

**UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION  
ATOMIC SAFETY AND LICENSING BOARD**

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

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In the Matter of:	)	September 14, 2007
	)	
AmerGen Energy Company, LLC	)	
	)	Docket No. 50-219
(License Renewal for Oyster Creek Nuclear	)	
Generating Station)	)	
	)	
	)	

**AMERGEN'S PRE-FILED SURREBUTTAL TESTIMONY  
PART 3  
AVAILABLE MARGIN**

**I. WITNESS BACKGROUND**

Q. 1: Please provide the Licensing Board with your names and current titles. The Board knows that a description of your current responsibilities, background and professional experience was provided in Parts 1, 2 and 3 of AmerGen's Pre-Filed Direct Testimony on July 20, 2007, so there is no need for you to repeat that information here.

A. 1: (FWP) My name is Frederick W. Polaski. I am the Manager of License Renewal for Exelon.

(DGH) My name is Dr. David Gary Harlow. I am a Professor in the Mechanical Engineering and Mechanics Department at Lehigh University located in Bethlehem, Pennsylvania.

(JA) My name is Julien Abramovici. I am a consultant with Enercon Services, Inc. located in Mt. Arlington, New Jersey, but formerly worked for the Oyster Creek Nuclear Generating Station (“OCNGS”).

(PT) My name is Peter Tamburro. I am a Senior Mechanical Engineer in the OCNGS Engineering Department.

Q. 2: Please summarize the purpose of your testimony and overall conclusions.

A. 2: (All) The purpose of this SurRebuttal Testimony is to respond to the information provided in Citizens’ Rebuttal Statement Regarding Relicensing of Oyster Creek Nuclear Generating Station (“Citizens’ Rebuttal Statement”) and in the Pre-Filed Rebuttal Testimony of Dr. Rudolf H. Hausler, regarding the topic of available margin. Our overall conclusions, as explained below, are that Dr. Hausler and Citizens have presented no new information that would call into question our previous testimony on available margin.

Q. 3: In their Rebuttal Statement, on page 3, Citizens appear to argue that “reasonable assurance” requires 95% confidence. What is your response to this argument?

A. 3: (All) Citizens have never clearly explained what they mean by the term “95% confidence.” In a statistical analysis of UT thickness data, this term could describe one of two distinct concepts. It is possible to calculate a lower and upper 95% confidence limit about the *mean*, *i.e.*, sample average, or a lower and upper 95% confidence limit for the *data*. The significant difference between these two

confidence limits is shown in Applicant's Exhibit 43, which displays the Bay 19 internal UT grid measurements from 1992.

In that Exhibit, the short dashed (blue) vertical lines indicate the  $\pm 3\sigma$ ,  $\pm 2\sigma$ , and  $\pm 1\sigma$  values for measurements which have an average of 0.800" and a standard deviation of about 0.059". The long dashed (red) lines are the 95% confidence limits computed for the mean ( $\mu$ ) using the student t distribution with 44 degrees of freedom. The difference between the actual measurements and the confidence limits for the mean ( $\mu$ ) are striking. This is because the distribution for the measurements (*i.e.*, the 49 points) and the distribution for the mean ( $\mu$ ) are actually different. The distribution for the measurements is "normal" whereas the distribution for the mean ( $\mu$ ) is the student t distribution. Consequently, describing the measurements and the confidence interval for the mean ( $\mu$ ) must be done precisely and carefully.

Q. 4: How do Citizens use the term "95% confidence"?

A. 4: (All) Citizens' Statement and Dr. Hausler's testimony suggests that Citizens are interested in the 95% confidence limit *for the data*. Examples of this argument include:

- Citizens' Exh. 39, page 6 ("the 95% confidence limits embrace 95% of all data . . . defined as the mean of the data +/- approximately two (2) standard deviations");
- Citizens' Rebuttal Statement, page 11 ("AmerGen bears the burden of evaluating the current margins using the estimated *lower* 95% confidence limits for the various required parameters...");

- Citizens' Rebuttal Statement, page 14 ("the external data do not comply with the acceptance criteria at the 95% confidence level if the *thinnest* measurements obtained are used.");
- Citizens' Rebuttal Statement, page 16 ("if the *lower 95%* confidence limit was compared to the acceptance criterion");
- Citizens' Rebuttal Statement, page 18 ("the lower 95% confidence limit for the thickness of certain parts of the drywell shell is below [the pressure] criterion" of 0.490");
- Citizens' Exh. 38, page 6 ("structures do not fail by averages....[they] fail where the deepest pit is located").

Q. 5: Is it appropriate to analyze UT measurement data in terms of a 95% confidence level for the data?

A. 5: (All) No. Citizens' argument that the *internal* UT data should be analyzed using a 95% confidence limit for the data is particularly absurd. This would result in an analysis that focuses on the thinnest UT data points from among the 49 internal UT measurements in each grid, effectively ignoring 48 other known data points from the same 6" x 6" grid. This approach has no scientific basis. As Dr. Harlow stated in his Rebuttal testimony (Part 3, A.22):

AmerGen is primarily interested in the data within a grid which are between  $\pm$  two sigma about the sample average because this region accounts for 95% of normally distributed data. If there is relatively little scatter in these data, which has been demonstrated elsewhere, so that they are also reasonably close to the sample average, then the sample *average* is the quantity that should be used in comparison to the general buckling criterion. The 5% of the data outside  $\pm$  two sigma about the sample average pose no threat to buckling; however, these data are considered relative to the pressure criterion.

Q. 6: But AmerGen uses only the average of the 49 points from an internal grid. Why doesn't AmerGen evaluate the internal UT grid data using a 95% confidence interval about the mean?

A. 6: (PT, JA, DGH) AmerGen *does evaluate* the 95% confidence interval of the sample average for each internal grid after each inspection to understand the variability of each calculated average. (Applicant's Exh. 20 (41 Calc)). The variability of the sample average demonstrates, however, that the calculated averages over time are well behaved and repeatable. There is an equal probability that the true mean is either greater or less than the calculated sample average within the 95% confidence interval because the internal grid data are normally distributed. Based on this calculation, and based on the Grand Standard Error calculation discussed in AmerGen's Rebuttal Testimony, A.17, it is concluded, therefore, that the average is the best representation of the thickness over the inspected area. Therefore, AmerGen uses the sample average to identify the available margin, without adjustment to include the lower 95% confidence limit.

Q. 7: Citizens allege that AmerGen is being inconsistent in that it evaluated future corrosion rates using a 95% confidence lower limit about the mean, but does not do that to evaluate the mean to identify the available margin. What is your response?

A. 7: (PT, JA, FWP) As described above in A.6, there is no discrepancy because this is a conservative approach.

Q. 8: Citizens argue that AmerGen has "erroneously claimed it has actually calculated the minimum margins based on the lower 95% confidence limit." (Citizens'

Rebuttal Statement, page 4 (citing Applicant's Exh. 3 at 6-15 to 6-16; Applicant's Exh. 12 at 13-14.)). What is your response?

A. 8: (PT, FWP) Citizens have identified an error in AmerGen's documents. The cited margins are not calculated with 95% confidence. Citizens' first citation is to Applicant's Exhibit 3, pages 6-15 and 6-16, which are two tables from a submittal to the Advisory Committee on Reactor Safeguards ("ACRS"), with titles that use the term "95% Confidence Level Average Thickness." These titles are based on the second document which Citizens cite (Applicant's Exhibit 12 (pages 13-14)), the LRA Supplement submitted to the NRC on December 3, 2006, which states, for example, that "Analysis of the 2006 UT data, at the 19 grid locations, indicates that the minimum 95% confidence level mean thickness in any bay is 0.807" (Bay #19). This is compared to the 95% confidence level minimum measured mean thickness in bay #19 of 0.806 and 0.800" measured in 1994 and 1992, respectively."

The statement is not correct as written. The values in the tables in Applicant's Exhibit 3, pages 6-15 and 6-16 are simply the calculated averages for each grid. This table does not report the upper or lower 95% confidence limits or the 95% confidence interval. The statement is correct if "95% confidence level" is deleted in both locations. As discussed in A.6, above, the 95% confidence lower limit was evaluated for the sample averages, so this only a cosmetic error.

Q. 9: Citizens state that "AmerGen argues that the external measurements are not accurate enough to allow margins to be determined, but AmerGen has also maintained that it can use those same measurements to determine whether the

shell complies with the acceptance criteria. This position is unsustainable.”

(Citizens’ Rebuttal Statement, page 10). Do you agree?

A. 9: (PT, FWP, JA) No. First, AmerGen does *not* claim that the “external measurements are not accurate enough.” The measurements are accurate over the very small area covered by the UT probe (less than 3/8” in diameter). Buckling, however, is a phenomenon that is implicated here when metal is lost over a significant area. The volumetric nature of the local buckling criterion is based on this principle: “[t]he entire [124.8 cubic inch] tray, on average, needs to corrode away for that loss of metal to be significant from a buckling perspective and to exceed the local buckling criterion.” (AmerGen Dir. Part 3, A.15). Thus any calculation of margin to the local buckling criterion must be expressed in cubic inches, not in inches, and there simply are not sufficient external UT data points to calculate such a volumetric margin.

As we explained in our Direct Testimony, A.29 and A.30, in the “24 Calc.” external single point UT data are averaged as a conservative method of “demonstrating compliance with the general buckling acceptance criterion.” It is simply not realistic to average these data for the purpose of quantifying the actual estimated available margin.

As explained in our direct testimony, in the 24 Calc. AmerGen uses conservative assumptions to demonstrate compliance with the ASME Code. These assumptions would not be appropriate for quantifying the actual available margin. “In other words, [the 24 Calc.] confirms that you meet the applicable ASME Code, but not by how much.” (AmerGen Dir. Part 3, A.29).

Q. 10: Please respond to Dr. Hausler's statement that, "[a] number of AmerGen evaluations of 'representative thickness' admit plainly that the internal grid data in certain Bays is not representative of the true mean thickness of the Bay because of the pattern of corrosion." (Citizens' Rebuttal Statement, page 12, citing Citizens' Exh. 45 at 3 (discussing this issue in Bay 1); Exh. 46 at OCLR29744-5 (discussing Bays 1, 3, 7, and 15).

A. 10: (PT, FWP) Dr. Hausler is taking these documents out of context. Citizens' Exhibit 45 and 46 are documents AmerGen used to develop inputs to a future containment analysis. This analysis is a commitment AmerGen made as documented in Exhibit 10, page 11 of 13 (Commitment #18). The inputs for thickness were selected to establish a thickness profile for the sand bed that was representative but appropriately conservative in representing the current thickness conditions. In general, internal grid thickness measurements were used. When appropriate, more conservative thicknesses were used such as adjacent bay thickness or UT data from the trenches. In no cases were external UT measurements used since they are not representative of the average thickness in the bays since they were biased as the thinnest points in the bay.

Q. 11: Citizens allege that Applicant's Exh. 16, pages 34 and 92-93 "shows a 3 foot by 3 foot area that is less than 0.736 inches in average thickness." (Citizens' Rebuttal Statement, page 16). Is this correct?

A. 11: (PT, JA, FWP) No. Dr. Hausler's statement is incorrect and misleading. Revision 2 of the 24 Calc. (Applicant's Exh. 16 at 92-93) concludes that there is a 3' by 3' area in Bay 19 that is "*at least 0.720*" thick." This is conservatively

based on only *two of the lowest* external points in this 3' by 3' area. The calculation does *not* conclude that this area is on average 0.720" thick. First, the external point measurements are taken at locations that "are biased thin compared to their surroundings," as stated in AmerGen Dir. Part 3, A.42. So even without more information, we know that the area in question is much thicker. Second, there is a third external point within the 3' by 3' area, between the two thinner points, that measured 0.736". Third, internal grids 19B and 19C coincide with the same 3' by 3' area and they have average thicknesses of 0.848" and 0.824", respectively. These data conclusively demonstrate that the area in question is thicker.

Finally, contrary to Citizens' implication, the 3' by 3' area is compared to the local buckling criterion, not the 0.736" general buckling criterion, so even if the area was, on average, 0.720" thick, it would not be significant from a buckling perspective.

Q. 12: In the previous Answer, you stated that the internal grids 19B and 19C coincide with specific external areas. How do you know that?

A. 12: (PT, FWP) We first relied upon Applicant's Exhibit 28, which generally shows the overlap of the internal grids and trench UT locations with the external data points. That Exhibit, however, is not to scale and shows all ten bays on a single sheet of paper. We then prepared similar maps for the bays identified as a concern by Citizens (Bays 1, 13, 17, and 19). Those maps, which are an excellent representation of the location of the UT measurement locations and are essentially to scale, are provided as Applicant's Exhibit 44.

Q. 13: In Dr. Hausler's Rebuttal Testimony, A.8 (referencing Citizens' Exh. 38), he states that he "refined [his] calculation of the sample standard deviation." How has Dr. Hausler "refined his calculations?"

A. 13: (DGH) It is unclear exactly how Dr. Hausler has "refined" his calculation. In footnote 4 of Exhibit 38, he appears to provide more detail: "[t]he standard deviations derived from repeat measurements shown in Table 1 differ slightly from those previously presented, because I have used a more rigorous calculation method than previously. [sic]" This statement makes very little sense, unless Dr. Hausler is correcting mathematical errors. The standard deviation for a set of measurements is defined as follows:

$$s = \sqrt{\sum_{k=1}^n (x_k - \bar{x})^2 / (n-1)}.$$

All standard software and all calculators use this as the definition for standard deviation. Spreadsheets have its computation built into the computation library so that its computation is simple. I cannot imagine what Dr. Hausler means by "a more rigorous calculation method than previously" used.

Q. 14: In Dr. Hausler's Rebuttal Testimony, A.11, he states: "the 2006 measurements showed that the shell is now approximately 2 to 3% thinner overall than measured in 1992." What is the basis for this statement?

A. 14: (PT, JA, FWP) We could not identify any basis for Dr. Hausler's statement other than the statement "[m]y analysis of the data."

Q. 15: Do you agree with Dr. Hausler's statement?

A. 15: (PT, JA, FWP) No. Visual observations and the results of the UT grid readings over time demonstrate that corrosion has been arrested.

Q. 16: In Dr. Hausler's Rebuttal Testimony, A.14, Citizens quote an OCNGS document from 1993, attached as Citizens' Exhibit 44 (on page 2) as follows: "I could not determine visually which of the thin spots are the thinnest." Does this quote accurately reflect this document?

A. 16: (PT, FWP) No, the quote is egregiously taken out of context. The full quotation, with italics for emphasis, is:

In addition to the dimples, there are spots that appear to be thinner than the general area. The dimples in the surface occur in these thin spots to the same degree as in the rest of the corroded portion of the shell. The "thin" spots are typically a foot to 18" in diameter and probably comprise about 20% of the corroded area. In general, except in Bay 13, the thin spots are not readily apparent. Therefore, a more detailed characterization is difficult for the other bays . . . . I could not determine visually which of the thin spots are the thinnest. However, due to the small differences between the "thick" areas and the "thin" areas, and the amount of metal removed in preparation for the UT measurements, *it is highly likely that the thickness readings reported in the UT measurements encompass the thinnest spots in the shell.*

Thus, Citizens' Exhibit does not support their conclusion. Instead, it supports the opposite conclusion, that the external points are biased thin.

Q. 17: In Citizens' Rebuttal, A.16, Dr. Hausler discusses the alleged "overgrinding" of metal at the external UT locations. In this discussion, he acknowledges that the curvature of the prepared area created an air gap on the exterior shell that may have created a bias in the 1992 UT data. He then argues that, "If this bias indeed

exists, the only explanation offered assumes that the measured points were not overground.” What is your response to this argument?

A. 17: (PT) We have previously testified that “additional good metal” may have been removed at some of the external data points, leading to some additional conservatism in AmerGen’s calculations. (AmerGen Dir. at A.42). Dr. Hausler’s statement assumes that the metal removal process would have eliminated any curvature in the prepared surface, thus eliminating the bias. This is wrong. Ultimately, the question of whether these areas were “overground” or not is significantly less important than the fact that they are biased thin when compared to the rest of the shell. So we believe that Dr. Hausler’s argument is a red herring.

Q. 18: In Dr. Hausler’s Rebuttal Testimony, A.19, he claims that it was “unlikely” that the corrosion occurred between 1986 and 1992 “because Bays 5 & 17 are the least corroded Bays and the estimated corrosion rate in Bay 17 was not significant or was very small (no corrosion rate was even estimated for Bay 5).” He does this in an effort to show that significant corrosion is occurring or can occur on the interior embedded surface of the drywell shell in the sand bed region. Do you agree?

A. 18: (PT, FWP) No. First, with respect to Bay 17, this trench was selected because it was representative of significant external corrosion, so Dr. Hausler is simply wrong. Data from bay 17 show significant external metal loss between 1986 and 1992. For example, as shown in Applicant’s Exhibit 3, page 6-15, the average measurement in grid #17D was 0.922” in February 1987 and 0.817” during the

1992 refueling outage; the average thickness in grid #17A bottom was 0.999” in December 1986 and 0.941” during the 1992 refueling outage.

Second, with respect to Bay 5, Dr. Hausler’s speculation of significant interior corrosion is also contradicted by all of the available evidence. We know from Barry Gordon’s Rebuttal Testimony that any corrosion from the interior would be expected to be “vanishingly small and of no engineering concern.” (AmerGen Reb. Part 6, A.10). We also know from visual inspections of Bay 5 following sand removal that some exterior corrosion was experienced prior to the 1992 refueling outage. This is documented in Applicant’s Exhibit 27, page 27 (the physical condition of bay 5 “was very similar to [the corrosion in] bay 3”). We know that the interior of the trench was observed visually during the 2006 refueling outage, and the surface was smooth with only minor surface corrosion. And we know from AmerGen’s Direct and Rebuttal Testimony, Part 5, that the epoxy coating is intact with no signs of deterioration, so we know that corrosion from the exterior has been arrested since 1992.

Q. 19: In Citizens’ Exhibit 38, page 3, Dr. Hausler states that “[d]uplicate & triplicate measurements were made externally in some bays” in 2006. Is this correct?

A. 19: (All) No. In some cases two and three UT thickness values were recorded at some external locations. However, the multiple measurements were *not* taken at the same exact points. They were taken about ¼-inch around the measurement points, but within the prepared area. This is documented, for example, in the 24 Calc., Applicant’s Exhibit 16, on pages 171 and 176, which are the data sheets for

bays 5 and 15. In all cases the 24 Calc. used the thinnest value recorded for each location.

But Dr. Hausler then uses these “duplicate and triplicate” measurements to generate an uncertainty value for the external data: “It was then possible to estimate the measuring error form [sic] these repeated measurements.” Dr. Hausler’s assumption that the differences in these values can be attributed to the “error in measurement only” is wrong because these data are not from the exact same points. So Dr. Hausler’s calculations are statistically improper.

Q. 20: Do you have anything else to add?

A. 20: (PT, JA) Yes. In our Rebuttal Testimony, A.54, we referenced ASME Code Case N513, NRC Bulletin 87-01, “Thinning of Pipe Wall in Nuclear Power Plants,” NRC Generic Letter 89-08, “Erosion/Corrosion-Induced Pipe Wall Thinning” ASME Code Section XI, and API 653 in our answer to the Board’s question on the statistical analysis of UT thickness measurements. Relevant portions of these documents are attached as Applicant’s Exhibits 45 through 49.

Q. 21: Does this conclude your testimony?

A. 21: (All) Yes.

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

  
\_\_\_\_\_  
Frederick W. Polaski

  
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Date

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Dr. David Gary Harlow

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Date

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Julien Abramovici

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Date

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Peter Tamburro

\_\_\_\_\_  
Date

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

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Frederick W. Polaski

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Date

*David Gary Harlow*  
\_\_\_\_\_  
Dr. David Gary Harlow

*9/13/07*  
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Julien Abramovici

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Peter Tamburro

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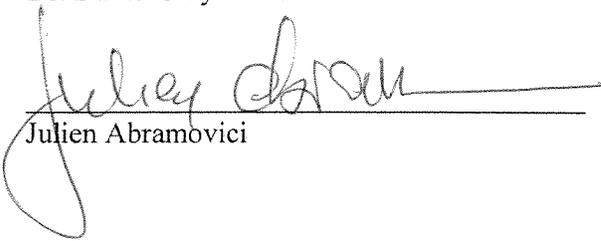
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Dr. David Gary Harlow

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Julien Abramovici

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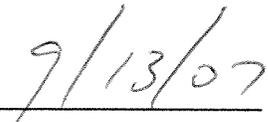
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