UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
OFFICE OF THE SECRETARY

ATOMIC SAFETY AND LICENSING BOARD

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

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

**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

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

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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

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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

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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,

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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

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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

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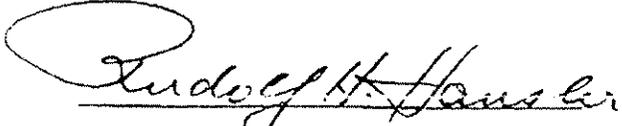
Q40. In summary, are you convinced that the drywell will meet safety requirements during any extended period of operation?

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.

Dr. Rudolf H. Hausler

9 - 13 - 200)

Date