-19-06

BAY #7 FLOOR AREA to LEFT of ACCESS TUNNEL.

1R21LR-004 Pg 6 of 6



10-19-06

NOTE: DRAIN IS PARTLY FILLED WITH CONCRETE PARTICLES.

REPORT # 1R21 LR-003 Pg 1 OF ~~3~~ 45

MMc 10-22-06

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: N/A Exam Date: 10-19-06

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2088918-06

Location: Building: RX Elev.: 15' Col.: N/A Row: N/A Azimuth/Radius: 150°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: C/S

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-19-06 Time: 2230

Special / Specific Instructions: N/A

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY #9 CONTAINMENT SURFACE REFERENCE SPEC. IS-328227-004 REV.13	X			NOTE: 1) VAPOR BARRIER/FLOOR COATING HAS AREA OF SEPARATION 2) 20" ~~PIPE~~ CONCRETE TUNNEL IS MISSING CAULKING AT FLOOR JOINT SRE 10-20-06

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☒ Yes ☐ No ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: Scott R. Erickson LEVEL II DATE: 10-19-06

NDE LEVEL III SIGNATURE: MMcAllist DATE: 10-20-06

RESP. INDIVIDUAL SIGNATURE: DATE:

FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

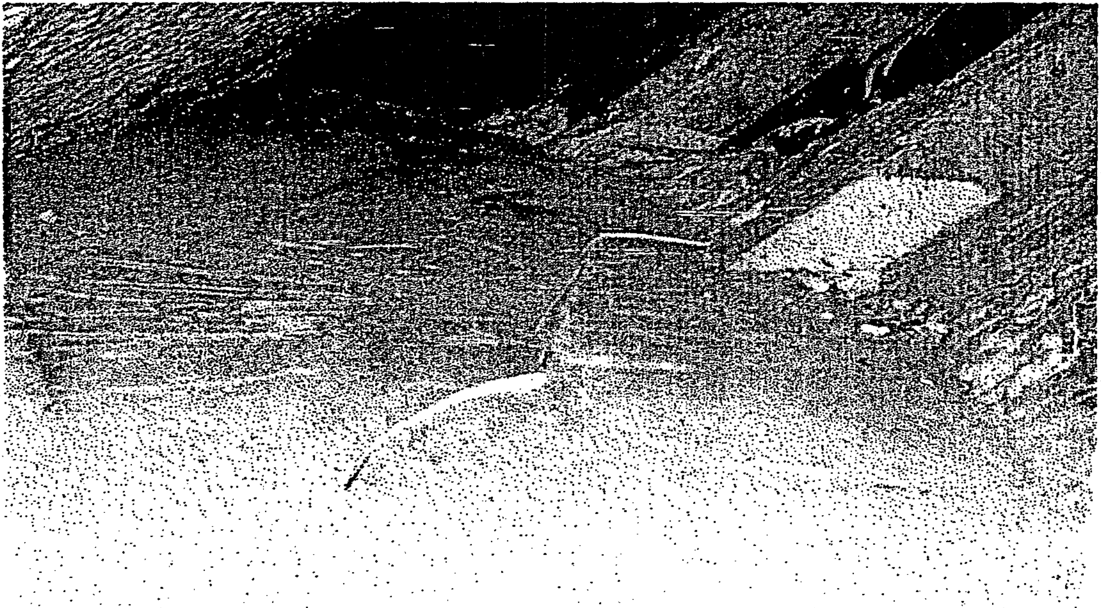
Comments:

ANII REVIEW SIGNATURE: DATE:

1R21LR-003 Pg 2 of ~~3~~ ~~4~~ 5

MMc 10-22-06

4



Bay 9

PICTURE TAKEN FOR
ADDITIONAL INFO.

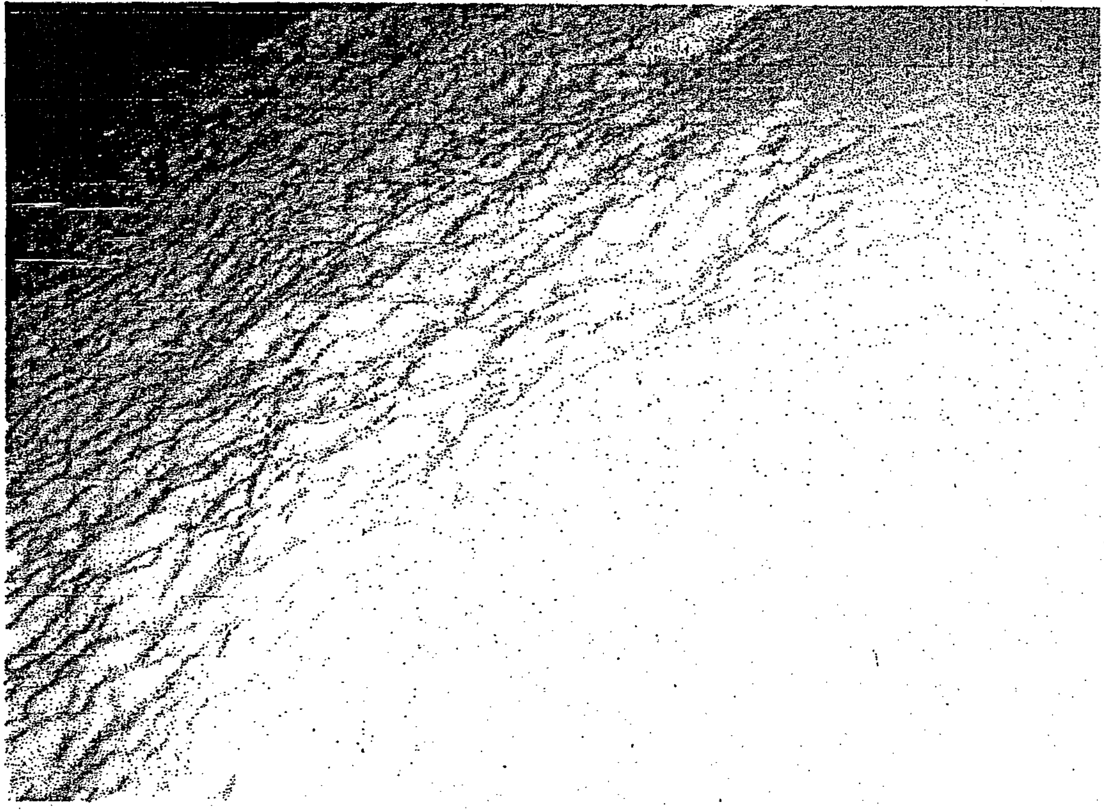
MMcL III 10-20-06

IR21LR-003 Pg 3 of ~~3~~ ~~4~~ ~~5~~
MMc 10-22-06
6

Bay 9

PICTURE TAKEN FOR ADDITIONAL INFO
MMc LIII 10-20-06

1R21LR-003 Pg 4 of 45 6
10-22-06

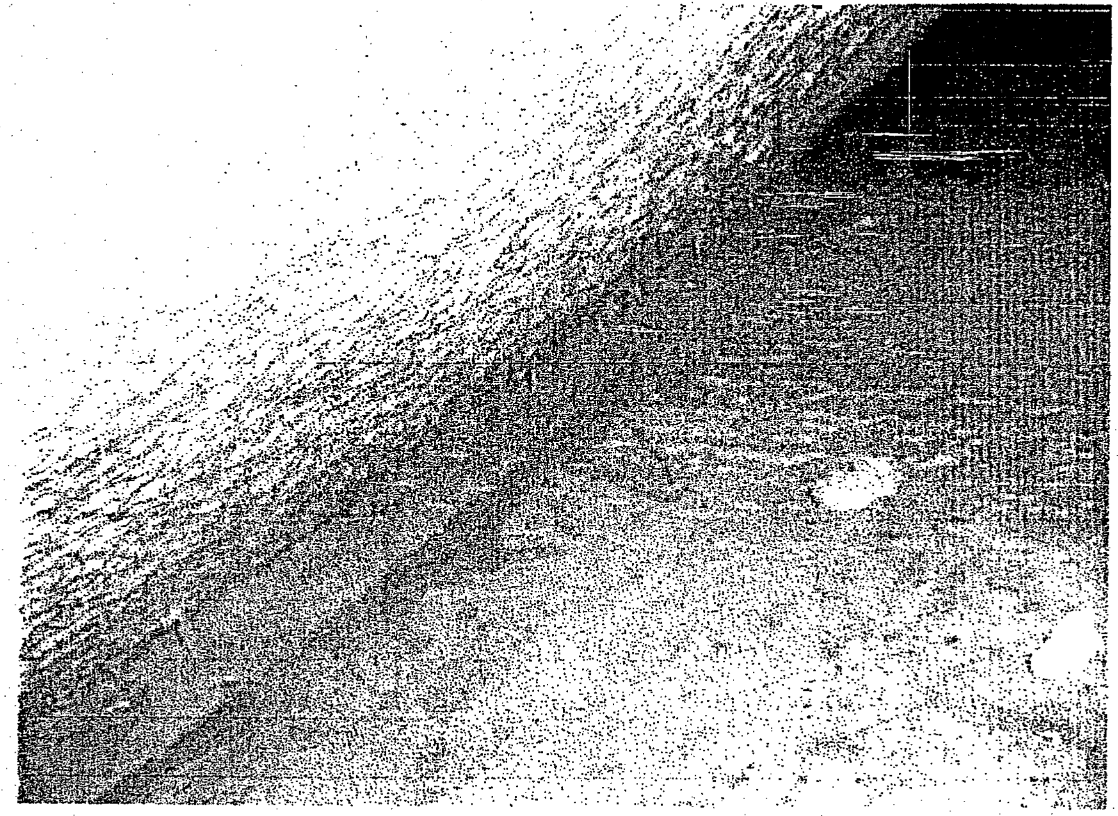


Bay 9 left side

10-22-06

1R21LR-003 Pg 5 of ~~5~~ 6

10-22-06



Bay 9 caulking

10 22-06

Pg 6 of 6
10-22-06

Bay 9 right side

1R21LR-007 Pg 1 of 5

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: Exam Date: 10-20-06 0310

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2092866-06

Location: Building: RX Elev.: 15' Col.: N/A Row: N/A Azimuth/Radius: 180°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: C/S

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-20-06 Time: 0310

Special / Specific Instructions: N/A

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY #11 CONTAINMENT SURFACE REFERENCE SPEC. IS-328227-004 REV.13	X			NOTE: VAPOR BARRIER / FLOOR COATING HAS AREA OF SEPARATION

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☒ Yes ☐ No ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: Scott R. Erickson LEVEL II DATE: 10-20-06

NDE LEVEL III SIGNATURE: DATE: 10-20-06

RESP. INDIVIDUAL SIGNATURE: L III 10-22-06 DATE:

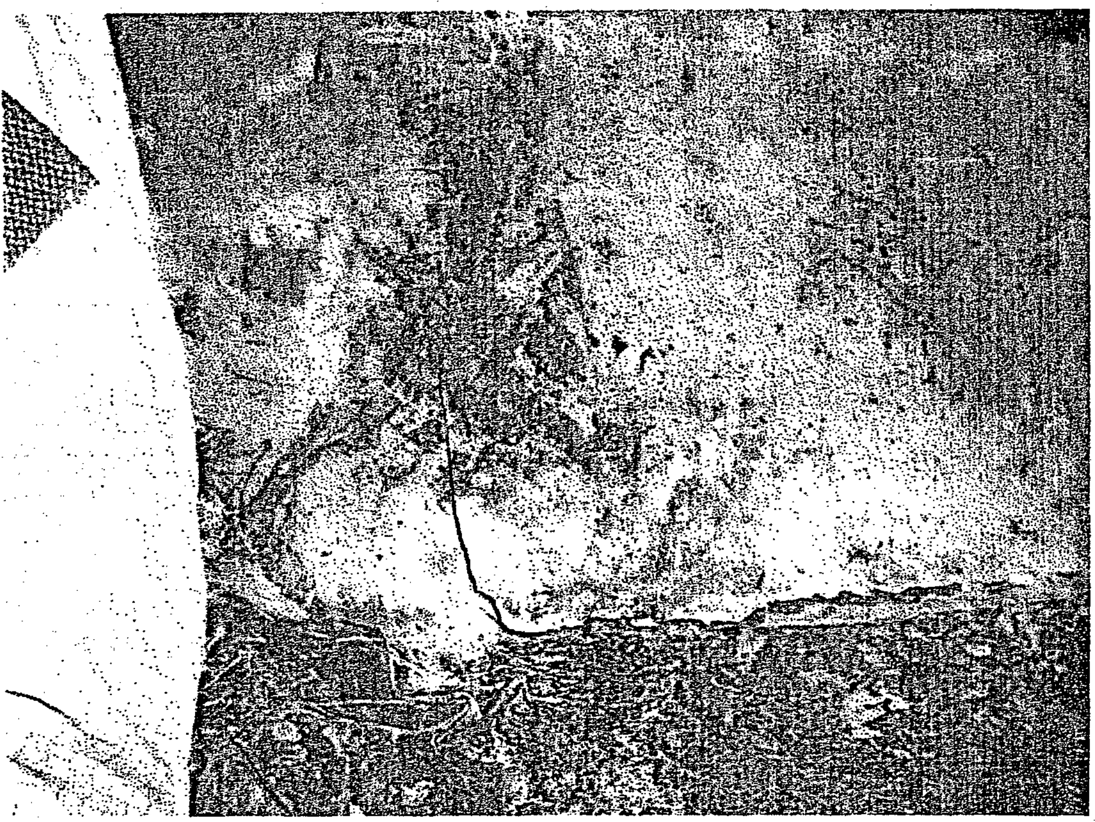
FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments:

ANII REVIEW SIGNATURE: DATE:

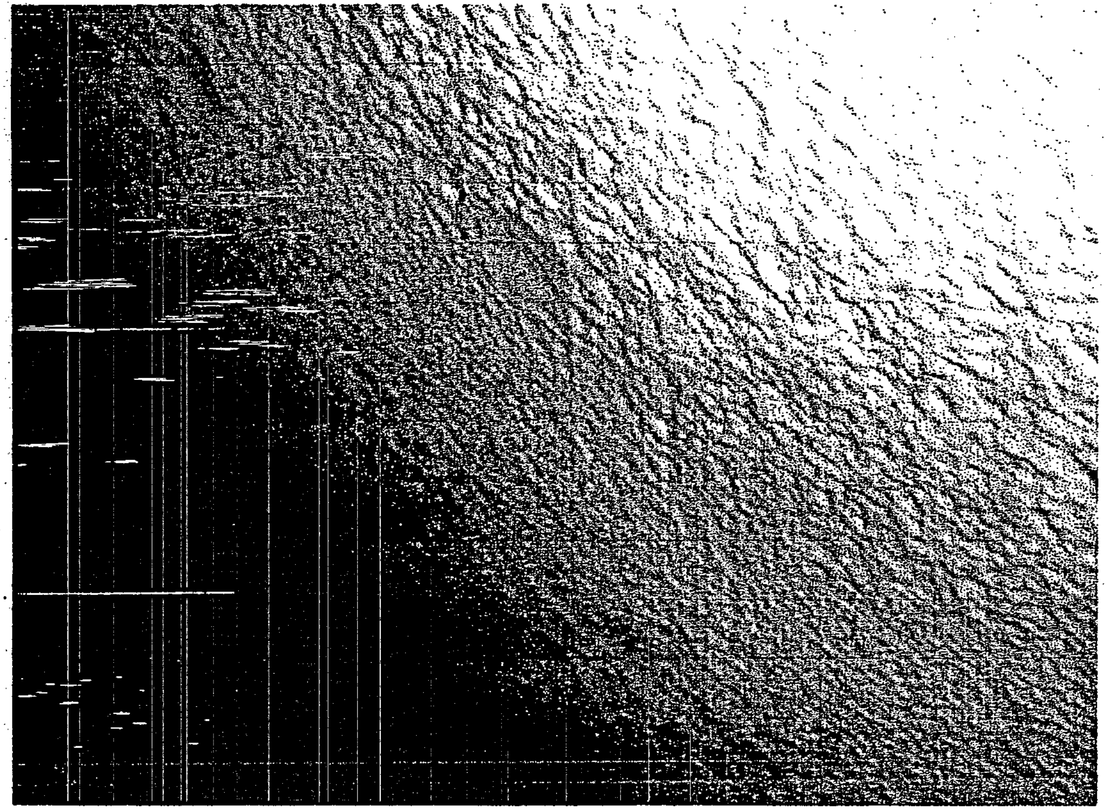
1R21LR-007 Pg 2 of 5

10-22-06



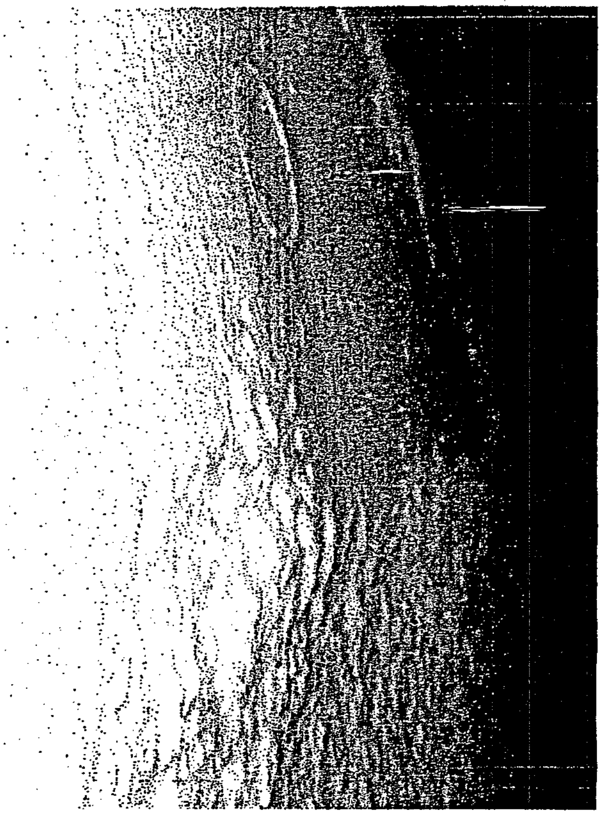
Bay 11

1R21LR-007 Pg 3 of 5
MJM 10-22-06



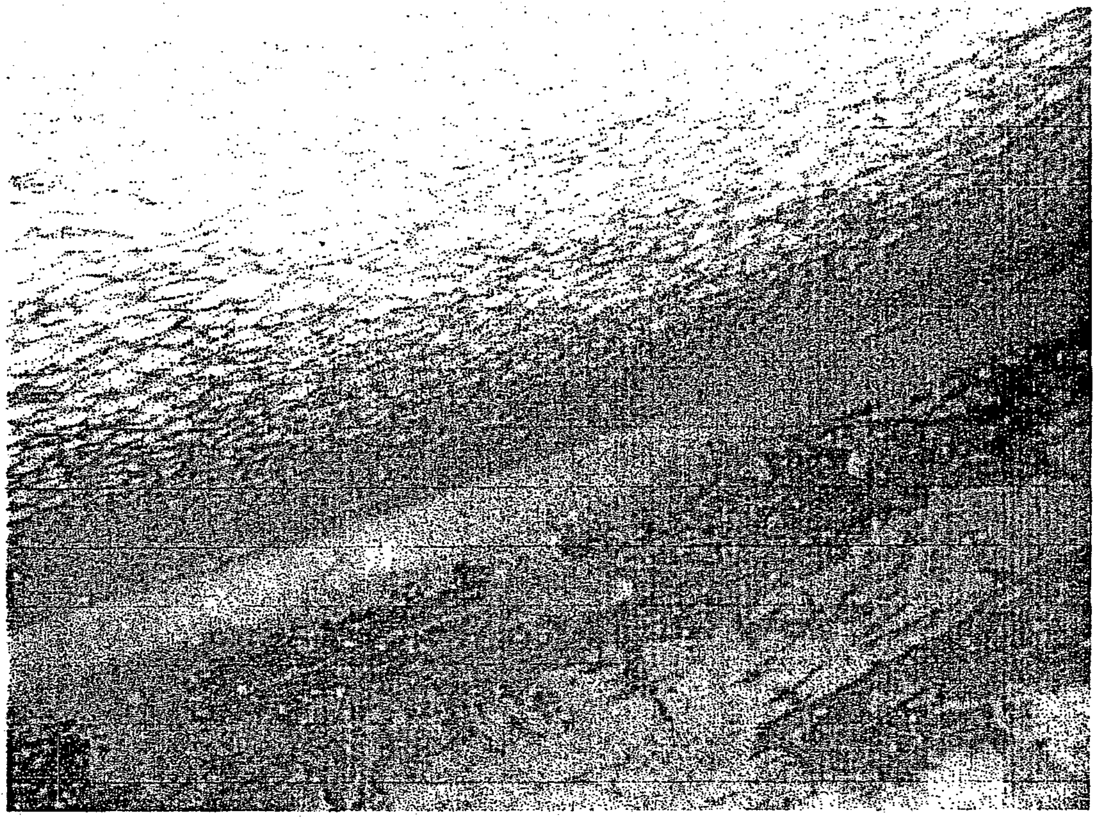
Bay 11 left side

1K212R-007 Pg 4 of 5
10-22-06



Bay 11 right side

1R21LR-007 Pg 5 of 5
10-23-06



Bay 11 caulking

1R21CR-009 Pg 1 of 4

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: Exam Date: 10-18-06

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2088920-06

Location: Building: RX Elev.: 15' Col.: N/A Row: N/A Azimuth/Radius: 220°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: C/S

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-18-06 Time: 2315

Special / Specific Instructions:

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY #13 CONTAINMENT SURFACE REFERENCE SPEC. IS-328227-004 REV. 13	X			N/A

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☒ Yes ~~☒ No~~ JKN 10-20-06 ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: Scott R. Erickson LEVEL II DATE: 10-18-06

NDE LEVEL III SIGNATURE: DATE: 10-20-06

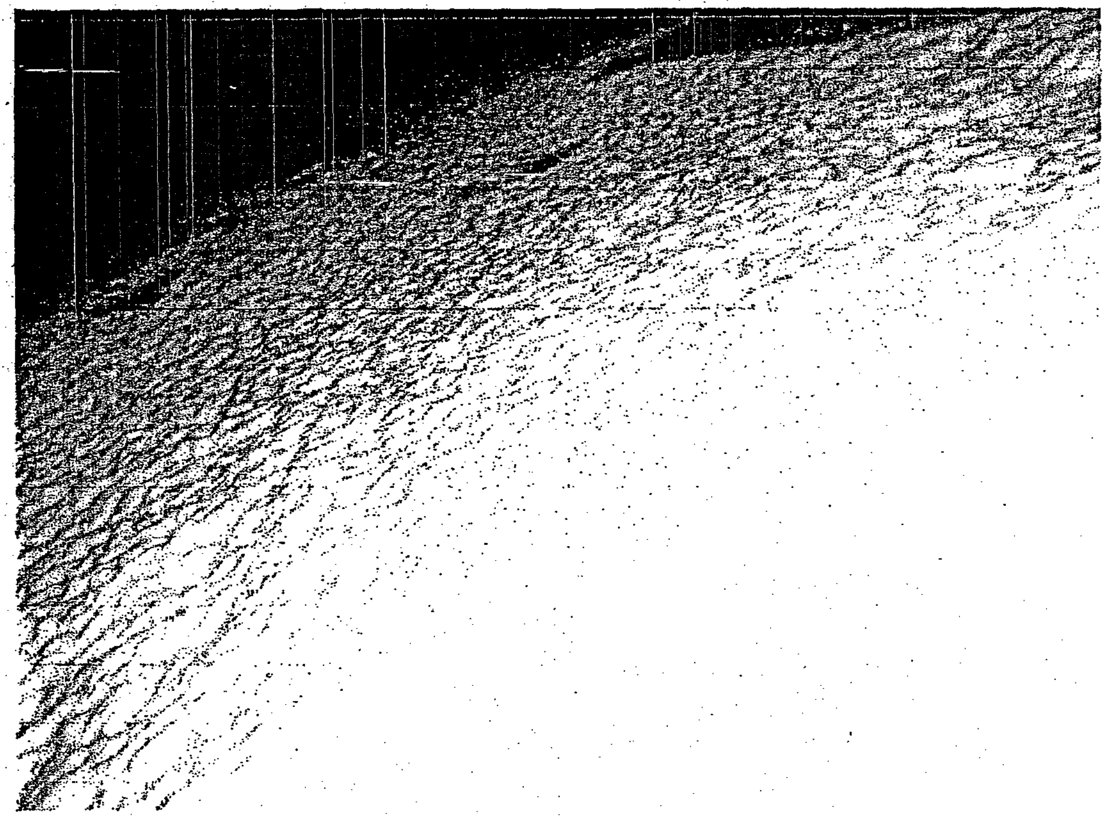
RESP. INDIVIDUAL SIGNATURE: L III 10-22-06 DATE:

FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments:

ANII REVIEW SIGNATURE: DATE:

1R21LR-009 Pg 2 of 4



Bay 13 left side

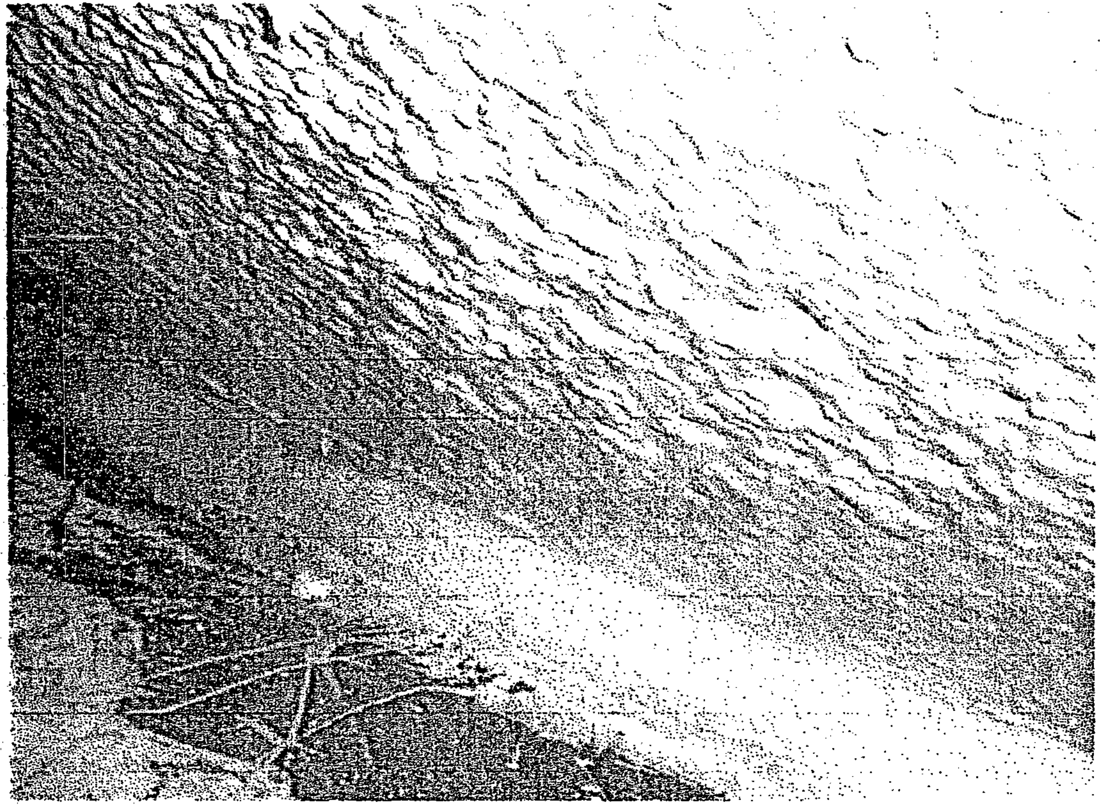
10-22-06

1R21LR-009 Pg 3 of 4

Bay 13 center

L III 10-22-06

IR 21CR-009 Pg 4 of 4



Bay 13 caulking

L III 10-23-06

1R21LR-016 Pg 1 of 5

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: Exam Date: 10-20-06

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2088924-06

Location: Building: RX Elev.: 15' Col.: N/A Row: N/A Azimuth/Radius: 255°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: C/S

Design Drawing(s) Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-20-06 Time: 0345

Special / Specific Instructions:

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY #15 CONTAINMENT SURFACE REFERENCE SPEC. IS-328227-004 REV.13	X			NOTE: VAPOR BARRIER / FLOOR COATING HAS AREA OF SEPARATION

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☒ Yes ☐ No ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: Scott R. Erickson LEVEL II DATE: 10-20-06

NDE LEVEL III SIGNATURE: L III DATE: 10-22-06

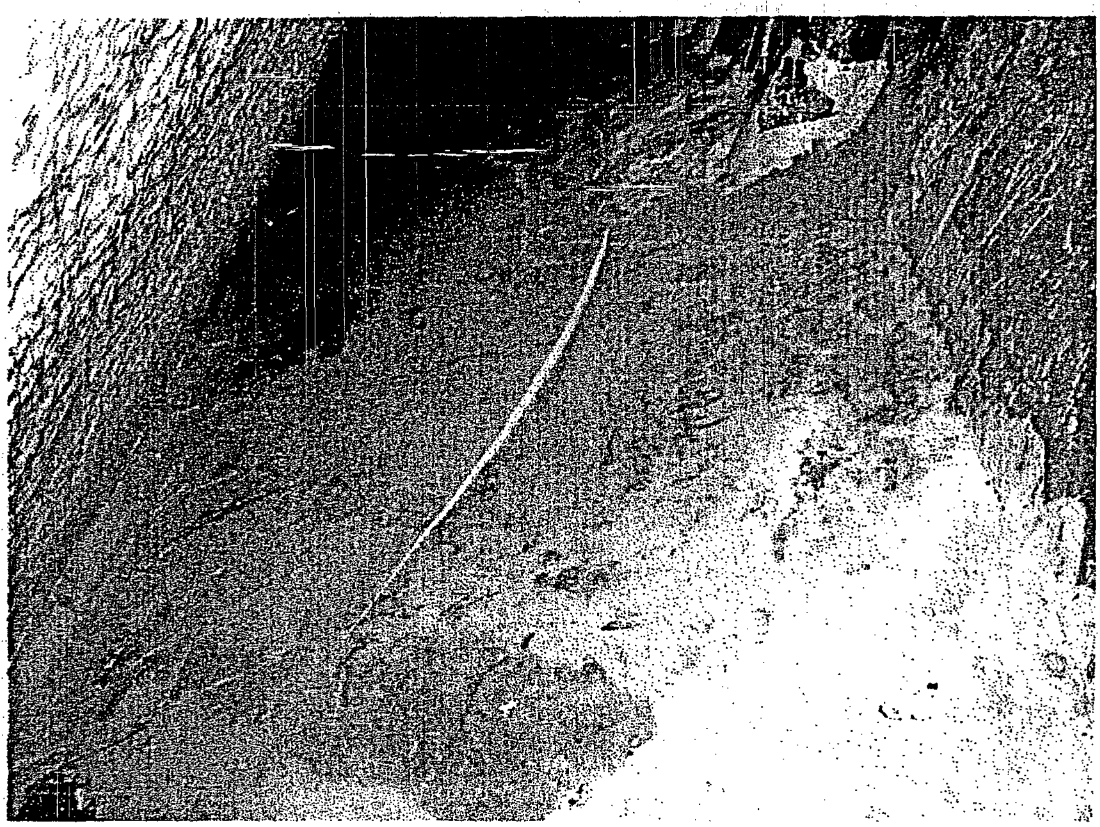
RESP. INDIVIDUAL SIGNATURE: DATE:

FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments:

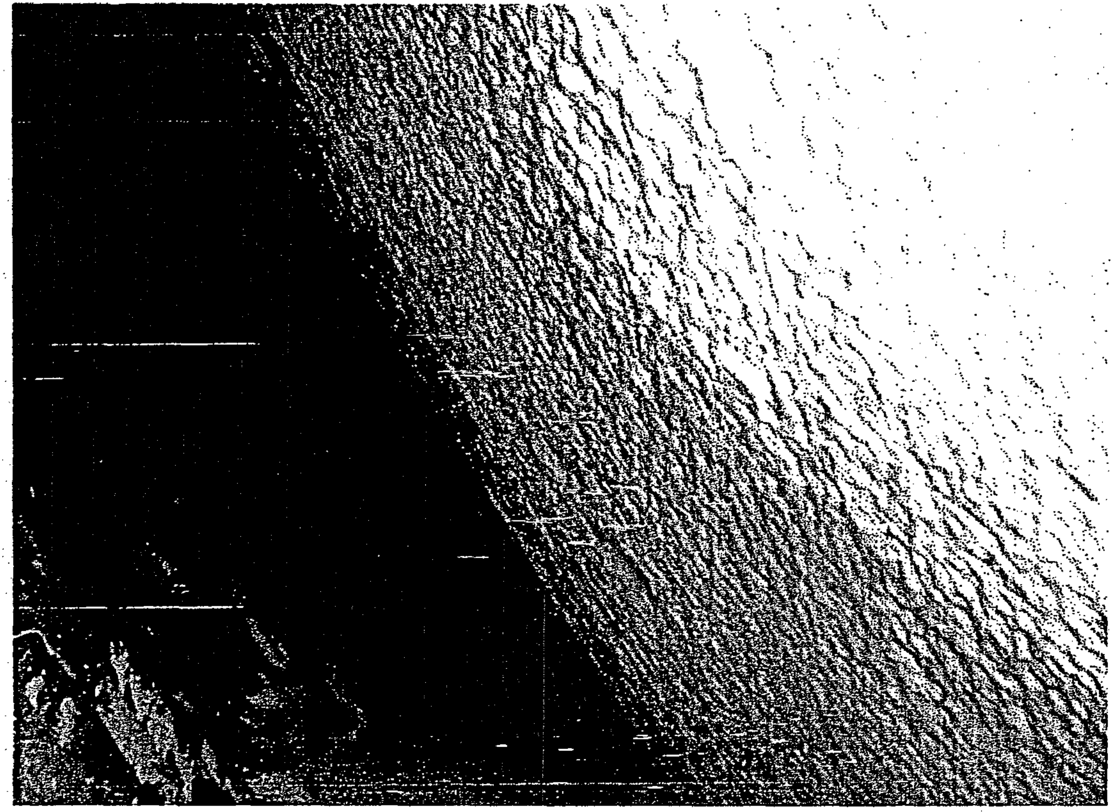
ANII REVIEW SIGNATURE: DATE:

1R21LR-016 Pg 2 of 5
MMc L III 10-22-06



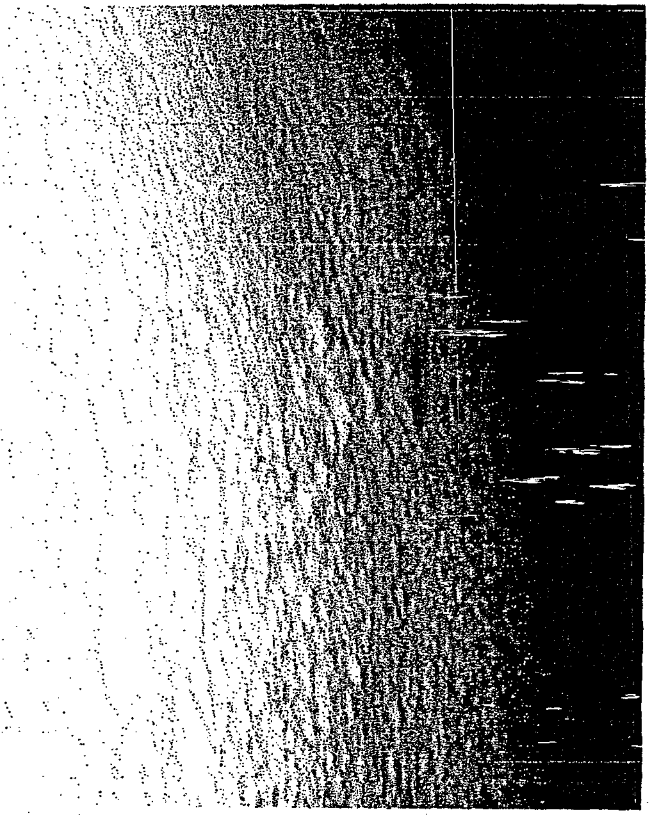
Bay 15

1R21LR-016 Pg 3 of 5
[illegible] c III 10-22-06



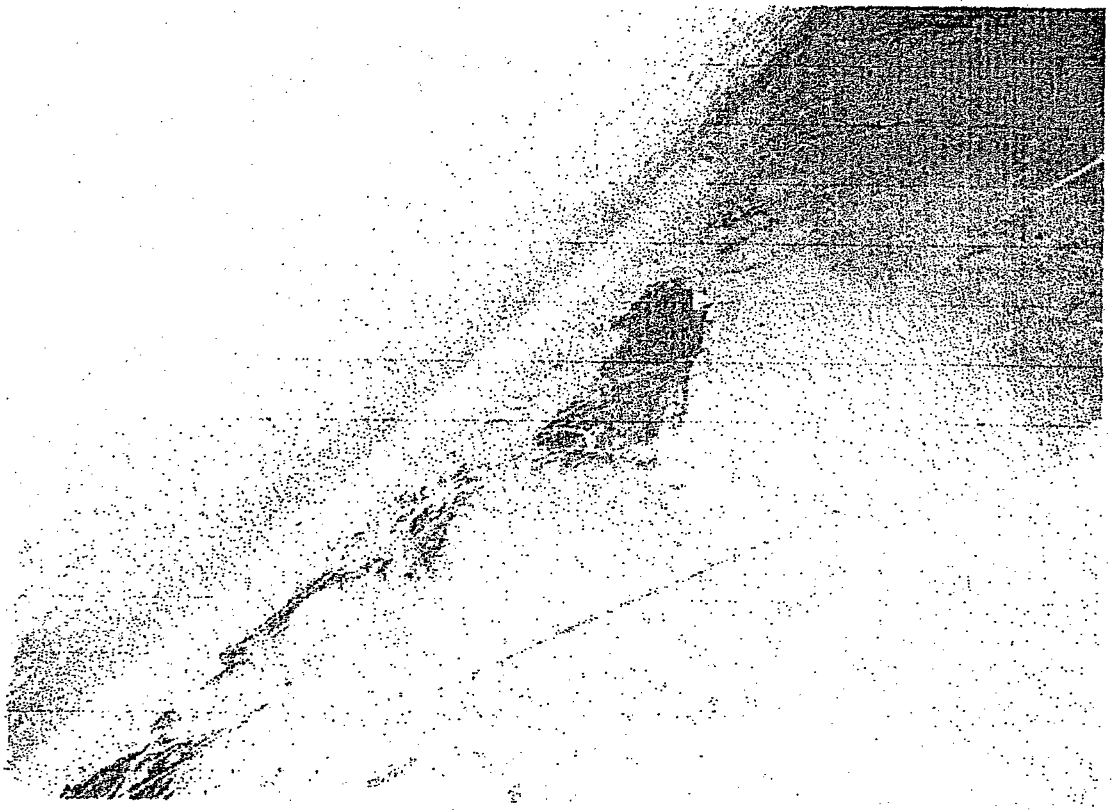
Bay 15 left side

1R21CR-016 Pg 4 of 5
10-22-06



Bay 15 right side

1R21CR-016 Pg 5 of 5
MMc 10-22-06



Bay 15 caulking

1R21LR-011 Pg 1 of 6

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: Exam Date: 10-20-06

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2092868-06

Location: Building: RX Elev.: 11' Col.: N/A Row: N/A Azimuth/Radius: 290°

Exam Type: ☐ DV ☐ GV ☐ VT-1 ☑ VT-3 Type Of Exam: ☑ Direct ☐ Remote Matl. Type: CS

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☑ YES ☐ NO

M&TE Used: FLASHLIGHT UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10.20.06 Time: 1130

Special / Specific Instructions:

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY #17 EXTERIOR LINER IN SAND BED AREA	X	N/A	N/A	SEE ATTACHED PHOTOS

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☑ Yes ☐ No ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: Ryan Taucher LEVEL II DATE: 10.20.06

NDE LEVEL III SIGNATURE: L III 10-22-06 DATE:

RESP. INDIVIDUAL SIGNATURE: DATE:

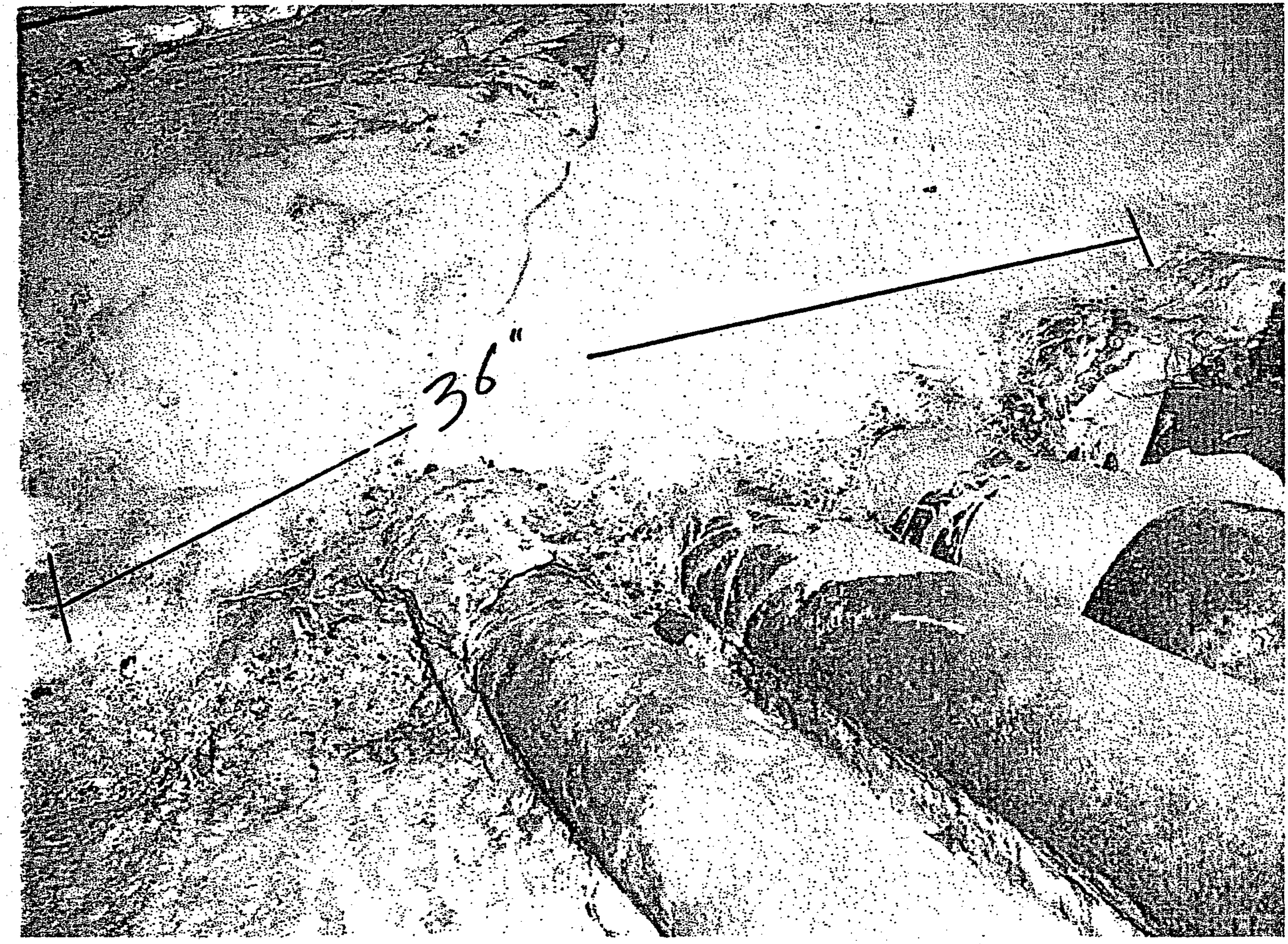
FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments:

ANII REVIEW SIGNATURE: DATE:

1R21CR-011 Pg 2 of 6

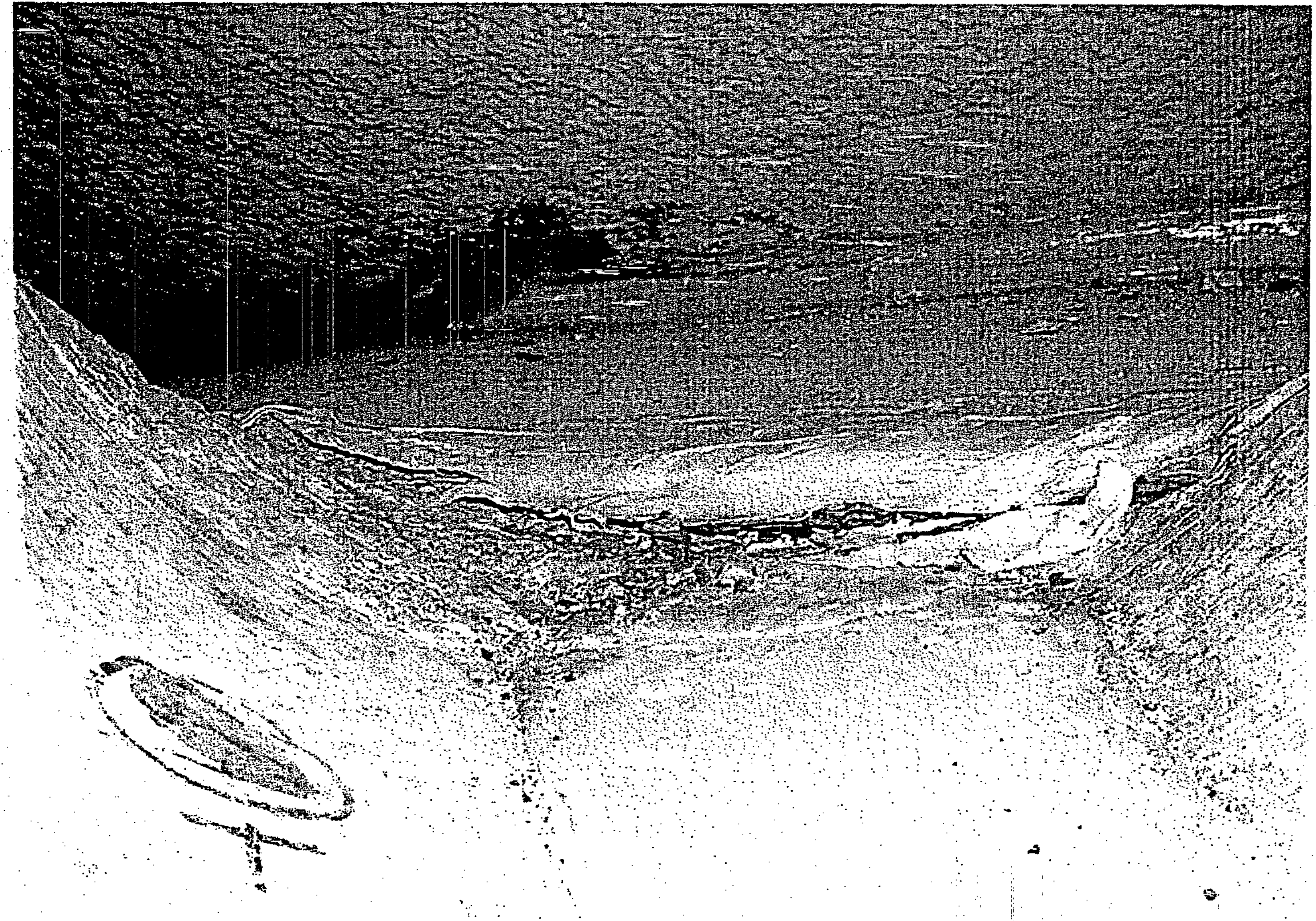
[illegible] L III 10-22-06



36" Floor Cracking to the right of manway.

1R21LR-011 Pg 3 of 6

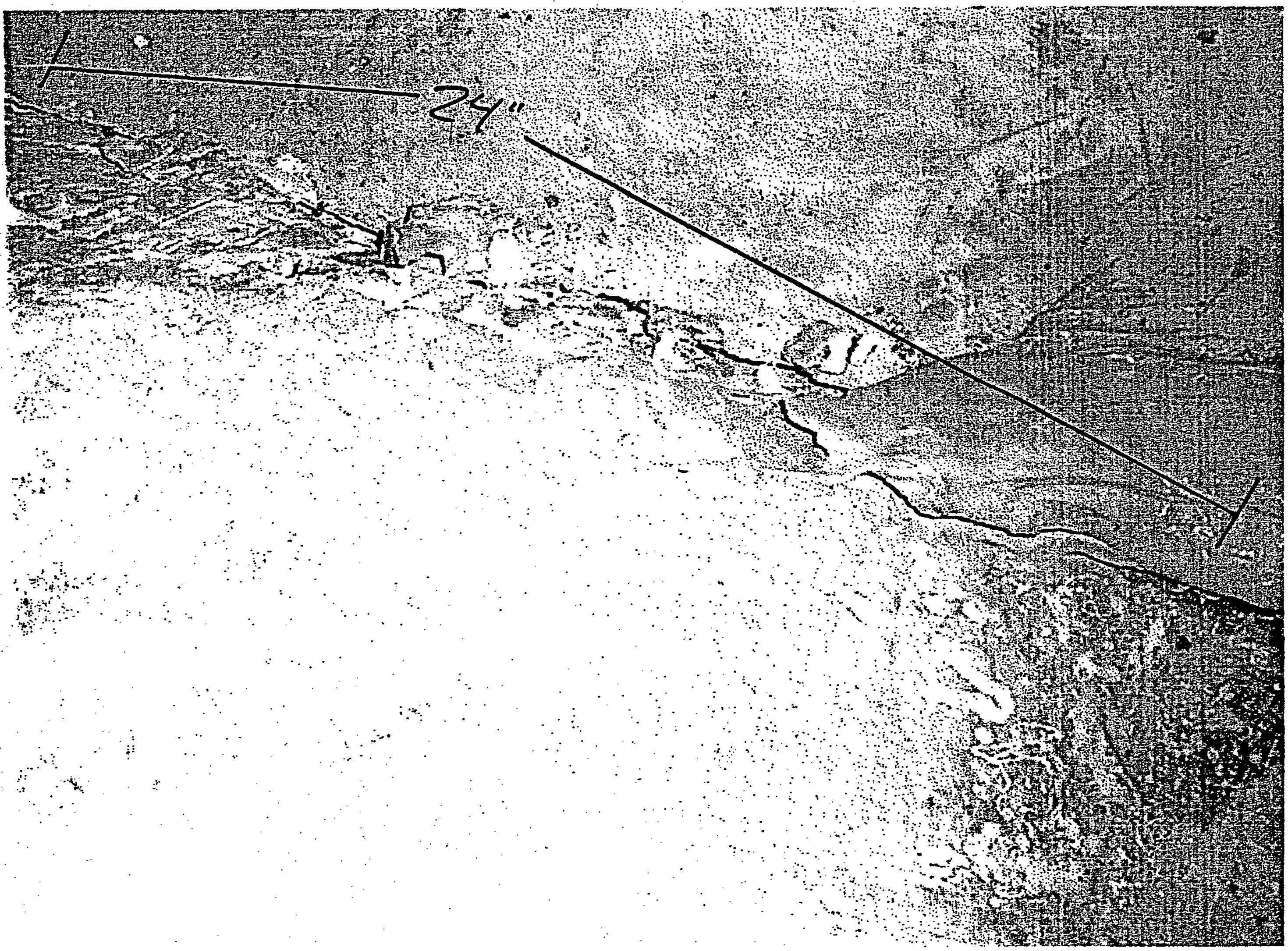
MM' L III 10-22-06



Caulking build-up at manway entrance.

1R21LR-011 Pg 4 OF 6

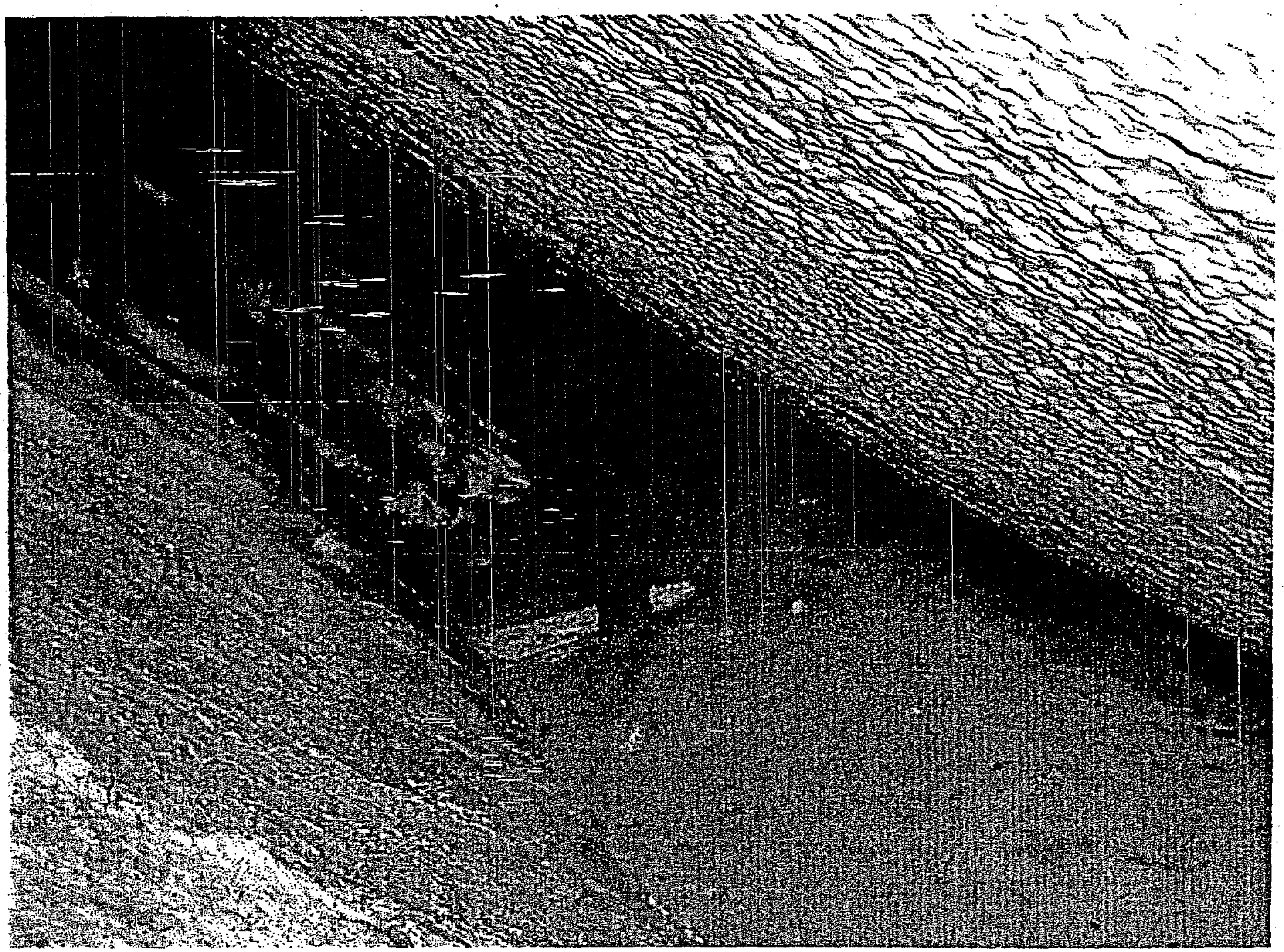
L III 10-22-06



24" Floor Cracking to the left of the manway.

1R21LR-011 Pg 5 of 6

L III 10-22-06



General Area Left of Manway.

General Area to the right of the manway. 1R21LR-011 Pg 6 of 6

1R21LR-018 Pg 1 of 6
MJM 10-22-06

ATTACHMENT 4
ASME IWE (Class MC) Containment Visual Examination Record
Page 1 of 1

Station: OYSTER CREEK Unit: 1 Exam Data Sheet. No.: Exam Date: 10-20-06

System: 187 Examination Procedure ER-AA-335-018 Rev. 3 Work Order No(s).: R2088926-06

Location: Building: RX Elev.: 15' Col.: N/A Row: N/A Azimuth/Radius: 320°

Exam Type: ☐ DV ☐ GV ☒ VT-1 ☐ VT-3 Type Of Exam: ☒ Direct ☐ Remote Matl. Type: C/S

Design Drawing(s) N/A Visual Aids: FLASHLIGHT

Surface: ID [✓ OD] Surface / Components Coated: ☒ YES ☐ NO

M&TE Used: N/A UTC or Serial No. N/A Cal. Due Date: N/A

Illumination Used FLASHLIGHT Illumination Verified: Date: 10-20-06 Time: 2130

Special / Specific Instructions: N/A

Component / Item Number and Description (e.g. EIN, EID, etc.)	RESULTS			Explanation / Notes (As a minimum, Record Location and Size of Recordable Indications as applicable)
	NI	RI TYPE	I.N.	
BAY #19 CONTAINMENT SURFACE REFERENCE SPEC. IS-328227-004 REV. 13	X			NOTE: 2 AREAS OF FLOOR COATING SEPARATION NOTED, ONE ON LEFT SIDE AND ONE ON RIGHT SIDE

Results Legend:
NI - No Indications RI - Recordable Indication I.N.- Indication Number (if applicable)

Recordable Indication Type Codes:

A.	Wear	G.	Blistering	M.	Missing Components	S.	Deviation From Design Drawing
B.	Corrosion / Pitting	H.	Peeling	N.	Loose Components	T.	Missing Paint Or Coating
C.	Mech. Damage	I.	Discoloration	O.	Tears	U.	Bulges / Deformation
D.	Erosion	J.	Pitting	P.	Coating Damaged	V.	Missing / Incomplete Welds
E.	Cracks	K.	Nicks / Gouges	Q.	Leakage / Moisture	W.	Arc Strikes
F.	Flaking	L.	Dents	R.	Dislodged Seal, Gasket, or Moisture Barrier	Z.	Other (Provide Explanation)

Supplemental Information : ☒ Yes ☐ No ☐ Sketch ☒ Photo ☐ Video ☐ Other (Describe):

VISUAL EXAMINER SIGNATURE: Scott R. Erickson LEVEL II DATE: 10-20-06

NDE LEVEL III SIGNATURE: DATE: 10-20-06

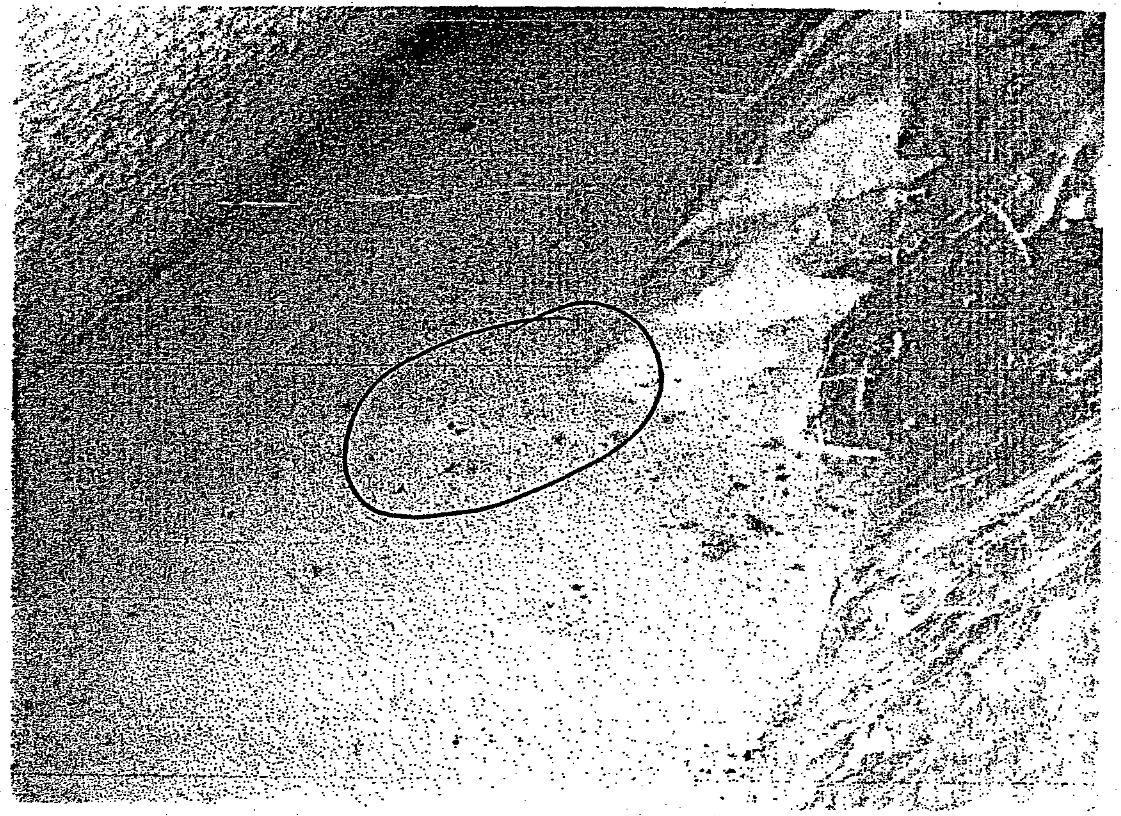
RESP. INDIVIDUAL SIGNATURE: DATE:

FINAL DISPOSITION BY LEVEL III / RESP. INDIVIDUAL ☐ Accept ☐ Reject

Comments:

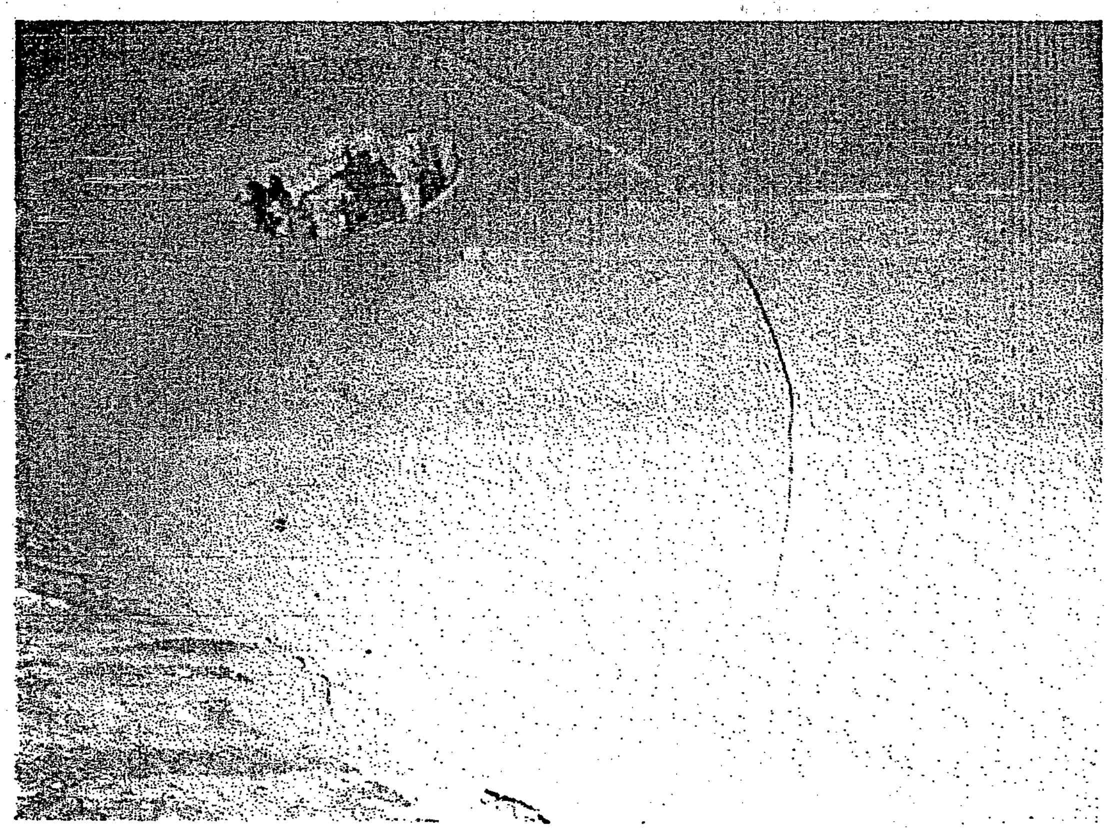
ANII REVIEW SIGNATURE: DATE:

1R21CR-018 Pg 2 of 6
MSM 10-22-06



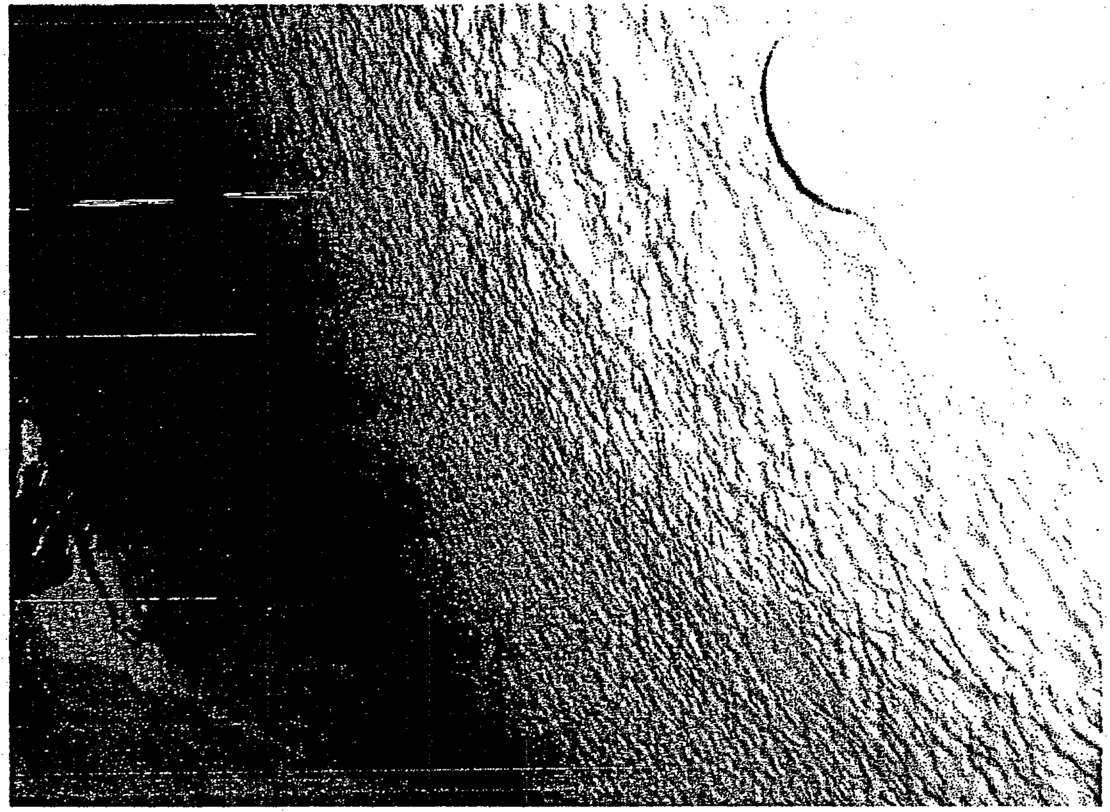
Bay 19 floor separation

IR21LR-018 Pg 3 of 6
10-22-06



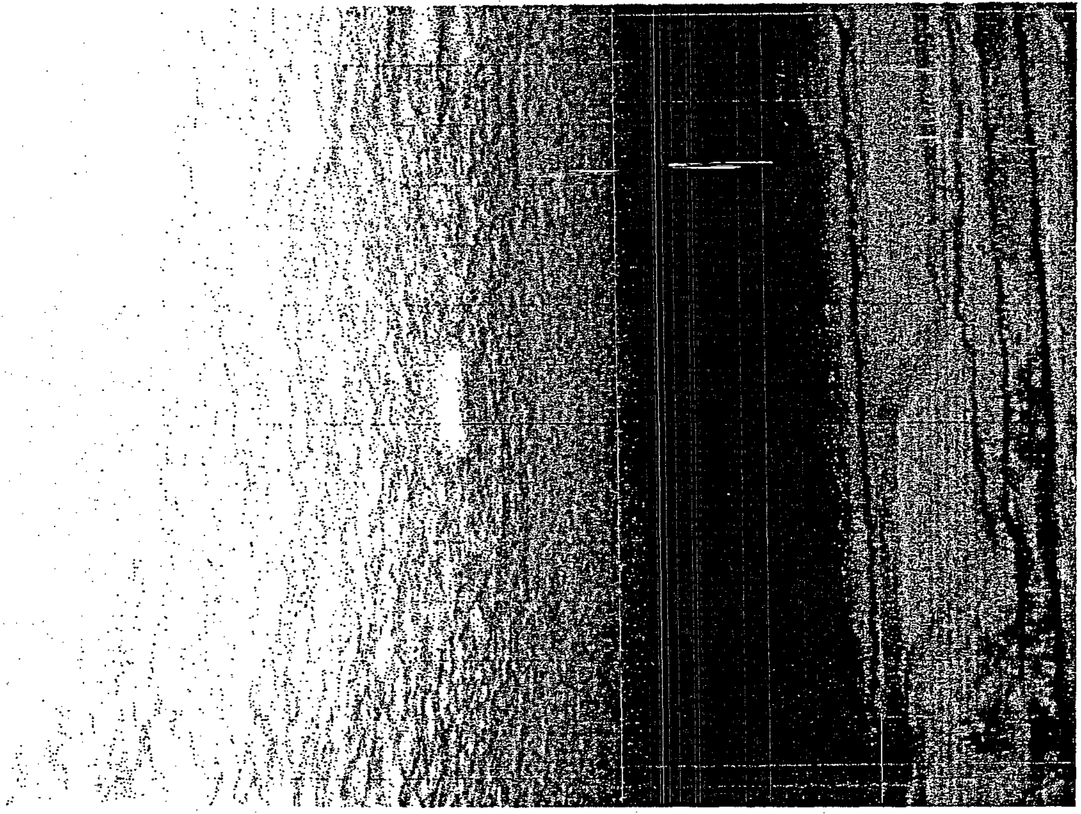
Bay 19 floor separation left side

1R21LR-018 Pg 4 of 6
10-22-06



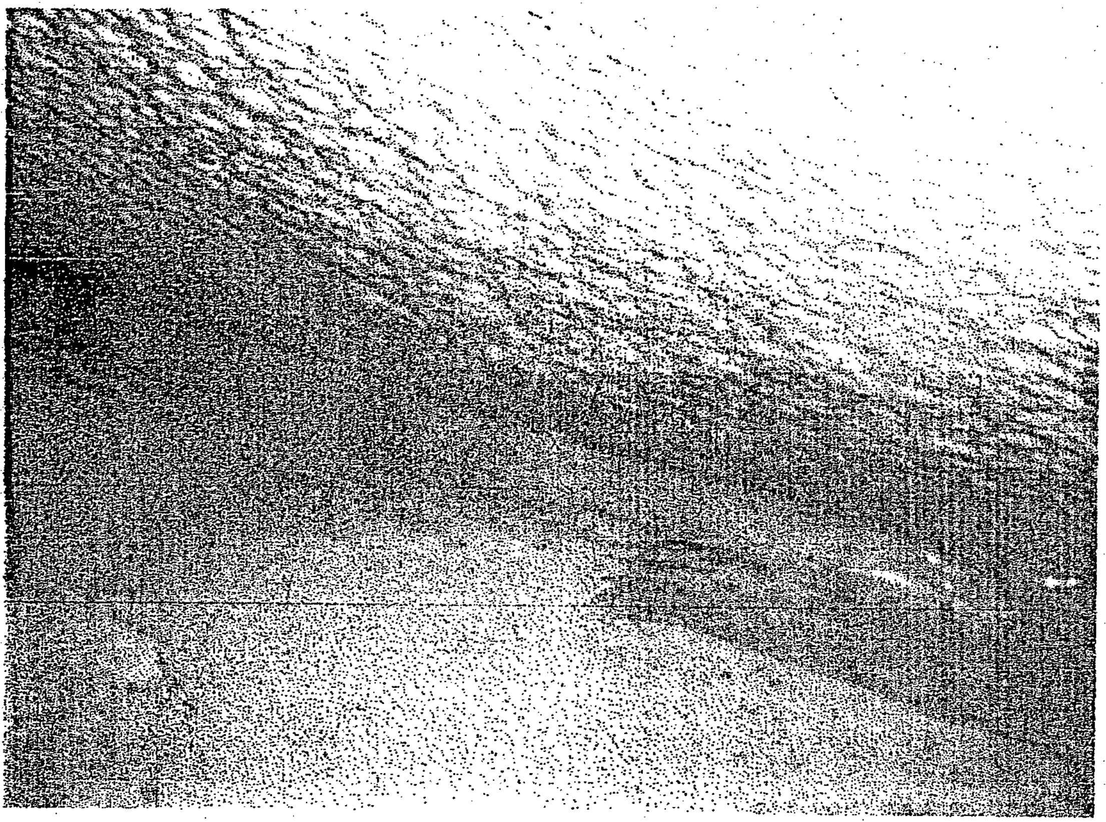
Bay 19 left side

1R21LR-018 Pg 5 of 6
NM 10-22-06



Bay 19 right side

1R21LR-018 Pg 6 of 6
10-22-06



Bay 19 caulking