

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

Before Administrative Judges:

**E. Roy Hawkens, Chair
Dr. Paul B. Abramson
Dr. Anthony J. Baratta**

)	
In the Matter of:)	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 6
FUTURE CORROSION**

I. WITNESS BACKGROUND

Q. 1: Please state 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 6 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: (BG) My name is Barry Gordon. I am an Associate with Structural Integrity Associates, Inc. ("SIA"), located in San José, California.

(EWH) My name is Edwin Hosterman, and I am a Senior Staff Engineer in the Corporate Engineering Programs Group in Exelon's Headquarters in Kennett Square, Pennsylvania.

Q. 2: Please summarize the purpose of this SurRebuttal Testimony and your 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 potential for future corrosion of the exterior drywell shell in the sand bed region. Our overall conclusions are that Dr. Hausler's Testimony, once again, is based on inapplicable analyses and mistaken assumptions, and that Dr. Hausler's expertise appears to be fundamentally inapplicable to the actual conditions of the drywell shell in the sand bed region.

II. POTENTIAL CORROSION RATE

Q. 3: Dr. Hausler has opined that sand bed region "corrosion could be as rapid as it was in the presence of the sand." (Citizens' Exh. 39, page 17). Do you agree with this statement?

A. 3: (BMG) No. There are three main reasons why this would not be the case. First, the drywell corrosion mitigation steps as described throughout AmerGen's testimony, such as applying a strippable coating to the reactor cavity liner, removing the sand, clearing the drains, and installing a three-layer epoxy coating system on the exterior drywell shell surface, will prevent this high rate of corrosion.

Second, as described in my Rebuttal Testimony, A.14, due to the above mitigation steps, the expected time of wetness, T_w , on the drywell shell has been dramatically

reduced to the point where the coated drywell exterior could be dry all of the time. If there is no moisture, there is no corrosion.

Third, as described in my Rebuttal Testimony, A.7, the rate of general corrosion decreases with time due to the formation of corrosion products/films on the metal surface. Therefore, any subsequent corrosion on a freshly-wetted, previously corroded surface would not corrode at the same rate as measured previously. General corrosion rates typically decrease with the square root of time.

Q. 4: With respect to potential corrosion from the interior, Dr. Hausler has testified that “[c]onsiderably higher short term [interior] corrosion rates have probably occurred. In the absence of any good information on this issue, I believe it would be prudent to allow for an interior corrosion rate that is a multiple of 0.002 inches per year, if new water is introduced into the interior floor by repairs to control rod drives, use of the containment spray, or other sources.” (Rebuttal Testimony, A.19). Is this realistic?

A. 4: (BMG) No, for the reasons provided in Part 6 of AmerGen’s Rebuttal Testimony, A.9 and A.10. “Any corrosion [in the interior embedded drywell surface] would be vanishingly small and of no engineering concern.” This is due to the high pH of any water in contact with the interior surface of the embedded drywell shell, the lack of measurable corrosion on the newly-exposed shell surface during the 2006 refueling outage, and the inerted air environment inside the drywell during operations.

Any new water introduced on to the concrete floor by “repairs to control rod drives, the use of containment spray, or other sources” will have its pH subsequently increased due to the high solubility of calcium hydroxide, $\text{Ca}(\text{OH})_2$, *i.e.*, the most soluble cement paste compound, from the concrete. This phenomenon is document in L.

Bertolini, et al., *Corrosion of Steel in Concrete – Prevention, Diagnosis, Repair*, Wiley-VCH, Weinheim, Germany, 2004, page 57. Relevant excerpts are attached as Applicant's Exhibit 60.

Q. 5: Apparently based on the interior corrosion rate of 0.002” per year postulated in Dr. Hausler's Testimony, A.19, Citizens' argue that, “[i]n the absence of any good information on this issue, it is prudent to allow for a corrosion rate of up to 10 mils per year after new water is introduced onto the interior floor by repairs to control rod drives, the use of containment spray, or other sources.” (Citizens' Rebuttal Statement, page 23) Do you agree with this statement?

A. 5: (BMG) There is absolutely no justification for multiplying this assumed general corrosion rate of 0.002” per year by a factor of five to derive an even a more dubious general corrosion rate of 0.010” per year. It is important to note that normal corrosion engineering practice is to conservatively double the general corrosion rate to provide extra margin, not to multiply the general corrosion rate by a factor of five.

The general corrosion rate of carbon steel embedded in clean concrete, *i.e.*, no chlorides or carbon dioxide, is negligible (<0. 000008” per year). This value is based on L. Bertolini, *et al.*, *Corrosion of Steel in Concrete – Prevention, Diagnosis, Repair*, Wiley-VCH, Weinheim, Germany, 2004, page 74. (Applicant's Exh. 60). Even in the presence of aggressive substances such as chlorides or carbon dioxide, which degrade the passive film formed on the carbon steel surface, at a high relative humidity (RH) of 80% and 90%, respectively, the general corrosion rate of steel is approximately only 0.0006” per year, as described in Applicant's Exhibit 60, page 74.

Thus, Citizens' postulated internal surface proposed corrosion rate is unreasonable and the added margin multiplier factor lacks any engineering basis.

Q. 6: Citizens state that the total (annual) corrosion rate could be 0.050" per year (Citizens' Rebuttal Statement, page 11). This is based on their estimate that "[f]uture corrosion rates after refueling outages are up to 0.01 inches per year from the interior and 0.39 inches per year from the exterior. The total corrosion rate could therefore be approximately 0.05 inches per year." Is this a reasonable estimate of the potential corrosion rate?

A. 6: (BMG) No. The highest historical general corrosion rate ever measured in the OCNGS sand bed region of 0.039" per year took place in a corrosion system consisting of water-saturated sand in direct contact with an uncoated carbon steel drywell. That corrosion system no longer exists, so the corrosion rate value is no longer valid. The corrosion system has changed as follows:

- The water-retaining and ion-containing sand has been removed
- The ingress of additional water has been mitigated
- The carbon steel drywell has been coated

Nevertheless, as I described in my Rebuttal testimony, A.15, even "if I assumed that the highest levels of corrosion ever experienced in the sand bed region could recur, the total potential corrosion rate," when accounting for the time of wetness ("T_w"), is only 0.007" over two years.

Citizens' estimate of the interior corrosion rate of 0.010" per year is unjustified, for the reasons described in A.5, above. Citizens also add 0.001" per year, for no apparent reason. Thus, there is no basis for a total corrosion rate of 0.50" per year.

Q. 7: Dr. Hausler cites the “Handbook of Chemistry and Physics” to counter AmerGen’s position that “corrosion product occupies from 7 to 10 times the volume of the iron from which it originates.” (Citizens’ Exh. 39, page 18). Please respond to Dr. Hausler’s statement.

A. 7: (BMG) In the information cited by Dr. Hausler from the “Handbook of Chemistry and Physics,” the relative densities of iron and its common corrosion products are based on theoretical values of pure oxides. In reality, oxides are not pure and usually occupy much larger volumes due to defects in the oxide/hydrate structure such as vacancies and voids.

III. AIR FLOW IN THE SAND BED REGION

Q. 8: Is Dr. Hausler correct when he says that “the exterior of the sandbed region . . . has very limited air exchange”? (Citizens’ Rebuttal Testimony, A22).

A. 8: (EWH) No. While the exterior of the sand bed region is not served by forced ventilation, air exchange will occur in the sand bed region in response to temperature changes in the drywell shell and the surrounding air. As explained in AmerGen’s SurRebuttal Testimony, Part 1, A.3, Applicant’s Exhibits 4 and 7 show that the drywell vents penetrate the concrete at the top of the sand bed region. The gaps between the vent headers and the concrete provide substantial area for air flow, as do many piping penetrations from the drywell. All of these openings combined with the air gap between the drywell liner and the concrete shield walls create a “chimney” which will tend to promote airflow in this area. In particular, as the drywell liner heats up following an outage, the resulting temperature differential between the drywell shell and the surrounding air will induce natural circulation air flow in the sand bed region.

Q. 9: Citizens have alleged that AmerGen’s testimony uses the incorrect equation to determine the evaporation rate of water from the drywell shell surface following an outage.

Specifically, Dr. Hausler states that because the air in the sand bed region is “totally stagnant,” the equation used “describes a steady state, while the rate of evaporation in the confined space of the sand bed area would have to be described by a transient equation.” (Citizens' Exh. 39, page 19). Is Dr. Hausler correct?

A. 9: (EWH) No. As I stated in my response above (A.8), the air in the sand bed region is not stagnant. Since air can, and does, flow through this area, the evaporation in this region would not have to be described by a transient equation.

Q. 10: In your direct testimony (A.19), how did you account for the potential low velocity of air across the shell surface?

A. 10: (EWH) I conservatively accounted for the low velocity of air across the shell by setting the wind velocity equal to zero. At this point, the evaporation is strictly governed by differences in saturation pressure between the water film assumed on the drywell exterior, and the air in the sand bed region.

Q. 11: Please explain why it is acceptable to use a velocity of zero in this equation, rather than using a different equation altogether.

A. 11: (EWH) Because air is free to be exchanged in the sand bed region, but the velocity is not known, setting the value equal to zero conservatively limits evaporation to differences in saturation pressure, which are temperature-driven. Because air is free to flow through the area, the air will not saturate and steady state equations will adequately describe evaporation in this area.

Q. 12: Do you agree with Dr. Hausler that, “[i]t is therefore likely that in the event of water leakage into the region, the air in the sandbed region would become fully saturated during the outage (transient phenomenon). It would then have very limited capacity to absorb

moisture as the temperature increased with plant start up.”? (Citizens’ Rebuttal Testimony, A22).

A. 12: (EWH) No. Once again, because air is free to circulate through this region, the air in the sandbed region will not become fully saturated, so Dr. Hausler is wrong.

Q. 13: Do you agree with Dr. Hausler that “[t]he ability of new air to reach the sand pocket has been reduced by the placement of tubes leading to polystyrene bottles in the sand bed drains. Thus, it is likely that any moisture on the exterior of the shell would evaporate slowly.”? (Citizens’ Rebuttal Testimony, A22).

A. 13: (EWH) No. As I stated in A.8, above, significant air flow area exists in the sand bed region, even with the drainage tubes installed in the sand bed drains.

IV. DR. HAUSLER’S EXPERTISE

Q. 14: Mr. Gordon, are you aware of any new information about Dr. Hausler’s expertise with regard to the potential corrosion rate in the OCNGS sand bed region?

A. 14: (BMG) Yes. Citizens submitted additional information about Dr. Hausler’s qualifications and the papers he has authored in their response to Amergen’s Motion in Limine of July 27. Dr. Hausler identified some articles that are attached as Applicant’s Exhibits 57, 58, and 59. I was not able to retrieve these documents in time to incorporate any comments on them into AmerGen’s Rebuttal Testimony. I have now reviewed these papers and the topics discussed in them confirm that Dr. Hausler’s expertise is primarily in oil field applications that have very little in common with the OCNGS sand bed region.

Q. 15: Do you have anything else to add?

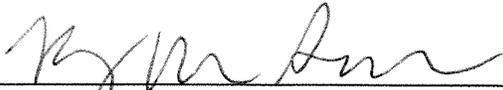
A. 15: (BMG) Yes. In my Rebuttal Testimony, A.10, I compared the chemistry sample results of water from the drywell shell interior to the guidelines in NRC Generic Aging Lessons

Learned (GALL) Report (Vol. 2, Rev. 1, at II A.1 through 5). Relevant portions of the GALL Report are attached as Applicant's Exhibit 61.

Q. 16: Does this conclude your testimony?

A. 16: (All) Yes.

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



Barry Gordon

9/12/07
Date

Edwin Hosterman

Date

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

Barry Gordon

Date



Edwin Hosterman

9-12-07

Date