RAS 14299

Citizens Exhibit C1

U.S. NUCLEAR REGULATORY COMMISSION
In the Matter of AmerGen Energy Co., LLC
Docket No. 50-0219-LR Official Exhibit No. Citizens EX C1
OFFERED by: Applicant Intervenor
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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
OFFICE OF THE SECRETARY

ATOMIC SAFETY AND LICENSING BOARD

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

DOCKETED
USNRC

October 1, 2007 (10:45am)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

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

PREFILED SUR-REBUTTAL WRITTEN TESTIMONY OF DR. RUDOLF H. HAUSLER REGARDING CITIZENS' DRYWELL CONTENTION

On behalf of Citizens, Dr. Rudolf H. Hausler hereby submits the following sur-rebuttal testimony regarding Citizens' contention.

Q1. Have you reviewed the rebuttal testimony of AmerGen and the NRC Staff in this case?

A1. Yes I have.

Q2. What is your overall reaction to AmerGen's rebuttal testimony?

A2. Overall, I think AmerGen is now trying to disavow its own data because they show that it is likely the drywell does not meet the acceptance criteria. If, as Amergen has alleged, the exterior measurements are not numerous enough to characterize the state of the drywell, and, as AmerGen has admitted and is obvious, the interior measurements are not representative of the drywell, then there is no reasonable assurance that any margin will exist at the start of any period of extended operation. Indeed, the NRC Staff experts have provided candid testimony stating that if my contour plots provided with the initial testimony are right, the drywell no longer meets

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the ASME code requirements. In this round of testimony I show that those contour plots probably underestimated the severity of the corrosion and AmerGen's assessment broadly agrees with mine, even though it suffers from numerous errors and is very crude. Thus, based on the testimony so far, I reasonably conclude that the critical effective factor of safety during refueling is less than the 1.9 that NRC Staff estimated. NRC Staff Rebuttal Test. at A.28. Because AmerGen has stated that the required factor is 2.0, AmerGen Rebuttal Test. Part 2 at A.6, I conclude that in its current state, the plant would not meet the safety requirements at the start of any period of extended operation.

Q3. Have you prepared a memorandum to accompany this testimony?

A3. Yes. The memorandum contained in Citizens' Ex. 61 deals with issues concerning the comparison between AmerGen's latest assessment of the external UT results and my own. It broadly shows that there is no major disagreement among the parties on how to treat the data, but my analysis is more sophisticated than AmerGen's and more objective and less error-prone. It is therefore more reliable. Both analyses show that the drywell does not meet the local area acceptance criterion, as might be expected given NRC Staff's conclusion that the factor of safety is now below which is acceptable. Therefore, the argument that contouring the data is somehow inappropriate is not only flatly wrong, it also largely irrelevant. Finally, my latest analysis confirms previous indications that areas of severe corrosion probably exist at the edges of the bays, in the areas considered by AmerGen to be most vulnerable to buckling. AmerGen Rebuttal Test. Part 2 at A.4. Because NRC's estimate of 1.9 was based on my previous analysis, my latest analysis shows that the factor of safety during refueling is probably considerably less than 1.9.

Q4. Is it correct that the GE sensitivity study modeled a contiguous area of 3 feet by 3 feet in each Bay that was less than 0.736 inches?

A4. No, in the GE sensitivity study, AmerGen Ex. 39, the tray-shaped cut-out that was thinner than 0.736 inches was 1.5 feet by 3 feet (6 elements by 12 elements) in total with a centre area of 0.5 feet by 1 foot (2 elements by 4 elements) which was modeled as both 0.536 inches thick and 0.636 inches thick. The cut-outs reduced the buckling capacity by 9.5% and 3.9% respectively. It is unclear to me whether the boundary conditions also led to the implicit inclusion of a second area of the same size in the adjacent Bay. However, what is critical is that the *continuous* area

thinner than 0.736 inches per bay modeled was only 4.5 square feet, not 9 square feet. Therefore, I believe that if the data are to be analyzed Bay by Bay, the maximum permissible *contiguous* area thinner than 0.736 inches in each bay should be less than 4.5 square feet. As discussed in my latest memorandum (Citizens' Exhibit 61) areas much larger than this have been estimated to be present by my analysis and by Amergen's. Thus, I believe that far from showing that the drywell meets the local area acceptance criterion to a high degree of certainty, AmerGen's own analysis, reinforced by my own, shows that there is little doubt that the drywell fails the local area acceptance criterion.

Q5. To your knowledge, is Citizens' Exhibit 61 and this testimony, true and accurate?

A5. Yes, Citizens' Exhibit 61 and this testimony provide, to the best of my knowledge, true and accurate statements of my responses to AmerGen and the NRC Staff. I should point out that in Citizens' Exhibit 61 I have refined my previous analysis in various ways in response to AmerGen's criticism. These revisions are spelled out in detail in the Exhibit. Because the revised calculations in Citizens' Exhibit 61 are the most accurate, these should be regarded as definitive.

Q6. Has AmerGen's and NRC Staff's rebuttal testimony changed your opinions regarding the state of the drywell shell?

A6. No, in fact for the reasons explained before, the rebuttal testimony reinforces my view that AmerGen has failed to establish reasonable assurance that the drywell meets the safety requirements.

Q7. Do AmerGen's analyses of the external data actually demonstrate compliance with the local area acceptance criteria?

A7. No, AmerGen's latest analysis actually demonstrates non-compliance with even the least stringent version of the local area acceptance criterion. Most obviously the assessment shows an area larger than 3 feet by 3 feet in Bay 1 that has an average thickness of 0.699 inches. *See* AmerGen Ex. 16 at 34, Citizens Ex. 61 at Fig. 1 (area illustrated on AmerGen Ex. 16 Figs. 1-2 and 1-7 is actually approximately 36 inches by 42 inches even though it is labeled as 36 inches by 36 inches). If the area were actually 36 inches by 36 inches, it would not encompass the

points that are shown to be inside it on AmerGen Ex. 16 Fig. 1-2. Furthermore, additional extrapolation of the data for Bay 13 shows that it is likely that a large continuous band of corrosion extends all the way across the Bay and is thinnest at the edge of the Bay, precisely where the drywell is most vulnerable to buckling. Citizens' Ex. 61, Figure 4. This area fails the local acceptance criterion for multiple reasons explained in detail in Citizens' Ex. 61.

Q8. Would you have included the internal data into the contouring if you had the coordinates at which the internal data was taken?

A8. Yes, but it was very difficult to finalize the location of the external points due to various discrepancies. Apart from AmerGen Ex. 28 (the map of all the points), which is too small and is not to scale, I have not seen any plots or data sheets that combine the internal and the external measurements. However I would welcome a contouring analysis that includes both the internal data (including the trench data) and the external measurements. Finally, I note that AmerGen's analysis of the 2006 external data also ignored the internal measurements, presumably for similar reasons. Instead of complaining that I did not do this, AmerGen should have done what it suggests should be done in its own analysis. I further question whether AmerGen's statements about internal grids being inches from the external points are valid because I have not seen a good table of data giving comparable coordinates for all the measured points.

Q9. Looking at AmerGen's allegations in their Rebuttal Test. Part 3 at A.2, does including the other grid data invalidate your argument?

A9. No, in Citizens' Ex. 61 I have revised the Figure to include the data cited by AmerGen. The revised Figure shows that the internal grid data are highly variable from grid to grid because some grids are in more severely corroded areas than others. It also shows that in this Bay the average of the external measurements is approximately the same as the average of the grid data at 11'3" but is quite a lot lower than the trench data. This really shows first that there is a lot of spatial variation in the corrosion in each Bay that cannot be captured by the internal girds at 11'3". It also illustrates that the external measurements are not biased to the thin side by very much. Finally, I don't think there can be any dispute that the internal grids in Bay 1 do not represent the thickness of that Bay, because the bathtub ring in that Bay is below the 11'3" level. Bay 13 also appears to suffer from a similar problem.

Q10. Which data is and is not capable of showing whether the local area acceptance criterion is met?

A.10. The internal grid measurements are certainly not useful for this purpose because they only consist of a few 6 inch by 6 inch grids taken at an elevation which is above the worst of the corrosion in many Bays. Similarly, the trench measurements were only taken in two lightly corroded Bays and therefore cannot assist with finding margins for the most corroded local areas. Therefore, in principle, only the external measurements could show whether the local area acceptance criterion is met. Consistent with this approach, AmerGen has tried (but failed) to convince us that the external data show compliance with the local acceptance criteria. E.g. AmerGen Ex. 16. Contradicting AmerGen Ex. 16, AmerGen now apparently alleges the external data cannot be compared to the local acceptance criterion. AmerGen Rebuttal Test. Part 3 at A.2. If this were true, AmerGen would not be able to determine whether the local acceptance criterion is met and would therefore have no reasonable assurance of meeting safety requirements.

Q11. Does AmerGen confuse the concepts of systematic error and random error in AmerGen Rebuttal Test. Part 3 at A.6 and 7?

A11. Yes. In the past the measurements have two kinds of error, systematic error and random error. Essentially, random error is when the errors in different measurements are uncorrelated, whereas systematic error results when there are correlations between the errors. In simple terms, random error is noise in the data, while systematic error is bias in the data. For both the external measurements in 1992 and the internal measurements in 1996, AmerGen has alleged and acknowledged, respectively, that there were systematic errors in the data. Unlike random error, systematic errors do not reduce the uncertainty of the mean as more data is taken. The sources of error that AmerGen has listed in AmerGen Rebuttal Test. Part 3 at A.6 could be sources of both random and systematic error and it is important to distinguish between the two, which AmerGen fails to do. In addition, the conclusion in AmerGen Rebuttal Test. Part 3 at A.7 that systematic error is not significant because the data are averaged over multiple sampling events and it is associated with a random variable is flatly wrong for multiple reasons, most importantly because more sampling does not eliminate or reduce certain systematic errors. (What AmerGen proposes

here is to confound random and systematic error again after the Analysis of Variance has separated them). Moreover, assessments of significance require comparison of one number to another. In the absence of any quantification of errors, AmerGen's conclusion is virtually meaningless. Finally, it has been agreed that systematic bias of around 0.016 inches was observed in the 1996 internal measurements. The error analysis fails to acknowledge that such a problem could recur and should be accounted for statistically.

Q12. Is AmerGen Rebuttal Test. Part 3 A17 correctly stated?

A12. No. The 95% confidence interval is approximately twice the standard error. Using a confidence interval of one standard error gives rise to a confidence level of 67%, which would be insufficient to maintain reasonable assurance that the ASME code and the acceptance criteria are met. Here, the Board asked for 95% confidence limits, but AmerGen appears to be trying to argue that 67% confidence limits are sufficient, without directly stating it.

Q13. Is AmerGen Rebuttal Test. Part 3 A20 correct?

A13. No. AmerGen takes account of possible systematic error when deciding whether corrosion is "significant" over time. In addition, in evaluating the 2006 external data, AmerGen specifically looked for systematic error. AmerGen Ex. 4. Furthermore, it is important to explicitly account for possible systematic error when evaluating the thickness measurements.

Q14. Is AmerGen Rebuttal Test. Part 3 A22 correct?

A14. No. Requiring that the average of a parameter meet a requirement without placing any limits on the confidence intervals of the mean is a recipe for allowing components to fail. To prevent failures we must be concerned with behavior that is unlikely but nonetheless could occur. AmerGen' answer unequivocally demonstrates that they do not understand some of the most basic principles of statistics: While data are (may be) randomly distributed about the sample mean with a frequency distribution resembling a Gaussian distribution, the sample means are equally distributed about the true mean of the population (according the to "central limit theorem). Therefore it makes sense to ask the question bout the lower (or higher) mean value within the 5% limits, because it might actually better represent the true mean than the measured mean. This is not idle speculation because if one has only one set of data, and hence only one

measured mean, the true mean may indeed lay somewhere under the Gaussian distribution curve for all "measured means", event though only one such mean had been experimentally determined. . At minimum in this context we believe the lower 95% confidence limit should be used for the observed mean. Requiring this limit to meet the acceptance requirements would mean that in one out of forty instances, the components could be below the requirements without us knowing it. Thus, if a single power plant were required to meet more than 40 acceptance criteria using the lower 95% confidence limit of the measured data, there would be a statistical likelihood that one of the parameters would be in violation. In contrast, allowing the calculated mean of the measurements to go as low as the acceptance criterion would mean that in 50% of instances the components would be thinner than estimated and would violate the requirements. This would mean that 20 of the 40 parameters would likely be below requirements. Because each power plant must meet many different criteria using measured data, even taking a 95% confidence interval could be too little. Using a 50% confidence interval makes it virtually certain that mainly unknown failures to meet safety requirements would exist at each plant. That would hardly provide reasonable assurance that the plants are meeting safety requirements.

Q15. Is AmerGen Rebuttal Test. Part 3 A29 correct?

A15. No. We believe AmerGen should compare the lower 95% confidence limit of the averages (means) of the internal grids minus an allowance for possible systematic error to the acceptance criterion. This procedure would not ignore any data at all; it merely avoids the statistical likelihood that the results appear to be better than they really are.

Q16. Is AmerGen Rebuttal Test. Part 3 A31 correct?

A16. No. To clarify, my assumption was that the standard error of the mean was 0.03. Thus the lower 95% confidence interval for the mean is approximately the (stated hypothetical) mean minus two times 0.03. This is another example of AmerGen's multiple attempts to misread and misrepresent statements.

Q17. Is AmerGen Rebuttal Test. Part 3 A32 correct?

A17. We have looked at the data from Bay 17 again. There were indeed two internal grid measurements, 17 A and 17D. 17 A reflects the more severe corrosion only at the highest

elevations (not what one would have expected) , 17 D on the other hand mirrors the corrosion observed in the trench, but only at lower elevation. We have now combined all data in Figure 5 of Citizens' Ex. 61 and hope that the elevation data as reported were in fact the correct ones. When looking at that figure, one must remember that the data are only plotted as a function of the vertical distance from the bottom of the sandbed, but no doubt the data are not in the same lateral positions. Rather than "our argument falling apart " (namely that "internal grid measurements do not reflect the true corrosion of the sand bed"), Figure 5 of the memorandum fully supports the notion that no single set of measurements fully represents the extent of corrosion in the sandbed. However, I also think that one needs to look first and foremost at the most serious corrosion damage, because there is the greatest danger of failure. This is often located below the 11'3" height where the internal grids are taken.

Q18. What are the ramifications of AmerGen Rebuttal Test. Part 3 A38 and 39?

A18. It is hard to understand how one could be reasonably certain that the measurements indicate compliance with an acceptance criterion without being able to make a numerical estimate of the value that parameter and also estimating the possible error associate with the numerical value. However, leaving this issue aside, if AmerGen really does not calculate the margins above the local area acceptance criterion, then there is no assurance that the monitoring frequency is based on the narrowest margin. At present AmerGen is assuming that the smallest margin is 0.064 inches which was derived from the internal grids, but according to A38 and 39 it cannot verify this assumption because it has not estimated the margin above the local area acceptance criterion. This is obviously unacceptable.

Q.19 Do you agree with AmerGen Rebuttal Test. Part 3 A41?

A19. Not completely. AmerGen's suggested approach to having an imperfect data set is to ignore it, even though AmerGen itself had the power to take better data. Furthermore, the analogy is completely wrong. As discussed in A. 14above, we believe the lower 95% confidence interval of estimates of each acceptance parameter must be compared to each acceptance criterion. For the mean thickness, this means the lower 95% confidence interval of the estimate of the mean should be compared to 0.736 inches. Although we have acknowledged at the time (based on the available documents and AmerGen's insistence) that the external data may be

biased somewhat low, we believe this bias provides assurance that systematic bias will not result in the plant violating the acceptance criterion for the mean. We have, however, never intimated, contrary to AmerGen, that averages obtained over a small area might be representative of the structure as a whole. Finally, I find it strange that AmerGen states here that extreme value statistics should be used to analyze the external data set and not averaging, when Amergen's own analysis of the external data, carried out by Mr. Tamburro, used simple averaging. I think I may point out at this time that AmerGen is not familiar with extreme value statistics, or else they would not make the statements they do in A 41 final paragraph. The use of extreme value statistics does not depend on whether the data set is biased toward low values or not. It only depends on whether the frequency distribution is Gaussian or exponential.

Q20. Do you agree with AmerGen Rebuttal Test. Part 3 A43?

A20. Not completely. Although I agree that scanning across the ground location is a good idea, in the initial report AmerGen did not use the thinnest measured reading as the basis for its initial evaluation. As it now appears to admit in A.44, this was a serious mistake. Furthermore, I note that the scan across the locations was only carried out for a few locations in four Bays. AmerGen has not explained why such a scan was not carried out at the other locations. The results from the scans clearly show that the results are highly variable and without such a scan any claim to have measured even the local thin spots on the drywell is invalid.

Q21. Do you agree with AmerGen Rebuttal Test. Part 3 A46?

A21. No. I make the same assumptions as Mr. Tamburro, I just used a better method to estimate the thin areas. As I show in Citizens' Ex. 61, AmerGen's position is founded on a non-rigorous analysis that should have concluded that at least Bays 1 and 13 fail the local area acceptance criterion.

Q22. Please comment on AmerGen Rebuttal Test. Part 3 A47 and 48.

A22. I recognized that my calculations presented in Citizens Ex. 13 had some shortcomings. As discussed in my rebuttal testimony A8, I therefore revised the calculations and presented the results in Citizens' Exhibit 38. I believe that my estimate of the standard deviation based on duplicate or triplicate measurements and reported there is the best estimate that we have,

although I agree that it would have been more ideal if AmerGen had gathered more data. Here, I believe AmerGen is allowing the perfect to become the enemy of the useful. While one can always criticize calculations based on imperfect data, the task here is to test whether the drywell meets the acceptance criteria with the required degree of confidence. That can only be done if we estimate the uncertainty in the measurements using statistics. I find the whole tone of AmerGen's statistical testimony rather strange. Instead of actually analyzing the data available, AmerGen seems to suggest the data is not good enough to be analyzed, forgetting that it designed the sampling strategy and should have considered how it was going to analyze the results before they were taken. It is hardly useful to spend time and money taking data which is then cannot be used for the purpose intended, which was to show whether the drywell met the local area acceptance criteria.

Q23. Do you agree with AmerGen Rebuttal Test. Part 3 A50 to 51?

A23. No, as I previously testified the micrometer results in Bay 13 actually show a surface roughness of 0.1 inches and because scans were not conducted at every location to find the locally thinnest point, it is inappropriate to make any correction for roughness. Instead AmerGen should use the raw results that it measured. Please note, that with all the talk about "evaluation thickness", starting with Calc. 24 Rev.0, Mr. Tamburro in his latest discussion (Calc. 24, Rev. 2) largely used the actual lowest measurements, thus demonstrating that these unfounded corrections for surface roughness are irrelevant.

Q24. Do you agree with AmerGen Rebuttal Test. Part 3, Section IV?

A24. No. My issues with the latest analysis of the external measurements are set out in detail in Citizens' Ex. 61. The page reference in Rev.1 to the assumption that all areas that are thinner than 0.736 inches are also less than 2 inches in extent is AmerGen Ex. 18 at 11, 13. In addition, AmerGen tries to imply that all the points were ground, which is incorrect. Furthermore, I note that Mr. Tamburro must have used some other method to derive the areas presented in the latest calculation, which are not all 36 inches by 36 inches. Finally, Mr. Tamburro's method effectively assumed that no areas larger than 36 inches by 36 inches that are on average thinner than 0.736 inches would exist. If he had used a 37 inch by 37 inch square or rectangular geometries and applied the same method he would have found a number of areas that are on

average thinner than 0.736 inches and are also larger than nine square feet, violating the least stringent acceptance criterion alleged by AmerGen.

Q25. Do you agree with AmerGen Rebuttal Test. Part 4 A4 and 5?

A25. Not completely. Citizens' Ex. 50 showed that the metal tape and strippable coating is not always effective in preventing significant leaks.

Q26. Do you agree with AmerGen Rebuttal Test. Part 4 A14?

A26. No. It is misleading to conclude too much from the leakage observed in the 2006 outage. Because Citizens' Ex. 50 showed that the metal tape and strippable coating is not always effective in preventing significant leaks, it is not possible to say that the trough drain capacity cannot be exceeded. Furthermore, Citizens Exs. 48 and 49 showed that the trough drain was found to be in a deteriorated condition in 1996 and it is subject to high temperatures which can degrade the concrete it is made of. Thus, it is not speculation to suggest that similar degradation could occur in the future.

Q27. Do you have other comments on Part 4 of AmerGen's rebuttal testimony?

A27. Yes. For the reasons I stated previously, the evaporation estimate provided by AmerGen is hopelessly over optimistic. Although I agree that coating failure is first manifested by pinpoint rusting and rust staining, the issue is how quickly more widespread failure could occur. I believe it is possible that such widespread failure could occur between coating inspections, which I understand are every four years. I note that AmerGen now suggests that the coating will require "proper maintenance" to last further decades. AmerGen Rebuttal Test. Part 4 A8. This is an acknowledgement by AmerGen that it is reasonable to expect some coating failures, which will require repair. With regard to the cracking of the epoxy floor, photographs show that the cracks were more widespread than AmerGen suggests in AmerGen Rebuttal Test. Part 4 A9. However, the key point is that in this very environment the floor epoxy cracked. Although the failure mechanisms for the thin epoxy coating on the shell are somewhat different, this is nonetheless a salutary lesson that it is necessary to regularly verify that the coating is working effectively, through both UT measurements and visual inspections.

Q27. Do you have any comments on Part 6 of AmerGen's rebuttal testimony?

A27. Yes. In A10, AmerGen mistakenly over-concludes from the UT measurements for the small area of the embedded region that was revealed. In fact, interior corrosion is most likely to occur in spurts at elevations that are in the sand bed region. Measurements in the embedded region cannot show lack of corrosion in the sandbed region. In A13, Gordon disputes the assessment of AmerGen's technical reviewer even though he carried out no new calculations in response to the comment. This is strange because at the time he said the "requested calculation" to respond to the comment was "rather straightforward." Citizens Ex. 36. He fails to explain why he did not make this calculation and continues to fail to present any quantitative response to the comment. Finally, I note that Gordon now does not say that corrosion has been arrested, as AmerGen did earlier, but rather the corrosion rate is "near zero." However, once again this answer lacks quantification. For example if the margins are 0.02 inches or less, a very small corrosion rate of 0.01 inches per year could consume the margin in two years, making that rate highly significant.

Q28. Turning to NRC Staff Rebuttal Test. A26, do you believe that "long grooves of corrosion" are present?

A28. The observations often refer to a "bathtub ring." I have used the term "long grooves of corrosion" to describe the "bathtub ring." Does using a different name for the same feature has any effect on the reality of what is there? More seriously though, Figure 5 of Citizen's Exhibit 61 shows that an abrupt decrease in wall thickness of 250 – 400 mils (22 – 35% of wall thickness) occurs over a vertical distance of about 2 to 3 inches. Then the trench data indicate that wall thinning continues to the bottom of the sandbed, although to a lesser extent. Maybe one should describe this as a horizontal "trough" rather than a groove, but clearly the distinction is one of width rather than depth.

Q28. Looking at NRC Staff Rebuttal Test. A27, do you have any comment?

A28. Yes. As AmerGen has pointed out, the contour plots cannot be very precise because they are based on only a few points and there are large areas of the drywell for which we have no measurements or incomplete measurements. In my latest calculations I have used various extrapolation techniques to make up for the lack of data. Although the results are extrapolations and therefore subject to interpretation, they provide the best estimates that I am able to produce

from the data we have. I do not believe it would be appropriate to measure the areas below certain thresholds from these plots very accurately. Instead, the plots provide a visual indication of how big the areas below each threshold are. Citizens Ex. 61 Figure 4 shows the extrapolated corrosion in Bay 13. It is clear from this plot that the area below 0.736 inches is large and cannot be bounded by a 3 feet by 3 feet square. Thus, I believe the local area acceptance criterion is violated by these data.

Q29. Looking at NRC Staff Rebuttal Test. A28, do you have any comment?

A29. Yes, I find it quite surprising that the applicant is arguing that it must meet the ASME code requirement of 2.0 during refueling, but the regulator appears to be saying that compliance with the ASME code is not required. I will leave it to the lawyers to argue about what is legally required, but note that it is very unusual to have the regulator leading the charge to relax standards that the licensee thought it had to meet.

Q30. Looking at NRC Staff Rebuttal Test. A31, do you have any comment?

A30. Yes. I wholeheartedly agree with this answer. This is precisely why AmerGen cannot continue to rely on the regression technique to determine the potential rate of future corrosion.

Q31. Looking at NRC Staff Rebuttal Test. A35, do you have any comment?

A31. Yes. Because it is difficult to predict the lifetime of the coating and it has already had a service life of 15 years, it is not reasonable to assume it will not fail during any extended period of operation.

Q32. Looking at NRC Staff Rebuttal Test. A36, do you have any comment?

A32. Yes. The very early stages of degradation below a coating will not be seen by visual inspection. Obviously, at some point the degradation becomes visible.

Q33. Looking at NRC Staff Rebuttal Test. A37 regarding the difference between pitting corrosion and general corrosion, do you have any comment?

A33. Yes. It is of course no surprise that different technicians or scientists should have different opinions about corrosion mechanism, because after all it is not long since pinhole

corrosion on organic coatings was likened to pinhole corrosion on metallic coatings, a comparison which we determined not too long ago was totally unjustified. Nevertheless, the corrosion rate on or in pinholes depends on mass transfer in or out of the pit. For corrosion to occur one needs first of all water, and then a corrodent, such as oxygen, and some sort of access to the metal surface. As corrosion takes place, corrosion products are formed. These will eventually put pressure on the coating to the point it first blisters and then cracks (depending on the physical properties of the coating). When the coating breaks open (often as a boil breaks open) access of corrodent, water, electrolyte etc. is facilitated, i.e. all mass transfer is accelerated and hence corrosion. Is this mechanism an over-simplification? Yes, because the details depend on a plethora of shifting parameters. However, the principle is correct, how processes occur over time (the kinetics) varies.

Q34. Looking at NRC Staff Rebuttal Test. A38 regarding the extent of the areas that are thinner than 0.736 inches do you have any comment?

A34. Yes. Having said that the NRC Staff did not rely on an estimate that the total area thinner than 0.736 inches was 0.68 square feet, the NRC Staff then erroneously draws a conclusion about the *maximum* area that could be thinner than 0.736 inches from the knowledge that the *minimum* such area that is 0.68 square feet. This is of course entirely illogical and irrelevant because the extent of the contiguous areas that are thinner than 0.736 inches is highly restricted to 4.5 square feet per Bay or less.

Q35. Looking at NRC Staff Rebuttal Test. A39 regarding the use of the acceptance criteria do you have any comment?

A35. Yes. This answer confirms that the cut-out areas in the sensitivity study were designed to "bound all degradation." Because both my analysis and AmerGen's now show that the corrosion is no longer bounded by these cut-outs, the modeling no longer shows that the degradation is acceptable, if indeed it ever did.

Q36. Looking at NRC Staff Rebuttal Test. A40 regarding the use of the external data do you have any comment?

A36. Yes. Because the internal grids are clearly placed above the worst corrosion in the most

corroded Bays it is not reasonable to rely on the internal measurements to estimate the drywell average thickness in every Bay. Even though the external measurements are slightly biased to the thin side and are admittedly incomplete, we have no other data to use estimate the thickness of the most corroded Bays. The initial question is not whether corrosion is ongoing, it is what is the current margin. Furthermore, AmerGen is no longer saying that corrosion has been arrested. I am puzzled by the reference to the "Staff's conclusion about the extent of corrosion." To date, the Staff have not stated any conclusions about the extent of severe corrosion except to say that is larger than 0.68 square feet and smaller than 700 feet. However, I am pleased to note that the Staff did not rely on the grid measurements to determine the extent of corrosion, although I am unclear which measurements they did rely upon, because they appear to criticize me for using the external measurements.

Q37. Looking at NRC Staff Rebuttal Test. Response 8 regarding the failure to take account of systematic error do you have any comment?

A37. Yes. I believe it is important to make an allowance of 0.01 to 0.02 inches for systematic error in the internal measurements because such error was observed at least once and possibly on two occasions in the past. For the 2006 external measurements, I have decided that it is reasonable to make no such allowance because there has at least been some attempt to bias the sampling locations to the thin side and the measurement technique seems robust.

Q38. Looking at NRC Staff Rebuttal Test. A11 (on page 26) regarding the calculation of the corrosion rate do you have any comment?

A38. Yes. It is not conservative to assume a linear corrosion rate of 2 mils per year. Experience from when the sand was in place shows that corrosion can happen much more quickly than that. The reason the observed rate from 1986 to 2006 in the trenches is so low is not known, but is probably due in part to the fact that the trenches were excavated in two of the least corroded Bays. Unfortunately, AmerGen has not presented any data analysis of the trench measurements and I have had limited time to spend on this issue. In the absence of a detailed analysis of the data, a more conservative but still reasonable assumption is that most of this corrosion was caused by degradation from the interior in fits and starts around refueling outages.

Q39. Looking at NRC Staff Rebuttal Test. Response 12(d) regarding the use of the contour plots do you have any comment?

A39. Yes. I would refer you to my previous answer in which I said NRC Staff are trying to be too precise here. The contour plots are designed to allow a better estimate for the extent of the areas thinner than 0.736 inches than merely greater than 0.68 square feet, but smaller than 700 square feet, which is all the Staff has said. They are also more accurate than AmerGen's estimate given in Rev. 2 of the 24 Calc. (AmerGen Ex. 16), which is that the extent of the areas thinner than 0.736 inches is approximately 21 square feet (at least 9 sq. feet in Bay 1, *id.* at 34, 1 sq. foot in Bay 13, *id.* at 62, 1 sq. foot in Bay 15, *id.* at 79, 1 sq. foot in Bay 17, *id.* at 89, and 9 sq. feet in Bay 19. *Id.* at 93)

Q40. In summary, are you convinced that the drywell will meet safety requirements during any extended period of operation?

A40. No. NRC Staff and AmerGen have created confusion and contradictions, which makes it difficult to show what the current situation is or how it could change in the future. However, I believe that it is likely that the drywell shell fails even the least stringent version of the local area acceptance criterion and the lower 95% confidence limit of the mean derived from the external results also violates the acceptance criterion for the mean in some Bays. Finally, I also believe the very local area acceptance criterion of 0.49 inches could be violated, based on extreme value statistics. Furthermore, all parties now agree that future corrosion could occur, but there is no certainty about the rate at which this could occur. Thus, it makes sense to err on the side of caution in selecting a monitoring frequency. To date, neither AmerGen nor NRC has justified a monitoring interval of once every four years was selected or how it was justified. In the absence of any further information, and if AmerGen could establish that some margin is available, I would recommend more frequent monitoring than once every four years, which should be calculated by taking the minimum values derived from dividing the amount by which the lower 95% confidence limit of the measured data for each acceptance parameter exceeds each acceptance criterion by a conservative estimate of the corrosion rate. A reasonably cautious estimate of the possible combined corrosion rate from the interior and the exterior is approximately 0.05 inches per year.

Q41. Have you now completed your sur-rebuttal testimony?

A41. Yes.

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

Rudolf H. Hausler

Dr. Rudolf H. Hausler

9-13-2001

Date

ATTACHMENT 1

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Memorandum

Richard Webster, Esq.
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13-Sept.-2007

Subject: Further Discussion of the External Corrosion on the Drywell Shell in the Sandbed Region.

I. Introduction

The objective of this discussion is to put a few misconceptions, erroneous statements and poor judgment in perspective. We never used the "wrong data the wrong way". We used AmerGen's data a different way, which we think, and will show below, leads to more concise conclusions. In the forefront of this discussion are the contours, or response surfaces, which we generated on the basis of the most accurate external (and in one case internal) UT measurements reported by AmerGen. It turns out, and is discussed below in meticulous detail, that the differences between Tamburro's methodology and that of the response surface methodology, is simply one of greater consistency and reduced arbitrariness.

I would like to highlight a statement which, to some extent, exemplifies the errant logic involved in much of AmerGen's testimony (Ref. 9, A7).

> *The contour plots presented by Dr. Hausler are not accurate* [1]*. The contours generated by Dr. Hausler show drywell thinning that has not been observed or measured by AmerGen.* [This testimony is ascribed to all members of this particular rebuttal group; see Ref. 9, at A7].

The above quote is a recurring theme in AmerGen's rebuttal testimony and therefore needs to be put in perspective.

At no point in time have we attempted to make the corrosion of the drywell shell to look more severe or extensive. While we have in the past deplored the fact that the external UT measurements had not been extended to a larger area, we have evaluated

[1]) Messrs Gallagher, Ouaou, and Dr. Metha, have not shown in their testimony how our contours are not accurate. It is an incredible disservice to the professionalism of these proceedings to promulgate such unsubstantiated accusations.

the data generated by AmerGen (and earlier by GPUN) by means of a standard well known method which, as it turns out, bears some similarities to Tamburro's procedures, but are far more systematic and much less prone to observer bias. The fact that averaging (which is also Tamburro's methodology) results in numbers, which have not been measured is inherent in the process of averaging. In fact, the entire approach of AmerGen is based on averages. AmerGen can hardly claim that Tamburro's averages are valid, while mine are not.

> Mr. Polaski, Dr. Harlow, Mr. Abramovici, Mr. Tamburro, and Mr. McAllister completely misunderstand (or are not familiar with) the process of generating iso-response line in a two-parameter field when they assert that *we have inappropriately statistically treated the external UT data (Ref. 10, at A 2).*

Let's be very clear about this, establishing the contour plots is only a statistical process to the extent taking averages is a statistical process. Both Tamburro and I use averaging to represent the surface, because there is no reasonable alternative approach. In this case I used the mathematical routine developed by the SAS Institute, Inc, (formerly known as Statistical Analysis Software, Inc.) in the Statistical Discovery Software, Ver. 3.1, Chapter 3, page 23, pg 443 of the User's guide. The process it uses was described in detail in previous submissions [2)].

> The gentlemen listed above assure us that *these data cannot represent the thickness of the drywell shell. First, there are two few of them for the points to be statistically representative of the shell as a whole. Second they are biased toward the thin side.* And finally, we understand that we have *ignored the limited number of data points,* and that we *have performed our calculations and computer contouring assuming that these external locations were selected at random and, thus, could be representative of the condition of the drywell shell in the sandbed region.* AmerGen Rebuttal Test. Part 3 A38-41.

However, AmerGen is once again being entirely inconsistent. It is precisely the external data, which have been used for the last 15 years to convince the NRC that the shell is still in serviceable condition. Although it was assumed that the most severe corrosion had been identified and that the rest of the sandbed area was less corroded, that assumption has never been verified [3)], and was designed solely to satisfy the NRC.

All parties to the proceeding are by now well aware of the paucity of data available, but we have to work with what we have. It is AmerGen that has to show that it can use the available data for the purpose of providing reasonable assurance that the drywell shell meets the CLB. It is therefore rather ironic that AmerGen has now decided that there are too few external measurements to be statistically representative

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[2)] R. H. Hausler Memorandum to Richard Webster, Esq., July 18, 2007 page 5 par. Chapter VI, The development of Contour Plots.

[3)] Indeed the task would be difficult. One must visualize an access hole (or canal) of 2 feet in diameter

of the shell as a whole. I have attempted to provide the best analysis possible given the limitations of the data. The ideal would probably be to combine all the data on a contour plot. Unfortunately, because the plot provided of all the data is at such a small scale and does not give exact locations, I have been unable to combine the locations of the internal data with those of the external data. The other alternative is to conclude that because neither the external measurements nor the internal measurements are representative of the drywell shell thickness, there is no reasonable assurance of compliance with the acceptance criteria or the ASME code. Unfortunately, instead of combining all the data, AmerGen has chosen to try to ignore the external data. This makes no sense, because when data is sparse, one should try to extract as much information as possible from what is available. And if there are apparent contradictions within the data it should be taken as and opportunity to learn more rather than a reason to discard one or the other of the data sets non representative.. Furthermore, AmerGen has ignored the trench data, which also contains valuable information.

AmerGen has stated in the past that the internal grids are not representative of the shell as a whole. I agree with this because the 600 odd internal UT grid measurements are not evenly (or randomly) spread over the area of the sandbed, but are in each bay centered on small 6" by 6" areas at height 11'3". These grids cannot capture the severity of corrosion in the bathtub ring in some of the most corroded Bays because they are located too high. They therefore systematically over-represent the average thickness in some of the most critical Bays. This is one of the reasons that the external UT measurements were required by NRC in the first place. The internal data also cannot be used to evaluate whether the drywell meets the local area acceptance criterion. [4]

It has been asserted by AmerGen time and time again that the locations for the external UT measurements were made visually and by micrometer measurements for the purpose of selecting the "thinnest" wall locations. The examples for Bays 1 and 13 to be discussed below clearly show that this assertion does not hold across the board.

And finally, we learn from AmerGen that in order to establish meaningful contour plots, the points of measurement would have to be selected randomly in order to represent the drywell shell in its entirety. AmerGen Rebuttal Test. Part 3 at A40. There is absolutely no such a priori requirement in the use of contour plots. As we have pointed out earlier, the only assumption that is being made in the interpretation of the contour plots (also sometimes called the response surface) is that the remaining wall thickness between two measured points can be represented by the average of the two points, or more accurately, by the slope of the line between the two points. That is exactly the same approach taken by Tamburro, as is explained below.

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[4] The fact that there are 49 data points in the internal grids versus at best 20 in the external data sets does not make the internal measurements any more representative of the rest of the bay than the external measurements, as AmerGen and the NRC might want to have it. More points on a smaller area simply do not increase the confidence for the state of the whole.

We have not assumed anything, other than that the points measured by UT and presented by AmerGen were reliable data. The contour plotting routine is an averaging routine and there is no up-front requirement for the data to have been gathered randomly. We have in fact questioned whether the available data would be representative of the drywell shell, which AmerGen has assured us they were, because there was apparently no need for additional measurements in areas where there might be any doubts.

To be absolutely clear about the intentions of this discussion: Our only intention is to try and answer the question as to how much confidence one can have in the integrity of the drywell shell. For that purpose we have among other things resorted to contour plots solely for the purpose of visualizing what one actually knows. In doing that we have done the same thing Mr. Tamburro has done, only using computers to the maximum extent possible rather than using largely manual methods, and have come to quite similar conclusions. Once the obvious errors in Mr. Tamburro's calculations are corrected, they broadly agree with mine within the range of the large uncertainties that remain.

To extrapolate beyond the area that was measured, one can use the response surface routine in the JMP module to extrapolate and predict the remaining wall thickness in the remaining areas of the sandbed region. I have now done this to show just how simplistic AmerGen's approach to this issue is. Although the results outside the measured area are spatial extrapolations from the data, and are therefore less certain than the contours within the measured area, they are better estimates than assuming no degradation in these areas.

II. Discussion of Bay 1

The attached Table 1 shows the external UT data for Bay 1 with the coordinates associated with each point. There were several sources for these data, which were reconciled. However, it turned out that point 6 had the same coordinates as point 17 (-48 vertical and 16 horizontal) but the reported measurements differed by 115 mils. We thought at first that point 6 should perhaps be at –16 horizontal, i.e. on the other side of the centerline. But then we found a graph where the positions of 6 and 7 were reversed to the right of the center line (positive coordinates) and finally there were representations were point 6 was indeed slightly higher and to the left of point 17. We therefore felt justified to change the coordinates from –48 and 16 to –44 and 14 as suggested by most of the graphical presentations.

The resulting contour plot is shown in Figure 1. We have inserted the measurement ID's for each point as well as the respective remaining wall thicknesses. Additionally, we have superimposed Mr. Tamburro's evaluation, which is merely a coarse manual version of the contour plot.

Tamburro in Fig. 1-2 (Ref. 4) defines three areas as shown in Fig.1 below for individual evaluation. Thus Area I contains points 5, 9 and 13 for an "average thickness of 718 mils in an area of 22 inch by approx. 30 inch, or 4.6 sq. feet. Strangely, in Fig 1-6 of Tamburro's work, the same area (referenced in Fig. 1-2) was narrowed and elongated to also contain points 4 and 19. The average residual thickness now was increased to 751 mils, while the estimated area was reduced to 23" by 16" or 2.6 square feet. Fig. 1 below, illustrates that the crude manual estimation by Tamburro is a coarse approximation to the surfaces generated by contouring. The advantage of using the computer is that the manual method is vulnerable to observer bias and does not provide an objective test of whether the results meet the local area acceptance criterion.

The important feature to recognize in all this is that both the contouring process and that used by Tamburro use averaging. However, the contouring is the preferred approach because Tamburro manually defines areas and then calculates average residual wall thickness from the measurements contained in this area, whereas the contours do not select specific areas, but use the measured point as a totality to calculate most likely average wall thicknesses between measured points.

Next, Tamburro defines in Fig. 1-2 an area, which he dubs the "Bathtub Ring". Curiously, he does not include points 11, 2, and 21 in this area even though they are clearly part of the bathtub ring (see Fig. 1 below), but includes these points in another area, which we identified as area III in Fig. 1 below. But when this area (Area III in our Fig. 1) is discussed by Tamburro in his Fig 3-1 (page 30 Ref. 4) he is not consistent in the dimensions. Nevertheless, he identifies this area as the 736 mil boundary and inserts in the same graph a 636 mil boundary somewhat arbitrarily in the middle. Now, Tamburro has identified an area of 14 x 18 inches in his Fig 1-3 as having an average wall thickness of 696 mils (points 7, 11 and 21) and being 1.75 sqft in area. But curiously, point 6 (clearly a companion point to 7 and certainly part of a corroded area) is left out of this exercise.

The peculiar thing about this is that we have been accused of *using the wrong data the wrong way*. The contours are calculated by triangulating between all the points. Tamburro averages (a primitive form of triangulating) across a few points. Please note that point 7 is a good 16 inches removed from points 21, 11 and 2, with other measurements (point 22) in between. The contours indicate that there is not a straight-line slope between point 7 and the others as Tamburro assumes, but that there is in fact a "hump" over point 22. Consequently, the interpretation of the external UT measurements by means of the response surface methodology results in a less severe picture than the one Tamburro arrives at.

There are, however, other, more serious slights of hand in the Tamburro evaluation. In Fig 1-4 (Ref. 4 pg 31) he compares the area covered by points 2, 7, 11 and 21 to the local buckling criterion. He tells us that the area covered by these points is 7 inch by 4 inch or only 0.2 sq feet, when it can easily be seen from our Fig 1 below that the

area attributed to these points would be of the order of 18 by 14 inches or nearly 2 sq feet. Figure 1-4 is therefore incorrect. The same error is repeated in Tamburro's Fig 1-5.

And when it comes to the bathtub ring (Fig. 1-6) and an assessment of points 5, 13, and 4 he conveniently adds points 9 and 19 (see Fig. 1 below) to arrive at an average wall thickness of 751 mils. There is no obvious justification for including point 19 in the bathtub ring. Without it the average would have been 722 mils over an area of about 14 by 14 inches or 1.4 sq ft.

When all is said and done, Tamburro rearranges the data again in Fig. 1-7 and finds an area of 9 sq feet that has a residual wall thickness of 696. However, as clearly shown on Figure 1 this Fig. 1-7 is again incorrect because the area selected must actually be at least 42 inches by 36 inches to capture all the points show on Fig. 1-7, which is considerably larger than 9 square feet.

The question now is how one can reconcile these results with the local buckling criteria. This was, and still is the objective of the external UT measurements (see Tamburro's Figs. 1-4 and 1-5).

1. Originally the local wall thickness criteria derived from the GE sensitivity study (AmerGen Ex. 39) which found that if a local area of 0.5 sq. ft. in two adjacent Bays has a residual wall thickness of 536 mils and then tapers back to a uniform 0.736 inches, the load factor is reduced by 9.5% compared with the load factor found for a uniform wall thickness of 736 mils over the sandbed area (which gave an EFS of 2.0 for the refueling case). Similarly if the 0.5 sq. ft. central area in each Bay has a residual wall thickness of 636 mils, the load factor is reduced by 3.9%. These reduced load factors correspond to EFS's of 1.81 and 1.92. It was stressed that this sensitivity study assumed that the local thinning would gradually over a distance of a foot taper up to the 736 mils specified for the general limiting buckling wall thickness. From these general local buckling wall thickness criteria resulting from the sensitivity analysis it was left to the individual engineer to decide whether a particular corroded area would violate the one or the other of these two cases. The problem is this, the area of reduced wall thickness below 736 mils was never conveniently in the shape of the modeled cut-outs. Therefore, it is unclear what is to be done with an area that measures say 6.9 sq feet with an average wall thickness of 704 mils (total bathtub ring area in Fig. 1 below) and which tapers asymmetrically on one side toward 800 mils and on the other side toward 1150 mils. If the intention was that the cut-outs would bound the corroded areas, the dimensions of the bath tub ring, which is 10 inches wide by 66 inches long exceed the boundaries of the cut-outs and therefore presumably must violate the acceptance criterion for local areas.

2. While the definition for the local buckling criterion used in the various revisions of Calc 24 has varied, in Rev. 2 a more restrictive definition was promulgated in: *If an area is less than 0.736 inches then that area shall be greater than 693 mil*

thick and shall be no larger than 6 inch by 6 inch. (It was admitted that Calc. 024 had previously positioned an area of this magnitude in Bay 13 [5]*).* It is clear, however, that areas of this magnitude exist with wall thicknesses less than 693 mils all through the sandbed area (see above discussion). Consequently, Mr. Tamburro devised a way whereby the measured corroded areas were broken up into separate "mini areas" of which it could be shown that, even though severe corrosion in excess of 736 mil residual wall thickness had been observed, these areas were small enough such that they would satisfy the local buckling criteria. The advantage, of course, of this formulation of the criteria was that one could choose the areas for analysis almost arbitrarily. The disadvantage is that the decisions are left to the judgment of the engineer, which may be biased or influenced by considerations other than the need for an objective assessment of the data. In the end, comparing the Tamburro assessment with Figure 2, we see that Tamburro's assessment is a crude version of the assessment produced by the more sophisticated analysis.

3. Figure 1-7, perhaps inadvertently, illustrates that, according to Tamburro, an area of average thickness 0.696 inches extends over an area that is larger than 9 square feet. Based on this assessment, Tamburro should have concluded that the drywell failed the local area acceptance criterion he was using, which required contiguous areas that are thinner than 0.736 inches on average to be less than 9 square feet in extent. It is unclear why he arbitrarily labeled the area as 36 inches by 36 inches.

The triangulation, on the basis of which the response surfaces are generated, first generates the equations (correlation functions) used to draw the contours. These same equations can then also be used to define a grid larger than the area that had actually been covered by measurements, and to extend the contours for the purpose of predicting, in this case, the extent of corrosion one might expect outside the measured areas. This was done in Figure 2 below for Bay 1. The reason why this was done was because it was suspected that the bathtub ring might extend away from the vent line into the center of the bay. Indeed, as can be seen from Figure 2, a large area of about 15 by 20 inches might exist with a residual wall thickness of less than 750 mils and might actually extend into Bay 19. This is a prediction based on the existing data, and if verification of this prediction is outside the scope of the present intervention, it is certainly a better prediction than the assumption that corrosion stopped with the evaluation of points 5 (680 mils), and 9 (745 mils) 30 to 35 inches below the top of the sandbed.

We also see from Figures 1 and 2 that at the top of the sandbed essentially no corrosion occurred. This is in agreement with the internal grid measurements which essentially showed the same thing, **and which is in part the reason why we have concluded earlier that the internal grid measurements do not reflect the corrosion in the sand bed area and are not in anyway representative of the corrosion of the drywell liner.**

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[5] This criterion is also repeated in Calc. C-1302-187-E310-041, pg. 11, 12/15/06.

III. Discussion of Bay 13

Table 2 below lists all the data for Bay 13 external UT residual wall thickness measurements. The original data were somewhat confusing. On 1/8/93 an initial set of 8 readings were obtained and listed from 1 through 8 with the associated coordinates. Then on 1/11/93 an additional set of 19 readings were obtained and again listed from 1 through 19 with the associated coordinates. Some of these readings from the second set were new, others were at or near the old coordinates. For this reason all the readings from 1/11/93 were given the suffix a. It appears that additional measurements were made at or near some of these older ones with only minimal grind of the surface (to better place the UT probe). However, these repeat or confirmatory measurements, which differed from the previous ones considerably, did not have the coordinates associated with them and could therefore not be officially included in the data set. (Nevertheless, attempts to insert these measurements at reasonable shifts of the coordinates might have better revealed the "pimpled nature of the surface.")

In 2006 it was reported that a number of the location identified in 1992 could not be "found" and therefore no 2006 data were reported for these locations. This was most unfortunate, because it appeared that one could not now deal with the spots of severe corrosion in the upper right hand corner of Figure 3. However, since it had been observed that on average all 2006 data were 20 mils lower than the 1992 results, the missing 2006 data were filled in with the corresponding 1992 data reduced by 20 mils. These "calculated" measurements are shown in the last column in Table 2 below in italics. Since there were duplicate measurements at the same coordinates, in some cases the coordinates of the second set of data were slightly shifted in order to include all data in the contours [6)]

Figure 3 below thus shows the response surface for the 2006 external UT measurements in the sandbed region. Superimposed are the three areas, I, II, and III,which Tamburro proposed in order to analyze Bay 13 corrosion in greater detail. Tamburro locates all measured points in an approximate graph of Figure 13-1 on page 63 of Ref. 4. It is noted first of all that the relative position of the individual points is distorted when compared to Fig. 3 below which is drawn with the accurate coordinates. Second, as one looks at the numbering of the points it is hard to believe that an argument could be made that the points to be measured **had not been selected at random**. Finally, we also notice that all measuring locations are indicated in Fig. 13-1, however, as we proceed to examine Tamburro's individual areas we find that for some unexplained reasons some of the most corroded points are left out. Thus within the three areas Tamburro proposes to discuss in Fig. 13-2 we find that points 1 and 2 and 1a and 2a are missing. Clearly, the absence of these heavily corroded areas from Tamburro's analysis grossly distort his conclusions.

[6)] When two points have the same coordinates, one set will be dropped from the triangulation even though the values may be different. By shifting the coordinates ever so slightly the particular location in question will be given more weight as it should be because of the additional data.

Tamburro and AmerGen have insisted all through these discussions that the most heavily corroded areas had been selected for UT measurements, and that their evaluation were conservative. However, in the final analysis the most heavily corroded areas are simply overlooked. It turns out that the bathtub ring in Bay 13 is not horizontal, but tilted toward the center of the bay.

Figure 4 shows the predictive contours derived from the triangulation correlations. Note, that the areas predicted to have less the a residual wall thickness of 750 mils (dark green shading) extend all the way up to 0 on the scale of vertical coordinates, a few inches below the "internal grid measurements." Three internal grids had been measured in this Bay (Ref. 11, Section 6, Table 6) with average residual wall thicknesses of 846 (13A). 904 (13D bottom), 1047 (13 B top) and 1142 (13 C). Thus, it is likely that the internal measurements are mostly above the angled bathtub ring, which is tapering out at 11'3" or thereabouts. **Clearly, however, none of the Internal Grid UT measurements reflects the severity of the actual corrosion in the sandbed area below 11'3" in Bay 13.**

IV. The Relationship between the Internal and External UT Measurements

Finally we find the need to comment on the comparison between the internal UT measurements in Bay 17 and their relationship to the external and trench UT measurements. It has been said that if we had chosen the internal grid measurements 17 D instead of 17 A the comparison between the external and trench measurements would have turned out different, and we might have concluded that the internal grid measurements actually did represent the overall corrosion damage of Bay 17 or in fact of all Bays (AmerGen Rebuttal testimony, part 3, pg 3.). As a consequence we have augmented Figure 4 from our Memo of April 25, 2007 to include both sets of internal grid measurements. The results are shown in Figure 5 below. Indeed the horizontal averages plotted as function of the elevation for the data 17 D show considerably more reduced wall thickness than those for 17 A. Now, one needs to remember that the lateral position in the Bay of these data is not represented in the Figure 5, in fact we don't know what the lateral position is because it has not been reported with any precision. Nevertheless, Fig. 5 clearly demonstrates the uncertainty of the assessment of the corrosion damage in the sandbed area if one were to rely on only one set of data, namely the internal grid data. This has earlier also been demonstrated by means of an analysis of the results for Bays 1 and 13.

V. Conclusions

The above discussion has shown that:

- Developing contours is not using "the Wrong Data the Wrong Way", but is in fact the most rational approach to visualizing the external UT measurements in the sandbed area.

- The response surfaces showing the correlations as well as the raw data present a more comprehensive way towards deciding whether certain corroded areas are within the acceptance criteria.
- The approach Tamburro took of dissecting the totality of the measurements for each Bay into mini areas, for the purpose of demonstrating agreement with the acceptance criteria, appears to be rather arbitrary and self-serving. At best, it is a crude approximation of the contouring which is carried out in an objective manner by a computer.
- The correlation equations on the basis of which the response surfaces are calculated allow extrapolation into areas of no measurements. **For certain, prediction on the basis of these equations as shown in Figures 2 and 4 carries more weight than the blanket assertion that there is no severe corrosion outside the areas examined. These predictions show that areas of severe corrosion are probably present at precisely the locations that AmerGen has admitted are most vulnerable to buckling.**
- Finally, reexamination of the data for Bay 17 show just how questionable the assertion is that the internal grid measurements are representative of the entire corrosion damage which may have occurred in the sandbed area.

References

A. Data Sources

1. GPU Nuclear; Calculation C-1302-187-5320-024 Rev. 1, 1/12/93, this revision contained the original raw data on pages 67 to 117,
2. GPU Nuclear, Calculation C-1302-187-5320-024, Rev. 0, 1/12/93, this document explains in detail the rational for the "Evaluation Thickness".
3. Passport 0054604907 (AR A2152754 E09), 11/2/06; this document contains the results of the 2006 external UT measurements.
4. Exelon Nuclear; Calculation C-1302-187-5320-024 Rev. 2, 3/28/07; this document also contains the rational for acceptance within the "acceptance criteria" of the areas which were most corroded.
5. IR 0553792-02 Drywell Structural Integrity Basis IR21 Inspection, 11/06/06, Document contains all 2006 internal Grid data

B. Rebuttal References

6. NRC Staff Rebuttal Testimony of H. G. Ashar, Dr. J. A. Davis, Dr, Mark Hartzman, T. L. O'Hara, A. D. Salomon.
7. NRC Staff Response to Initial Presentations and Response to Board questions.
8. Affidavit of Mark Hartzman, PhD, Aug. 23,2007, par. 2
9. AmerGen's Pre-filed Rebuttal Testimony, Part 2, Acceptance Criteria, by M.P. Gallagher, A. Ouaou, H. S. Metha, PhD,

AmerGen's Pre-Filed Rebuttal Testimony, Part 3, Available Margin: by F. W. Polaski, D. G. Harlow, PhD, Julien Abramovici, Peter Tamburro, and M. E. McAllister.

11. 2006 Inspection Report for ACRS

Bay 1 UT Measurements for External Corrosion.

Measurement ID	Vertical Position inches	Horizontal Position inches	Remaining Wall Thickness 1992 inches	Remaining Wall Thickness 2006 inches	Comments
1	-16	30	720	710	
2	-22	17	716	690	
3	-23	-3	705	665	
4	-24	-33	760	738	
5	-24	-45	710	680	
6	44	14	760	731	location given as -48/16 - duplicate of 17 not likely, therefore moved closer to point 7
7	-39	5	700	669	
8	-48	0	805	783	
9	-36	-38	805	754	
10	-16	23	839	824	
11	-23	12	714	711	
12	-24	-5	724	722	
13	-24	-40	792	719	
14	-2	35	1147	1151	
15	-8	-51	1156	1160	
16	-50	40	796	795	
17	-48	16	860	846	
18	-38	-2	917	899	
19	-38	-24	890	856	
20	-18	13	965	912	
21	-24	15	726	712	
22	-32	13	852	854	
23	-48	15	850	828	

Bay 13 UT Measurements for External Corrosion.

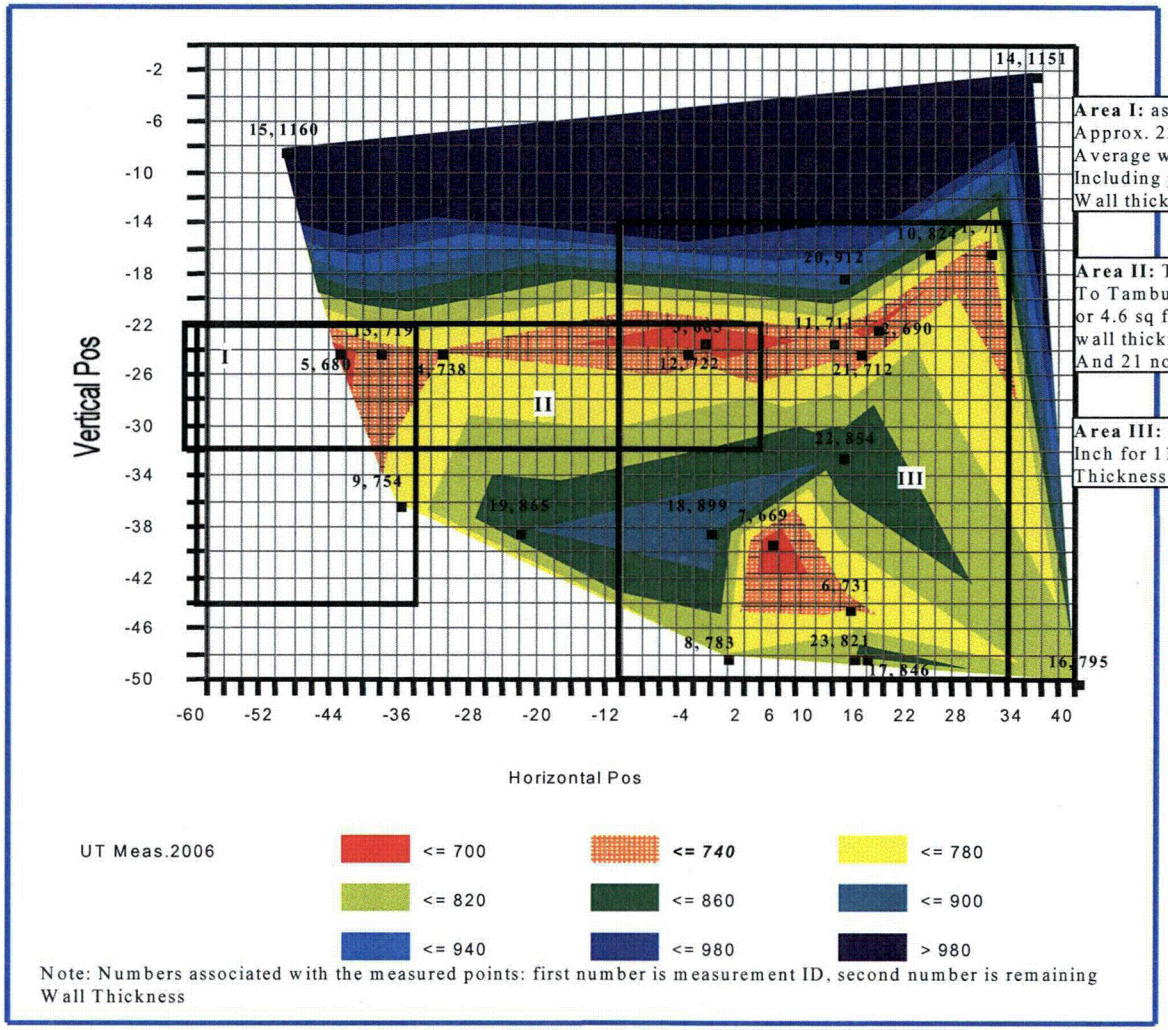
Measurement ID	Vertical Position inches	Horizontal Position inches	Remaining Wall Thickness 1992 inches (1)	Vertical Position inches	Horizontal Position inches	Remaining Wall Thickness 2006 inches (1)	Comments
1a	1	45	672	1	45	***652***	
2a	1	38	727	1	38	***705***	
3a	-21	48	941	-21	48	923	
1	-6	46	814	-6	46	***873***	
2	-6	38	615	-6	38	***595***	
3	-26	42	934	-26	-42	***914***	
4	-12	35	914	-12	-35	***894***	
4a	-12	36	915	-12	36	873	
5	-26	6	735	-26	6	***715***	
5a	-21	6	713	-21	6	708	
6	-24	-8	683	-24	-8	***663***	
6a	-24	-8.5	655	-24	-8	658	
7	-17	-23	632	-17	-23	***612***	
7a	-17	-23	616	-17	-23	602	
8	-22	-20	744	-22	-20	***724***	
8a	-24	-20	718	-24	-20	704	
9a	-28	41	924	-28	41	915	
10a	-28	12	728	-28	12	741	
11a	-28	-15	685	-28	-15	669	
12a	-28	-23	885	-28	-23	886	
13a	-18	40	923	-18	40	814	
14a	-18	8	868	-18	8	870	
15a	-20	-9	683	-20	-9	666	
16a	-20	-29	829	-20	-29	814	
17a	-9	28	807	-9	28	***787***	
18a	-22	38	825	-22	38	***805***	
19a	-37	38	912	-37	38	916	

Calc. 24, Rev. 1 measurements 1/8/93
The numbers with postsript (a) are dated 1/11/93 and are in part duplicate measusrements from the previous entry and in part new measurements
bold numbers in italics are numbers missing in the 2006 survey. They have therefore been calculated by subtracting 20 mils from the 1992 measurements.
This was necessary because otherwise the upper right hand corner of the plot would have been grossly and erroneously distorted.

Bay 1 Contour Plot for 2006 External Measurement Data

Individual Evaluation Areas from Tamburro Analysis superimposed [see Calc. 24 Rev. 2 Fig. 2-1]

Figure 1



Area I: as defined by Tamburro
Approx. 22 x 30 inch for 4.6 sq feet
Average wall thickness 718 mil
Including pts 2 and 19 results in average
Wall thickness of 751 mils

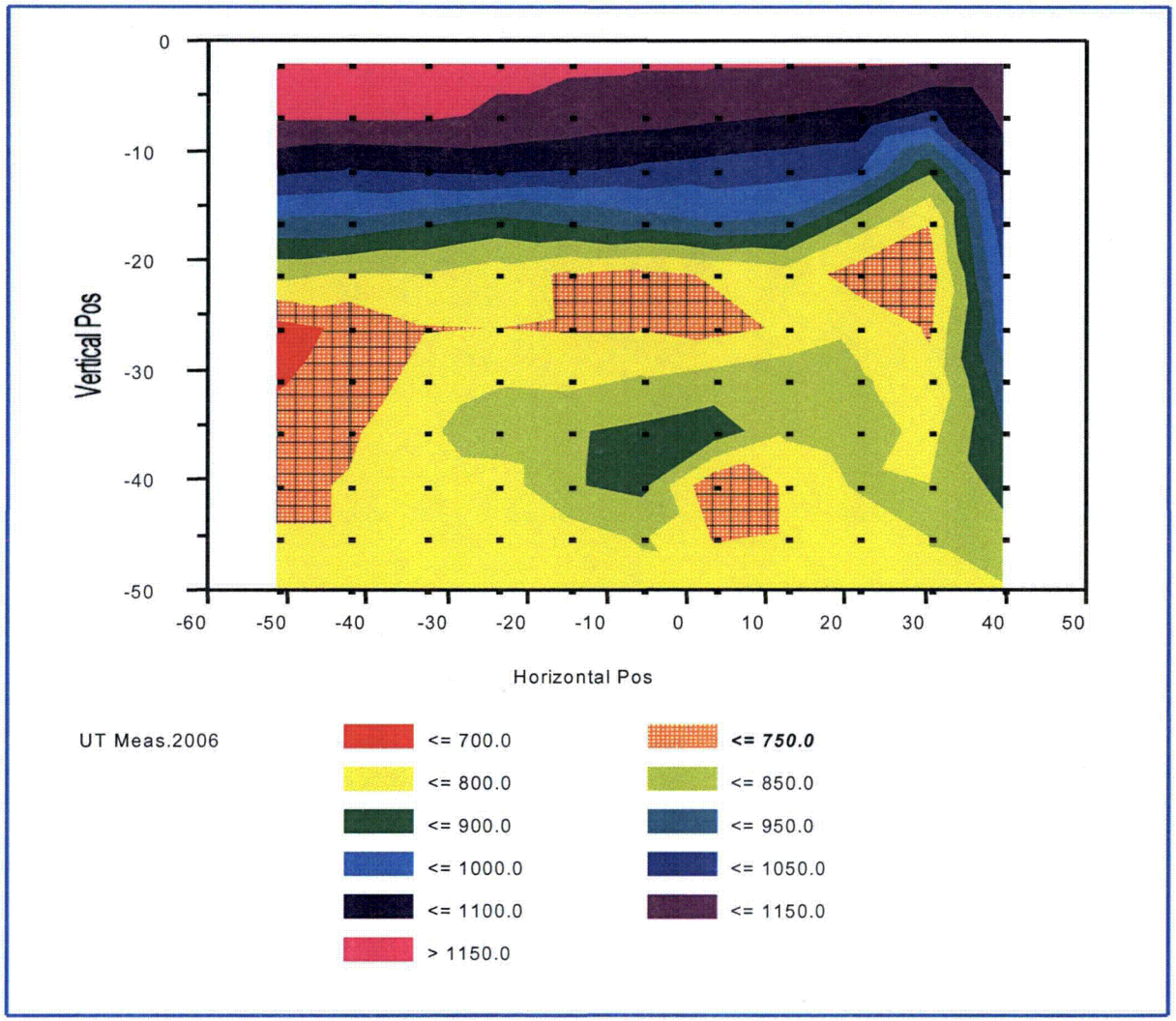
Area II: The Bathtub ring, according
To Tamburro approx. 10 inch by 66 inch
or 4.6 sq feet for an average residual
wall thickness of 705 mils, except pts 11, 2,
And 21 not included in this area

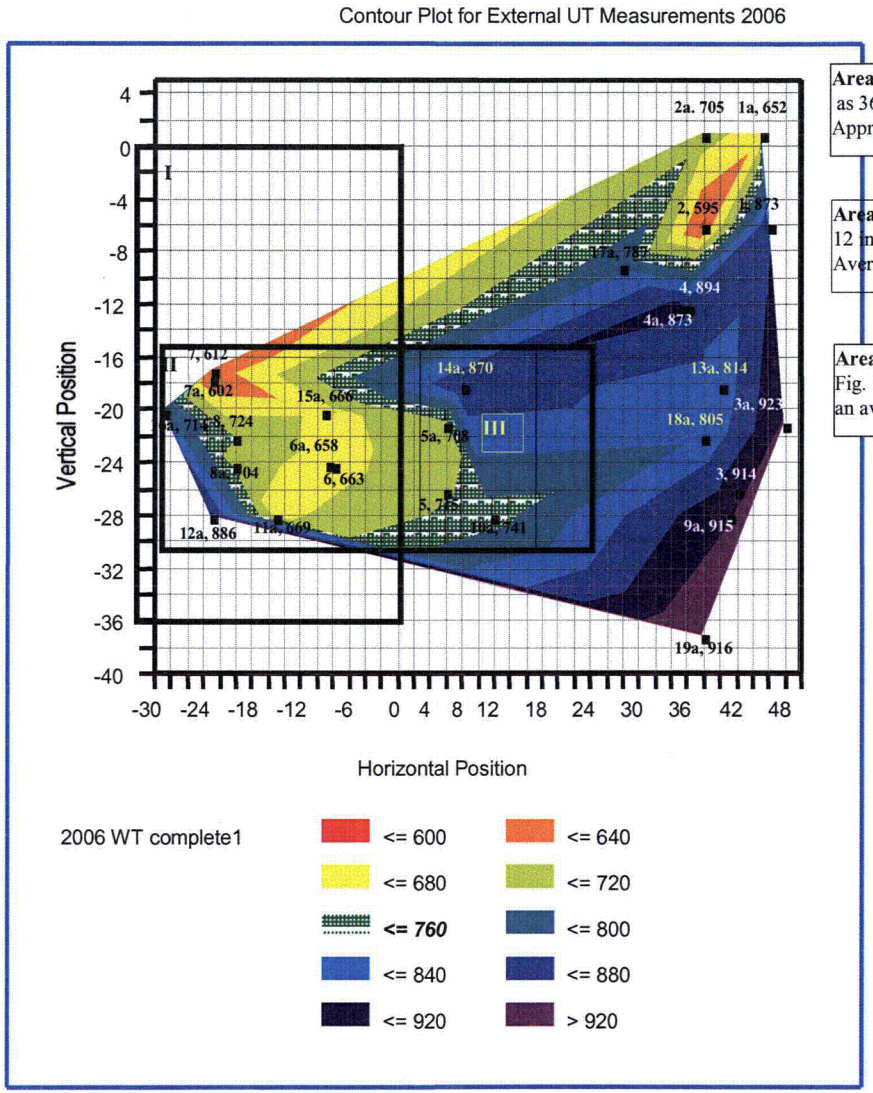
Area III: according to Tamburro 36 inch by 44
Inch for 11 sq feet and an average residual wall
Thickness of 695 mils

Note: Numbers associated with the measured points: first number is measurement ID, second number is remaining Wall Thickness

Bay 1 Predictive Response Surface Calculated from Triangulation
External UT Measurements 2006

Figure 2





Area I: Defined by Tamburro's Fig. 13-2 as 36 inches by 36 inches. 36 inches is Approximately the height of the sandbed.

Area II: Defined by Tamburro's Fig. 13-2 12 inches by 54 inches, 4.5 sq feet with an Average residual wall thickness of 710 mils.

Area III: Defined by Tamburro Fig. 13-2 and Fig. 13-6 actually contains 4 measurements with an average residual wall thickness of 758 mils

Figure 3

Figure 4

Predicted Response Surface for area of Bay 13
Contiguous Areas which are less than 725 mils about 12 sqft
Bordered by the dark green areas.

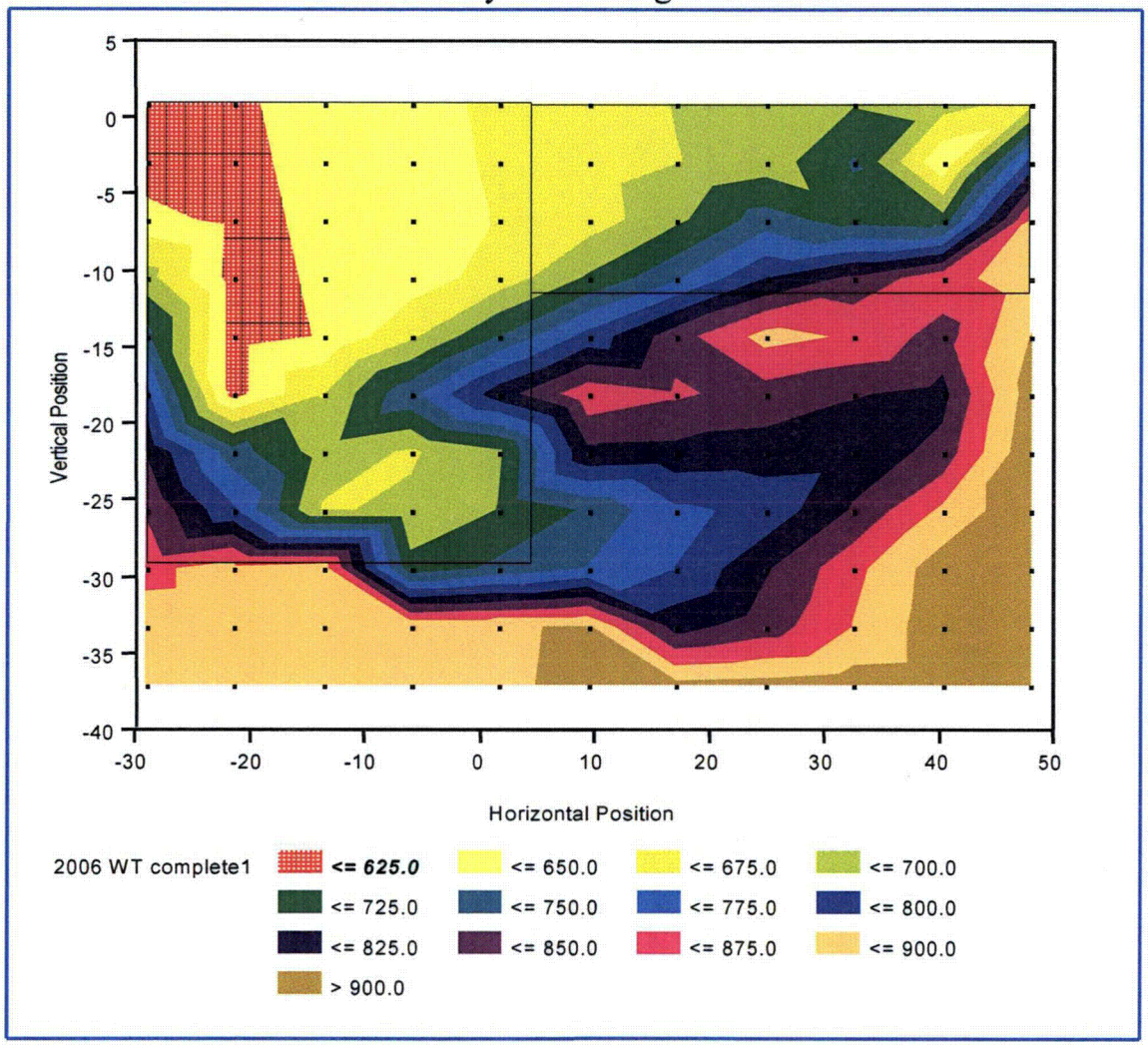
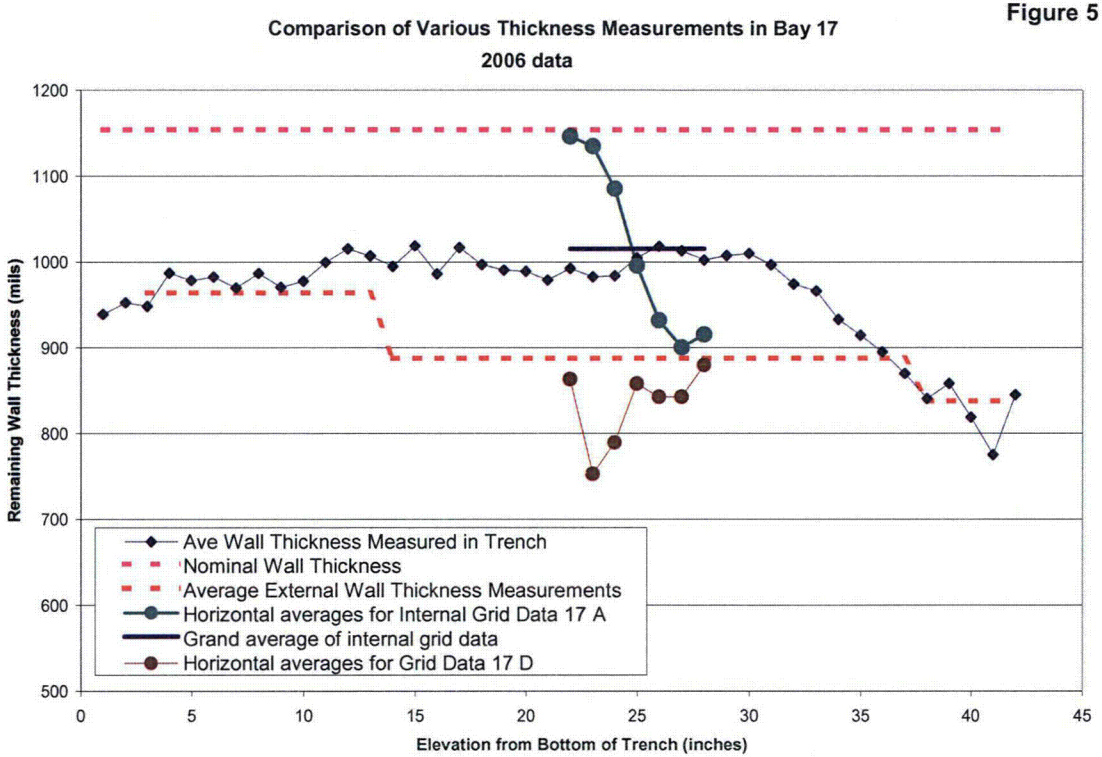


Figure 5


Comparison of Various Thickness Measurements in Bay 17
2006 data
Remaining Wall Thickness (mils)
1200
1100
1000
900
800
700
600
500
0
5
10
15
20
25
30
35
40
45
Elevation from Bottom of Trench (inches)
Ave Wall Thickness Measured in Trench
Nominal Wall Thickness
Average External Wall Thickness Measurements
Horizontal averages for Internal Grid Data 17 A
Grand average of internal grid data
Horizontal averages for Grid Data 17 D