Citizens Exhibits 37

RAS 14354

STATEMENT OF FACTS

I. Current Margins

A. Established Acceptance Criteria

AmerGen has established that, on average, each Bay must be thicker than 0.736 inches and that no area should be thinner than 0.49 inches. In addition, AmerGen has recognized the need for a local acceptance criterion to control the extent of contiguous areas that are less than 0.736 inches. However, AmerGen's practice regarding this criterion has been inconsistent so that the Board must determine which is the most appropriate local area acceptance criterion.

B. The Local Area Acceptance Criterion

Until recently, the reactor operator consistently used the local area acceptance criterion to accept areas that were thinner than 0.736 inches, larger than 2 inches in diameter, but less than one square foot in extent. For example, in March of 2006, Mr. Tamburro, AmerGen's employee who has authored many of the reports accepting the measurements, wrote that calculation C-1302-187-5320-024 "uses a Local Wall Acceptance Criteria . . . [which] can be applied to a small area (less than *12 by 12*), which are less than 0.736 inches thick so long as the small area is at least 0.536 inches thick." Ex. 3 at 2 (emphasis added).

Ultimately, the NRC Staff also adopted this approach in the SER by quoting AmerGen's Request for Additional Information ("RAI") response of April 7, 2006 stating that:

> UT measurements identified isolated, localized areas where the drywell shell thickness is less than 0.736 inches. Acceptance for these areas was based on engineering calculation C-1302-187-5320-024. The calculation uses a "Local Wall Acceptance Criteria." This criterion can be applied to small areas (less than *12" by 12"*) which are less than 0.736" thick so long as the small *12" by 12"* area is at least 0.536 inches thick.

SER at 4-56 (emphasis added). After discussion of buckling issues, the quoted document applied that criterion, stating that the total area thinner than 0.736 inches was 0.68 sq. ft, and thus less

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than one square foot. *Id.* at 4-58. AmerGen continued "these local areas [that are less than 0.736 inches] could be continuous, provided their total area did not exceed one square feet *and* their average thickness was greater than . . . [0.536 inches or 0.636 inches]." *Id.* (emphasis added). Thus, prior to April, 2006 AmerGen documents state that the local acceptance criterion can only be applied to small areas that are less than one square foot in area and NRC Staff adopted this approach in the SER.

Mr. Tamburro's memorandum of March 2006, expressed concerns that calculation C-1302-187-5320-024 was deficient, even though it was the only safety related calculation demonstrating that the drywell shell in the sandbed region met safety requirements. Ex. 3 at 1. Mr. Tamburro himself noted that when a nine square foot area thinner than 0.736 inches was modeled by General Electric, the buckling capacity of the shell decreased by 9.5%. *Id.* at 2. Thus, Mr. Tamburro recommended that calculation C-1302-187-5320-024 be revised to ensure that "a 9.5% reduction in buckling load still meets code allowables." *Id.* at 4. He also noted numerous other deficiencies, the most glaring of which was that four engineers with at least 15 years experience had reviewed the calculation and none could understand how the calculation method and acceptance criteria demonstrated the conclusions of the calculations. *Id.* at 1.

Revision 1 of calculation C-1302-187-5320-024, dated September 21, 2006, did not take the path recommended by Mr. Tamburro. Instead, the authors adopted a more stringent local area acceptance criterion. In a summary table on page 2, the revised calculation applied a local thickness criterion of 0.636 inches to areas that are less than 12 inches square. AmerGen Ex. 17 at 5. The calculation also applies this criterion in the text. *E.g. Id.* at 17, 36. However, while it never clearly states the origin of the criterion employed, it does state that modeling done by General Electric ("GE") used tapered shapes with minimum thickness 0.536 inches and 0.636

inches. *Id.* at 10-11. Thus, although the document authors were aware of the approach previously taken, which was to compare the measurements over a 12 by 12 inch area to 0.536 inches, they took a more conservative approach by using 0.636 inches as the allowable thickness over a one square foot area.

In December 2006, AmerGen applied the following local area acceptance criterion: "if an area is thinner than 0.736" thick, then that area shall be greater than 0.693 inches thick and shall be no larger than 6" by 6" wide." Calculation C-1302-187-E310-041, AmerGen Ex. 20 at 11. This is yet more stringent than the criterion previously put forward by AmerGen. More recently, for the purpose of summary disposition, AmerGen alleged that the "local area average thickness" criterion is 0.536 inches for a 1 square foot area, but the total area that can be thinner than 0.736 inches is *nine square feet.* Affidavit of Peter Tamburro, dated March 26, 2007 ("Tamburro Aff."), Ex. 6 at ¶¶ 20-23 (emphasis added). This 2007 criterion is considerably less stringent than that used in December 2006. Furthermore, Mr. Tamburro failed to provide justification of why a 9.5% reduction in bucking capacity would be acceptable, contrary to his March 2006 recommendations.

Most recently, revision 2 of calculation C-1302-187-5320-024, dated May 18, 2007, authored by Mr. Tamburro, discusses yet another less stringent criterion. The report requires the UT results to either meet the requirements for general wall thickness given in Section 6.1, or the requirements for local areas that are less than 36 inches by 36 inches in extent given in Section 6.2. C-1302-187-5320-024 rev. 2, AmerGen Ex. 16 at 10. The acceptance criterion for general wall thickness requires the average thickness of a 36 inch by 36 inch area to be greater than 0.736 inches. *Id.* If an area fails Section 6.1, it must meet Section 6.2 regarding local wall thickness. In turn, the local wall thickness criterion requires areas that "an evaluated area for local buckling shall not be larger than 36" by 36" wide." *Id.* at 10, Figure 6.2-1. In addition, the 12 inch by 12 inch center of the evaluated area must be thicker than 0.636 inches on average, and the area surrounding that area must be "on average thicker than the transition from 0.636 inches to 0.736 inches." *Id.*

In summary, the SER and AmerGen documents show that AmerGen first established an acceptance criterion that required a contiguous areas thinner than 0.736 inches to be smaller than one square foot area and thicker than 0.536 inches on average. This was accepted by NRC Staff in the SER. Thereafter, in response to internal concerns, AmerGen made the criterion more stringent requiring areas thinner than 0.736 inches to be smaller one square foot and thicker than 0.636 inches. In December 2006, AmerGen then used a still more stringent criterion: "if an area is thinner than 0.736" thick, then that area shall be greater than 0.693 inches thick and shall be no larger than 6" by 6" wide." Calculation C-1302-187-E310-041, AmerGen Ex. 20, at 11. In 2007, AmerGen then deviated from past practice by allowing contiguous areas of up to nine square feet in extent to be thinner than 0.736 inches on average.

Another major issue with the local area acceptance criterion is that it assumes that the corroded areas are squares. The NRC Staff did not consider this issue in the SER because they erroneously believed AmerGen's representation that the total area thinner than 0.736 inches was around 0.68 inches. SER at 3-128, 4-58. As shown below, in some Bays, the areas thinner than 0.736 inches are long, thin grooves running almost horizontally along the drywell shell. These grooves could undermine the stability of the drywell more than square areas of corrosion of the same size. Therefore, great care must be exercised in applying acceptance criteria based on modeling of square areas to such grooves. As such, Dr. Hausler believes that at minimum, local areas thinner than 0.736 inches should be smaller than one square foot and thicker than 0.636 inches on average, as AmerGen required in September 2006.

C. Methods Employed For Measuring Drywell Thickness

The available UT data fall into three categories, 6 inch by 6 inch grids of data taken above the interior concrete floor of the drywell, additional grids of data taken in two trenches that were created on the inside of the drywell before the sand in the sandbed region was removed, and data taken from the exterior of the sandbed region. The grid and trench data consists of 49 points taken at one inch spacing over various 6 inch by 6 inch areas. In each trench six such areas were measured. The drywell shell in the sandbed region is divided into odd numbered bays numbered from 1 to 19. The locations of the grids taken above the interior concrete floor were selected by a horizontal scan in accessible areas below the downcomers at elevation 11'3." SER at 3-137. Grids were taken at the worst 12 of these locations in Bays 9, 11 (two areas), 13 (two areas), 15, 17 (two areas), 19 (three areas), and the frame between bays 17 and 19. Ex. 7 at 16. At 7 other locations a single horizontal line of 7 points was taken in Bays 1, 3, 5, 7, 9, 13, and 15. *Id.* at 16. Measurements were taken at the 12 grids at various times between 1986 and 1992, and then in 1992, 1994, 1996, and 2006. *Id.* at 18; AmerGen Ex. 19 at 7.

AmerGen only measured the thicknesses in two trenches below the drywell interior floor thrice, in 1986, 1992, and in 2006. *Id.* at 4. The reactor operator created the two trenches in Bay 5 and 17 to a depth about equal to the sandbed floor on the outside. *Id.* at 1. These trenches enabled the operator to perform UT measurements below the interior concrete floor prior to removal of the sand from the outside. Finally, measurements have been taken from the exterior in 1992 and 2006 at various locations that were visually identified as the thinnest points before the 1992 measurements. Calculation C-1302-187-E310-041 rev. 0, AmerGen Ex. 20 at 48.

However, in 2006 it emerged that these results were not actually measured at the thinnest points. Because the locations of the points measured in 1992 were not marked on the coating, the exact locations could not be repeated. *Id.*; *see also* AmerGen Ex. 19 Attachment 4 at 8 (some locations not found). However, the results for 2006, show that at some points in Bays 7, 15, 17 and 19 AmerGen scanned a 0.25 inch area around the nominal location of the point. *Id.* at 8, 16, 18, 20. Strikingly, in Bay 15, the reported results were actually the *maximum* readings obtained. In this Bay, the *minimum* readings were as much as 0.068 inches less than the recorded value. *Id.* at 16. Similarly, in Bay 19 the recorded results were up to 0.07 inches more than the minimum measured value. *Id.* at 20.

D. Margins Based On Mean Thickness

1. Interior Data Taken Above The Curb

The latest grid data show that the mean thickness of the normally distributed data taken in the grids at 11'3" varied from 0.800 inches in Bay 19 to 1.122 inches in Bay 17. Where corrosion was occurring, AmerGen compared the current and projected lower 95% confidence limit of the means to the acceptance criteria for the uniform thickness. SER at 4-60. AmerGen has previously estimated that the uncertainty in the mean of the 49 measurements in a grid is around 0.021 inches, consisting of the standard deviation of the mean, 0.011 inches, plus 0.01 inches allowance for "instrument accuracy." Ex. 10 at 2; SER at 3-121. Confirming that AmerGen really was referring to the standard deviation, the standard deviation of the data set from the interior grid at location 19A is around 0.06 inches, AmerGen Ex. 5 at 50, giving rise to a standard deviation in the mean of around 0.01 inches, because 49 points were used to calculate the mean. However, AmerGen appears to have mistakenly only applied one standard deviation to derive the uncertainty. Using normal statistics one should use 1.96 standard deviations as the

95% confidence interval. Thus, using AmerGen's own approach, the uncertainty in the means of the interior grids at 95% confidence is around 0.02 inches of random error plus a possible 0.01 inches of systematic error, giving an uncertainty of plus or minus 0.03 inches.

Moreover, AmerGen has admitted that it must determine the variance of the means of these data and compare the "mean and the variance" to the acceptance criterion. SER at 4-55. Indeed, in 2006, AmerGen mistakenly stated that it had used the 95 percentile of the measured means to calculate the margin. AmerGen Ex. 12 at 13. In fact, to date AmerGen has largely failed to take account of the variance of the means or the uncertainty regarding systematic error when comparing them to the acceptance criteria, except prior to 1992, when corrosion was clearly ongoing.

Confirming the importance of considering both random and systematic errors, Citizens highlighted systematic errors in the 1996 UT data. After Citizens pointed out that the 1996 means were consistently higher than the 1992 means, NRC Staff also "pointed out a definite bias in the 1996 readings because the average thicknesses . . . increased at almost all locations." SER at 3-127. The Staff also noted that "UT measurements taken from inside the drywell after 1992 show a general increase in metal thickness." SER at 4-53. The Staff further expressed doubt about the validity of the 1994 and 1996 results stating "it appears that the UT measurements taken after 1992 require proper calibration." *Id.* After discussing a response by AmerGen, Staff concluded that the 1994 and 1996 readings were "anomalous." SER at 4-55. Providing the magnitude of the systematic error, AmerGen calculated that the 1994 values were on average 0.015 inches thicker than those taken in 1992, while the 1996 results showed 0.021 inches increase. Ex. 11 at 1. Thus, an allowance of at least 0.01 inches to control for systematic error is justified.

2. Interior Data Taken In The Trenches

Unfortunately, the trenches were dug in Bays 5 and 17, which are the least corroded bays. The trench data are therefore of little assistance in deriving margins. However the data are helpful to examine how representative the grid data are and to see how the external measurements compare. Dr. Hausler's analysis shows that the interior grids may overestimate the overall thickness of the drywell shell and that the external results may more accurately represent the thickness of certain areas of the drywell shell.

Figure 2, attached to Ex. 12, plots all individual 2006 measurements from the trench in Bay 17. The 6 traces represent the variation of the wall thickness in the horizontal direction while the traces themselves extend from the bottom of the trench (left hand side) to the top of the trench (right hand side). The undulations of the 6 traces, which are at times (at the same elevation) in synch and at other times out of phase show the nature of the "golf ball type" surface described in AmerGen literature. Where the undulations are in synch, the pit at that location extends over an area larger than just one inch in diameter. The average amplitude of the undulations in Figure 2 are of the order of 0.1 inch.

Figure 2 further shows that the corrosion is most severe at the top, almost uniform in severity over most of the depth of the sandbed and again somewhat more severe at the very bottom. To shed light on these issues, Figure 4, also attached to Ex. 12, compares the average remaining wall thickness from trench measurements (averaged over the horizontal direction) with the average of the 6 by 6 grid measurement from the inside and the direct UT measurements from the outside. Also graphed in this figure are the averages of the external measurements for the three zones for which data are reported.[1] The averages for the grid and the trench data

1 The zones are: Zone 1 < 9'4" wetted surface; Zone 2 9'4" to 10'3" floor; Zone 3 10'3" to 12'3" curb; Zone 4 >12'4" above curb. Licina Analysis, dated January 4, 2007.

overlap quite well at the same elevation, but the floor and above curb zones are significantly thinner than the curb zone in which the grids are located. Figure 4 actually shows that the external data better represent the floor and above curb zones.

Finally, confirming that the uncertainty in the trench data is similar to the interior grids, in taking account of the variability of the mean of the measured data in the trenches, AmerGen subtracted 0.02 inches before it compared the mean to the acceptance criterion. *See e.g.* AmerGen Ex. 19 at 8.

3. Data Taken From The Exterior

Turning to the measurements taken from the exterior, the results taken in Bay 11 show that the measured average thickness was 0.783 inches. Calculation C-1302-187-5320-024 Rev. 2, AmerGen Ex. 16 at 52. For Bay 1, the mean of the points is 0.801 inches. *Id.* at 21, and the mean of the minimum data measured at each point in Bay 15 is 0.768 inches. *See* Ex. 12 at Table 1.

AmerGen has argued that applying uncertainty to these results is unnecessary because they are already biased toward the thin side. However, this qualitative reasoning is undercut by Ex. 4, Figure 4, which compares all the data available for Bay 17. It shows that while the external data are indeed biased low for the middle elevations, they overestimate the mean thickness compared to the trench data for the most extreme upper and lower elevations. Thus, it is necessary to take account of the uncertainty in the external data to derive statistical estimates of parameters of interest, such as the mean.

For example, looking first at the random errors, in Bay 11, the standard deviation of the data set is 0.048 inches (this includes the random error of the instrument and the variability of the surface itself). Because eight points were measured, the standard deviation of the mean is 0.017

inches. Therefore, the lower 95% confidence limit for the mean thickness is 0.750 inches. Similarly, in Bay 15, the lower 95^{th} percentile of the mean of the corrected data is 0.731 inches, and in Bay 1, it is 0.747 inches. Ex. 4 at Table 1.

In addition to the random error, it is also important to take account of the possibility of systematic error. Indeed, AmerGen has claimed that the 1992 measurements were biased high by 12 to 20 mils. Ex. 9 at 5-2. Although AmerGen has reasonably claimed that the 2006 technique was an improvement over the previous method, *id*, it is prudent to allow for the possibility of systematic bias. Citizens believe that the best approach to this problem is to regard the external readings as representative, even though they might actually be biased to the thin side by their method of selection. This approach ensures that the required degree of conservatism is maintained.

4. Margins Derived From Mean Values

The acceptance criterion for the mean values is 0.736 inches. The lowest estimated mean from the 2006 interior grids is 0.807 in Bay 19 plus or minus 0.03 inches at 95% confidence. Thus, the estimated lowest mean margin derived from the interior grids is 0.071 inches and the lower 95% confidence limit is 0.041 inches. However, the trench data suggest that the means of the external data more accurately represent the true state of the drywell, at least at the extreme upper elevations and below the level of the interior floor. The means of the exterior measurements are 0.783 inches in Bay 11 and 0.768 inches in Bay 15 (using the corrected data). Thus, the mean margins in these Bays are 0.047 inches and 0.032 inches respectively. At the lower 95% confidence limit the means derived from the external data in Bays 11 and 15 are 0.750 inches and 0.731 inches. Thus, these data indicate that there is currently no reasonable assurance that AmerGen can meet its acceptance criterion for the means in Bay 15 and the margin in Bay 11 is a miniscule 0.014 inches of margin at the lower 95% confidence limit.

E. Margins For Very Small Areas

The lowest single point measurement is 0.602 inches taken from the exterior in Bay 13. The 95% confidence limits on single point measurements are around plus or minus 0.09 inches. Ex. 13 at 6. Adding in a possible 0.01 inches of systematic error means that this measurement could represent a thickness of 0.502 inches at the lower 95% confidence limit. Based on an acceptance criterion of 0.49 inches, this means the lower 95% confidence limit of the margin is 0.012 inches.

The lack of certainty on single point values comes in part from the inconsistent search for the thinnest points at each location and the failure to take account of the repeat values where such a search was conducted. In addition, high uncertainty may well be inherent in the measurement methodology. The lack of certainty is illustrated by the scans around the nominal points in Bay 15, where the minimum readings were as much as 0.068 inches less than the recorded value, SJA 2 at 16, even though the nominal point was visually chosen as the thinnest point.

Another way of approaching this issue is to look at the statistics for the external data, divided into zones, which correspond to the interior wetted surface, the elevations beneath the interior floor, the elevations above the floor but below the curb, and the elevations above the interior curb. Licina Analysis, dated January 4, 2007 at Figure 4-6. Figure 6 attached to the Affidavit of Dr. Hausler, dated April 25, 2007 shows that in zone 3, above the interior floor, but below the curb, the lower 95% confidence limit is around 0.456 inches. The uncertainty in estimating the minimum thickness of this area stems from large measured differences in a few data points. Because the lower 95% confidence limit is below the acceptance criterion of 0.49 inches, AmerGen has failed to establish that it has any margin above the very small area criterion.

F. Margins For Local Areas Larger Than Two Inches In Diameter

1. Existing Local Areas Thinner Than 0.736 Inches

AmerGen evaluated the 2006 external results in revision 2 of Calculation C-1302-187-5320-024. The new revision shows that AmerGen now estimates that over 20 square feet of the drywell shell in the sandbed region is thinner than 0.736 inches. Calculation C-1302-187-5320-024, Rev. 2 at 29, 64, 79, 89. This contrasts with the estimate contained in the previous version of the calculation that only 0.68 square feet of the drywell shell was thinner than 0.736 inches. Calculation C-1302-187-5320-024, Rev. 1 at 13. The expansion of the critically thin areas is caused in part by the reduction in measured thickness in 2006 and in part by a change of estimation technique.

The latest revision to Calculation C-1302-187-5320-024 also shows a 9 square foot area in Bay 1 that is 0.696 inches thick. Calculation C-1302-187-5320-024, Rev. 2 at 26, 34. Looking at Figure 1-2 on page 29, there is no data just outside the boundaries of the 36 inch by 36 inch box used for the assessment. *Id.* at 29. In fact, this box could have been drawn considerably larger without including any more measurement points. Furthermore, the "bathtub ring" shown on Figure 1-2 appears to be even more extensive than estimated by AmerGen. Thus, based on AmerGen's own estimates, it is possible that an area exists in Bay 1 that is thinner than 0.736 inches but thicker than 0.636 inches and is larger than nine square feet in extent.

To take a more systematic approach than merely drawing shapes around data points, Citizens applied a contouring program to produce unbiased interpolations of the data. This approach estimated that Bay 1 has two areas thinner than 0.736 inches. Figure 3, attached to the Hausler Memorandum dated July 19, 2007. The first is a long thin groove that is around 3 square feet in extent and the second is a smaller area that is around 0.4 square feet in extent. The actual extent of the first area could be considerably larger because it is not bounded by the data on the left hand side.

Similarly, on the top left of Bay 13, there could be a rectangular area which is 28 inches high by 84 inches wide (16.3 square feet) that has an average thickness of 0.692 inches. *See* Calculation C-1302-187-5320-024, Rev. 2 at 64. The contouring program confirmed these findings. The best fit for the data show an area thinner than 0.736 inches that is around 5 square feet in extent, but is not bounded by the data. Figures 4 and 5, attached to the Hausler Affidavit dated July 19, 2007 (the thin area on the upper right of Bay 13 is not shown on the 2006 plot because AmerGen failed to repeat the measurement at point 2, which was 0.615 thick in 1992). Indeed, the thinnest point is at the edge of the predicted area.

Finally, Bay 19 has an elongated area that is thinner than 0.736 inches, but is very poorly defined spatially. Calculation C-1302-187-5320-024, Rev. 2 at 95; Figure 1 attached to the Hausler Affidavit dated July 19, 2007. The extent of this area could range from around 3 square feet to much more than 9 square feet.

Turning to the thickness of areas that are greater than 2 inches in diameter, but less than one square foot, in 1992 the thinnest local area measured was 0.618 inches thick at point 7 in Bay 13, which AmerGen stated could extend over a 6 inch by 6 inch area. Calculation C-1302-187-5320-024, Rev. 1 at 36. In 2006, the thickness at the same location was measured at 0.602

inches. Ex. SJA 2, Attachment 4 at 14. The data show that this point is adjacent to point 15, which has measured thickness of 0.666 inches. 24 Calc Rev 2 at 58, 63-64. Thus, that data show that an area of over one square feet at thickness 0.636 inches could exist in Bay 13. AmerGen appears to have omitted consideration of the reading at point 15 from its calculations, but based on readings at points 7, 8, and 11, it has concluded that the thinnest one square foot area in Bay 13 is 0.658 inches. Calculation C-1302-187-5320-024, Rev. 2 at 59. Notwithstanding the omission of point 15, because the 95% uncertainty limits of a mean based on three points are at around plus or minus 0.05 inches, AmerGen's own calculation shows that at 95% certainty an area of one square foot in extent could be less than 0.608 inches thick.

The area estimates are highly uncertain because large areas of the sandbed have not been measured at all. This means that the areas thinner than certain thresholds cannot be accurately estimated numerically because those areas are often not bounded by the data points. The estimates of area given by the contouring program should therefore be regarded as a floor rather than a ceiling.

2. Margins Based on Local Area Criteria

The various formulations of the local area acceptance criteria restrict the area of the drywell that can be below certain thicknesses. Citizens have shown that the mid-range estimate of the largest contiguous area thinner than 0.736 inches in Bay 1 is probably larger than 3 square feet and the area thinner than 0.736 inches in Bay 13 is probably larger than 5 square feet. Upper bound estimates put the largest contiguous areas in Bays 1 and 13 thinner than 0.736 inches at around over nine square feet. Most versions of the acceptance criteria for local areas requires contiguous areas thinner than 0.736 inches to be smaller than one square foot. It is therefore highly likely that Bays 1 and 13 violate these criteria. Even the most expansive version of the local area acceptance criterion only allows a contiguous area of 9 square feet to be thinner than 0.736 inches. Because the thin areas in Bays 1, 13, and 19 are not bounded, it is not possible to demonstrate that these areas meet even that minimum requirement with 95% certainty.

Figure 1-5 of Calculation C-1302-187-5320-024, Rev. 2 applies the latest version of the local area acceptance criterion to the thickness measurements taken in the transition zone from the thinnest area and shows that according to AmerGen at locations 1 and 5 in Bay 1 the margin is around 0.01 inches. At the lower 95% confidence limit either of these readings could be 0.09 inches lower. Thus, AmerGen cannot show that Bay 1 even meets the latest applied version of the local area acceptance criterion with anything like 95% confidence. This means that there is no reasonable assurance that Bay 1 meets Amergen's current required acceptance criteria for local areas thinner than 0.736 inches. Figure 19-4 of Calculation C-1302-187-5320-024, Rev. 2 shows a similar problem in Bay 19.

Turning to areas of around one square feet in extent, it is likely that an area of thickness 0.636 inches that is larger than one square foot exists in Bay 13. Most versions of the local area acceptance criteria require thin areas of one square feet in extent to be thicker than 0.636 inches. It is likely that Bay 13 violates these versions of the local area acceptance criterion for areas of around one square feet in extent.

II. Potential For A Corrosive Environment To Exist

A. Exterior Corrosion

Epoxy was applied to the shell in the sandbed region in two different ways. For most of the shell, a two-layer epoxy coating with a primer was painted onto the metal of the drywell. However, for a small potion of the shell just above the uneven concrete floor of the sandbed region, it was covered by epoxy poured upon the floor to direct any water reaching the sandbed region away from the drywell shell and into the drains. The epoxy coating on the floor was poured before the epoxy was painted on the rest of the drywell shell. *See* Photograph of "Bay 5 before shell coating" provided by AmerGen as reference material to the ACRS, Ex. SJA 3. Thus, portions of the shell above the sandbed concrete floor, but below the level of the epoxy coating applied to the floor, are protected only by the epoxy coating on the floor.

Corrosion on the exterior of the drywell shell will occur if the epoxy coating is not intact and water is present. Looking first at the integrity of the coating, there are always holidays or pinholes present when coatings are installed that can provide sites for corrosion to develop. Here, the reactor operator did electrical testing of the coating in a mock-up outside the system, ACRS Meeting Jan 18, 2007 at 151; OCLR13720, but failed to monitor the actual coating in a similar way relying instead on visual inspection. Transcript of ACRS meeting on October 3, 2006 at 60:20-61:2; OCLR13720. Because AmerGen's expert, Mr. Cavallo, acknowledged that "usually holidays are not visible," ACRS Meeting Jan 18, 2007 at 151, it is likely that there were at least some pinholes in the coating from the start.

The next question is whether the coating could deteriorate over time. Mr. Cavallo in his affidavit for summary disposition did not dispute that deterioration of the coating could occur, indeed he admitted that it was possible that repair of the coating might be necessary at some point. Affidavit of Jon R. Cavallo, dated March 26, 2007 at ¶ 22. Furthermore, AmerGen has admitted that the epoxy coating has a limited life of between 10 and 20 years. Transcript of ACRS meeting on October 3, 2006 at 61:12-22. The coating was applied in 1992 and is now around 15 years old. Thus, it is reasonable to assume that the coating could fail at any time during any extended period of operation.

Showing that the potential for the epoxy coating to deteriorate is not mere speculation, since 1996, inspections have found that the epoxy coating on the floor was separating from the concrete underneath. Ex. ANC 5 at 1. The latest inspections showed separated seams and voids in Bays 1, 7, 9, 15. *Id.* These defects meant that water could have penetrated the epoxy coating on the floor prior to its repair. *Id.* at 2. This means that any water in the sand pocket would not necessarily have been directed to the drains.

With regard to the potential for water to be present, operating experience shows that much water entered the sandbed region in the past. For example, AmerGen found water in the sandbed drains as recently as March 2006. Letter from Conte to Webster, dated November 9, 2006 *available at* ML063130465. The source of this water was not determined. *Id.* Furthermore, it has not been established that the only source of water is the reactor fueling cavity. Indeed, documents indicate that the equipment pool has also leaked. OCLR 29277. Other documents indicate that fuel pool water that did not originate from the reactor cavity has been found in the sandbed region. OCLR 28915. In addition, some water will result from condensation during outages. *See* OCLR 13354 (water found in bottles in April 2006 had no activity). Moreover, AmerGen has admitted that it has not yet devised a means of preventing the reactor fueling cavity from leaking. Transcript from ACRS Meeting on Feb. 1, 2007 at 217-222. Thus, it is entirely reasonable for all parties to assume that water may enter the exterior of the sandbed region during any extended period of licensed operation.

B. Interior Corrosion

In the October 2006 inspection, AmerGen unexpectedly found water in the trenches. Letter from NRC to C. Crane, dated January 17, 2007 enclosing summary of results of in-service inspection from October 16 to December 6, 2006 ("Inspection Report") *available as* ML070170396 ("water was discovered in the drywell trenches . . . . The presence of water was not expected by AmerGen. . . . AmerGen determined that an environment/material/aging effect combination exists that had not been previously included in the Oyster Creek license renewal application. AmerGen's letter to the NRC (2103-06-20426), dated December 3, 2006 addresses this issue. . . ."); *see also* Ex. ANC 1 at 2 ("as a result of performing planned inspections [in October 2006] of the internal surface of the drywell shell trenches excavated in the concrete floor in 1986, AmerGen identified an environment/material/aging effect combination that was not included in the LRA.")

Comments by AmerGen presenters at the meeting of the ACRS on January 18, 2007 confirmed that the finding of the wet interior condition was unexpected. Mr. Gordon described it as "surprise water." Transcript of ACRS meeting on January 18, 2007 at 210:17-19. Mr. Gallagher stated "we believe that the whole inside of the drywell below the floor has water in there," *id.* at 217:2-3, and then confirmed that AmerGen believes that "there's water in this lower part of the sphere . . .between the concrete and the shell." *Id.* at 217:4-9. In fact, the Inspection Report 05000219/2006013 revealed that contrary to AmerGen's assertions, this condition had been previously identified in 1992 and 1994, but not addressed:

> The inspectors noted that the presence of water in the bay 5 and bay 17 trenches inside the drywell had been reported in Structural Inspection Reports in 1992 and 1994. The Structural Inspection Report from 1994 (dated January 3, 1995) indicates that the rectification of the situation will require prevention of water from reaching the trenches with proven material(s). However, this condition and the evaluation were not addressed by the corrective action process in effect at the time.

Id. at 9.

NRC staff have stated that corrosion has occurred at other reactors in containment steel plates where wet concrete abuts the steel liner, where there were voids or foreign objects in the concrete. SER at 4-51. Indeed, it was partly the possibility of "some insignificant corrosion" on the interior that led AmerGen to commit to further external UT monitoring in 2008. AmerGen

Letter of Dec 3, 2007 at 14. Finally, AmerGen has tried to suggest that inerting of the atmosphere inside the containment during reactor operation would prevent a corrosive environment on the interior of the drywell. That is incorrect, because other BWRs have experienced corrosion *inside* their drywells. SER at 4-67 (emphasis added). Even at Oyster Creek, some rust was observed when the trenches were opened in October 2006. Transcript of ACRS meeting on January 18, 2007 at 222, 232. In fact, the precise description was that the "surface had traces of red primer and gray sealant layer. Bare metal had a light oxide layer and areas of light to moderate pitting. . . . In areas of pitting no attempt was made to clean out or 'chase the pits.'" OCLR 14454. Furthermore, Oyster Creek has experienced corrosion inside the drywell in the reactor building closed cooling water system. OCLR13629. The observed corrosion can probably be explained because the specifications only require oxygen to be below 5% during operation, they do not require the deywell to be completely inerted. *Id.*

In summary, it is substantially certain that a potentially corrosive environment exists on the interior of the drywell liner in the sandbed region. The critical issue whether the corrosion rate could be significant.

III. Future Corrosion Rate

A. Exterior Corrosion

For the grid data taken from the inside of the drywell liner AmerGen established a statistical method to project the past corrosion rate to the future in situations where the past corrosion rate was linear and significant. SER at 4-60. It did this by trending the mean of the grid data and then projecting the lower 95% confidence limit of the projected thickness into the future. *Id.* This method worked well before the sand was removed from the drywell because the corrosion rates were quite large. For example, the mid-range estimates of the corrosion rate from mid-1989 to early 1990 were up to 0.069 inches per year. Ex. NC 9 at 7. Long term corrosion rates were lower, at up to 0.035 inches per year. *Id.* The estimates of the corrosion rate were quite uncertain, depending on how many results were used to generate the estimate. However, after 1992, where no trend was visually identifiable, AmerGen tried to use the established statistical method, but found it inapplicable because there was no significant slope. It then assumed the corrosion rate to be zero and failed to analyze the uncertainty in the data. NC 1 at 19-30.

In Calculation C-1302-187-E310-041 AmerGen took a different approach when considering the external data. It compared the points measured in 1992 with those measured in 2006 and found that the largest apparent corrosion rate was 0.034 inches per year. Ex. SJA 1 at 49. It then calculated that at this rate the thinnest measured point would be 0.515 inches thick in 2008. *Id.* It therefore decided to take another round of external measurements in 2008.[2] *Id.*

To illustrate the potential for corrosion from the outside, using a set of assumptions that included a corrosion rate of 0.039 inches per year, Mr. Gordon estimated that if the coating failed and moisture got to the metal surface, metal loss could be up to 0.042 inches in the 56 weeks following an outage. Affidavit of Barry Gordon, dated March 26 2007 at ¶ 18. Thus, Mr. Gordon appears to believe that additional corrosion at an appreciable rate could occur if the coating fails and wet conditions are present. This supports Citizens' position. The difference is that because Citizens believe that that the margins are, at best, less than 0.04 inches, Citizens conclude that a monitoring frequency of every 4 years is too long. Indeed, even if Mr. Tamburro

2 In fact, inspection of the results shows that the thinnest measurement at the location used to calculate the corrosion rate (point 2 in Bay 17) was 0.663 inches, not the 0.681 inches reported. Using the thinnest point measured at this location, as was apparently done in 1992, would therefore yield a corrosion rate of 0.04 inches per year. Applying this rate and a single point uncertainty of 0.09 inches to the thinnest measured result in Bay 13 of 0.602 inches would mean that the acceptance criterion for areas of less than 2 inches in diameter could be violated in 6 months. Citizens provide this analysis to illustrate the consequences of applying AmerGen's approach to any extended period of operation.

were correct that the minimum margin is 0.064 inches, the possibility that 0.042 inches could be lost each outage if coating decay commences would still indicate that monitoring should be undertaken every outage.

B. Interior Corrosion

Although AmerGen believes the rate of interior corrosion will generally be small, New Jersey has recently written to NRC providing cautionary expert comments. Letter from Lipoti to Kuo, dated April 26, 2007 attaching letter from R.M. Latanision, dated March 26, 2006. Mr. Latanision, an expert retained by New Jersey, warned that interior corrosion could be appreciable if voids are present in the concrete adjacent to the steel shell. In addition, he warned that if the water chemistry changed, corrosion accelerate in the future. He therefore suggested that real time monitoring of the thickness of the drywell at the thinnest spots should be considered. *Id.*

Even the members of the ACRS recognized the dangers of interior corrosion. For example, Dr. Shack commented at the January 18, 2007 meeting:

> Well, the surprise for me today was the notion that we have water in the imbedded region. That concerns me a little bit. I mean, I fully agree with the argument that it's a fairly benign environment and the corrosion rates are low, and in a containment that didn't have the already substantial corrosion that this one does, I would sort of agree that its probably not a problem. But this is a containment where there isn't a whole lot of margin, and you know, the estimate was you had 41 mils lost and that was less than one mil per year. Well, I do the arithmetic and I get more like two mils per year.

ACRS Meeting 1/18/07 at 372.

The 41 mils Dr. Shack is referring to came from an effort to measure corrosion in Bay 5 below both the exterior sandbed floor and the interior floor. The UT measurements at this location showed 41 mils of wall loss. AmerGen Dec 3 letter at 20. In this region the interior was wet from at least 1994 onwards. However, it is unclear whether the exterior was wet. Bay 5 was the bay with the least corrosion. Therefore, assuming negligible exterior corrosion, and that the wall loss occurred between 1994 and 2006, the average interior corrosion rate would be around 2 mils per year. This corrosion rate will also apply to the interior of the sand bed region below the 10 feet 3 inches level, which is the height of the interior floor. At minimum, this should be added to estimates of corrosion rate from the exterior to derive a combined corrosion rate.

In addition, it is possible that water chemistry could change in the future and accelerate the interior corrosion rate. Indeed AmerGen's own consultant has stated that AmerGen's assessment of negligible corrosion on the interior relies in part on the high pH of the concrete pore water in contact with the drywell shell, but at times the pH of that water drops significantly due to control rod drive maintenance. E-mail from Schlaseman to Ray, dated November 2, 2006, OCLR15433-34. Indeed, the consultant stated "the protective pH cannot be assumed to exist during outages anywhere below the 10'3" level in the DW [drywell]." *Id.* at 2. Another potential source of water to the interior of the drywell shell is the containment spray. Recently, on July 17, 2007, Citizens understand that the containment spray was used during an unplanned outage. It is currently unclear what quantities of water were released or whether that water contained impurities that could accelerate interior corrosion. To date, AmerGen's assessment of corrosion from the interior has failed to take account of the pH variation on the interior and the potential for the core spray to add significant amounts of water. Thus, there is inadequate assurance that the past low rate will be maintained in the future.

ARGUMENT

I. AmerGen Must Prove Its UT Monitoring Frequency Is Adequate

In an operating license proceeding, the licensee generally bears the ultimate burden of proof. *Metropolitan Edison Co. (Three Mile Island Nuclear Station, Unit 1)*, ALAB-697, 16 NRC 1265, 1271 (1982), citing 10 C.F.R. § 2.325. Here, a renewed license may only be issued if AmerGen demonstrates that its aging management program for the drywell shell provides reasonable assurance that the Current Licensing Basis ("CLB") will be maintained. 10 C.F.R. § 54.29. The Commission confirmed in *Florida Power & Light Co. (Turkey Point Nuclear Generating Plant, Units 3 and 4)*, 54 NRC 3, 10 (2001) that because corrosion and other effects become more severe over the extended license period, an applicant for license renewal must demonstrate that its programs are adequate to manage the effects of aging, including sufficient inspections and testing:

> Part 54 requires renewal applicants to demonstrate how their programs will be effective in managing the effects of aging during the proposed period of extended operation. . . . Applicants must identify any additional actions, i.e., maintenance, replacement of parts, etc., that will need to be taken to manage adequately the detrimental effects of aging. Adverse aging effects generally are gradual and thus can be detected by programs that *ensure sufficient inspections and testing*. [60 Fed. Reg. 22,462 (May 8, 1995)] at 22,475.

54 N.R.C. at 7 (emphasis added). Here, the admitted contention to be litigated is "AmerGen's scheduled UT monitoring frequency in the sand bed region is insufficient to maintain an adequate safety margin." LBP-06-22 at 9. One of the Staff's proposed license conditions is that AmerGen must conduct "full scope inspections" of the sand bed region of the drywell shell, including UT monitoring from inside and outside, once every other refueling outage (i.e. once every four years). SER at 1-18, A-32-33.

In its ruling on July 11, 2007, the Board clarified that AmerGen bears the burden of showing that the drywell shell will not violate the minimum required thickness at 95%

confidence. Board Memorandum dated July 11, 2007 at 3-4. Thus, to prevail AmerGen must now show first that it currently has margin with 95% confidence and second that it can maintain that margin with the proposed UT testing frequency of once every four years. As a corollary, Citizens may prevail either by showing that at 5% confidence the drywell thickness is already below the established acceptance criteria, or that the thickness could go beyond any established margin within four years.

II. There Is No Reasonable Assurance That The Drywell Shell Would Meet The Current Licensing Basis On Renewal

The evidence shows that there is no reasonable assurance that the CLB will be maintained. In fact, it is highly probable that the shell does not currently meet the established acceptance criterion for local deterioration of square areas bigger than 2 inches in diameter. In addition, there is a greater than a 5% chance that the shell fails acceptance criteria for mean thickness and thickness of local areas smaller than 2 inches in diameter. Furthermore, because of the high uncertainties, AmerGen cannot demonstrate the drywell shell meets even the most lenient acceptance criteria ever applied for deteriorated local areas larger than 2 inches in diameter at 95% confidence.

Because AmerGen has made no proposal to repair the deteriorated areas, the current state of the drywell shell is the best state the drywell shell could be in during any period of extended operation. Thus, because the shell probably already fails some established criteria and there is a reasonable possibility that it could be failing others, AmerGen cannot maintain the CLB during license renewal.

A. Established Acceptance Criteria

The Board has ruled that established, valid practices are generally those accepted by the NRC Staff in approving AmerGen's application. Board Memorandum dated July 11, 2007 at

Note 4. Citizens generally may not challenge such practices, but may point out deviations from such practices. Board Memorandum dated June 17, 2007 at 8. The acceptance criteria for mean and local area less than two inches in diameter are not in dispute, but considerable uncertainty remains about the local area acceptance criterion. In the SER, NRC Staff accepted the explanation that square contiguous local areas thinner than 0.736 had to be both thicker than 0.536 inches and smaller than one square foot in extent. SER at 4-56, 4-58. However, subsequently AmerGen questioned the validity of this approach and revised the acceptance criterion to be more stringent, requiring one foot by one foot areas to be thicker than 0.636 inches. Most recently, AmerGen used an approach to acceptance that was less stringent than that described in the SER, without explaining why it had done so.

Citizens assert that the Board should find that the best statement of the local area acceptance criterion applying to square areas of local corrosion is contained in Revision 1 of Calculation C-1302-187-5320-024, because that version was rewritten to address the deficiencies pointed out by AmerGen. Although the Board has generally found that the SER will provide the established valid criteria, it appears that AmerGen did not share its concerns about the validity of calculation C-1302-187-5320-024 revision 0 with NRC Staff. AmerGen should not be permitted to gain any advantage from its lack of candor to the Staff. Having decided that the approach that Staff endorsed was invalid, AmerGen can hardly now claim that the approach was valid and therefore not litigable in this proceeding. Therefore, this Board should find that the established acceptance criterion for square local areas thinner than 0.736 inches on average is that they must be smaller than one contiguous square foot and thicker than 0.636 inches on average.

Finally, Staff and AmerGen appear to have given little consideration to acceptance of corroded areas that are not square. Citizens assert that the groove shaped thin areas found on

Bays 1 and 19 reduce the buckling capacity more than squares of similar area. Therefore, a more stringent local area acceptance criterion must be applied to such areas. There is no established acceptance criterion for such areas and in the absence of any modeling it is impossible to quantify how much more stringent the criteria should be. However, given the sizes of the local areas assessed, this issue should not be important unless the Board decides that the established local area criterion allows square areas thinner than 0.736 inches to be up to nine square feet in extent.

B. AmerGen Probably Violates The Appropriate Local Area Acceptance Criterion

AmerGen's latest assessment is that in Bay 1 there is an area 9 square feet in extent that has average thickness of 0.695 inches. This area is nine times larger than is permitted by the established acceptance criterion for square areas. Dr. Hausler estimates that the areas below 0.736 inches in Bays 1, 13 and 19 are larger than 3 square feet, 5 square feet, and 3 square feet respectively. Leaving aside the issue that these areas are not square and therefore should have a more stringent criterion applied, they easily violate the established acceptance criterion for square local areas. In addition, in Bay 13, it is likely that there is an area that is larger than one square foot of thickness 0.636 inches. This violates the version of the local area acceptance criterion that Citizens assert the Board should apply.

C. AmerGen Cannot Meet The Established Acceptance Criteria With 95% Confidence

The established acceptance criterion for the mean thickness of the drywell shell is 0.736 inches. The external measurements show that Bay 15 has a mean thickness of greater than 0.731 inches with 95% confidence. Thus, there is a greater than 5% chance that the mean thickness of Bay 15 violates the established acceptance criterion. The very small area acceptance criterion is

0.49 inches. The external data in zone 3 of Bay 1 shows that the mean thickness there is greater than 0.45 inches with 95% confidence. Thus, there is a greater than 5% chance that the thinnest small area in zone 3 of Bay 1 is thinner than 0.49 inches.

With regard to the local area acceptance criterion, the uncertainties are hard to quantify because there are very few points and each point itself has some uncertainty attached. However, Dr. Hausler has estimated that the areas thinner than 0.736 inches in Bays 1, 13, and 19 could reasonably be larger than nine square feet. Thus, Citizens assert that at there is more than a 5% chance that these Bays fail even the most expansive version of the local area acceptance criterion, which in any event Citizens assert is not applicable to the groove-shaped areas found in Bays 1 and 19.

Moreover, reference to Figure 1-5 of Calculation C-1302-187-5320-024 Rev. 2 shows that if points 1 and 6 in Bay 1 were around 0.01 inches thinner, the Bay would violate even the latest less stringent criterion applied by AmerGen. Because the uncertainty in the thickness of each point is around 0.04 inches, this shows that there is a greater than 5% chance that Bay 1 fails that latest version of local area acceptance criterion applied. Moreover, upper range estimates for the contiguous areas thinner than 0.736 inches in Bays 1, 13, 15 and 19 are greater than nine square feet. Thus, AmerGen cannot show that these Bays meet even the least stringent the local area acceptance criterion with 95% confidence.

III. Minimum Monitoring Frequency Is Less Than Once Per Year

AmerGen's own assumptions show that the proposed monitoring frequency of once every four years is inadequate. AmerGen has established that to determine the UT monitoring interval based on the mean thickness acceptance criterion, the lower 95% confidence limit of the mean thickness of the thinnest Bay should be projected forwards until it reaches the acceptance criterion. However, because no statistically significant slope has been observed since 1992, Amergen found that the regression method used to achieve this goal before 1992 ceased to be applicable. Since 1992, AmerGen has used various other approaches to estimate future corrosion, none of which are mentioned in the SER. For example, AmerGen's expert, Mr. Gordon, estimated that a total of 0.042 inches of metal could be lost every refueling outage, at a rate of 0.39 inches per year, even if no water penetrated into the sandbed region during operation. Gordon Aff. at ¶ 18.

The goals of the established method can be met by combining the various approaches used by AmerGen. For example, the estimate for the minimum margin derived from the mean of the 49 point grids is 0.064 inches, without applying any uncertainty. Using an uncertainty of plus or minus 0.03 inches, as suggested by AmerGen, shows that the margin is 0.034 inches at 95% confidence. Then, using Mr. Gordon's technique to project forwards, AmerGen would have to monitor slightly less than one year after a refueling outage. If it then found minimal corrosion, the plant could then operate to the next refueling cycle. Citizens assert that even this approach is not sufficiently conservative because it does not take account of the possibility of water leaking into the sandbed region during operation, interior corrosion accelerating, or the much narrower margins shown by the external measurements. However, even if this Board finds that AmerGen has established 0.034 inches of margin at 95% confidence, has eliminated all water sources except those that could occur during refueling, and has shown that external corrosion will remain insignificant, the minimum monitoring frequency would be effectively once per year in order to maintain reasonable assurance that the drywell is meeting the CLB.

CONCLUSION

For the foregoing reasons, Citizens' position is that the record shows that Oyster Creek cannot be relicensed because the drywell shell has suffered from age-related degradation to the point that there is no reasonable assurance that the drywell shell can meet the current licensing basis. Furthermore, even if the Board accepts AmerGen's past arguments about the available margin, the uncertainty, the potential water sources, and the limits on the future corrosion rate, it should decide that the required UT monitoring frequency is effectively once per year.

Respectfully submitted

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