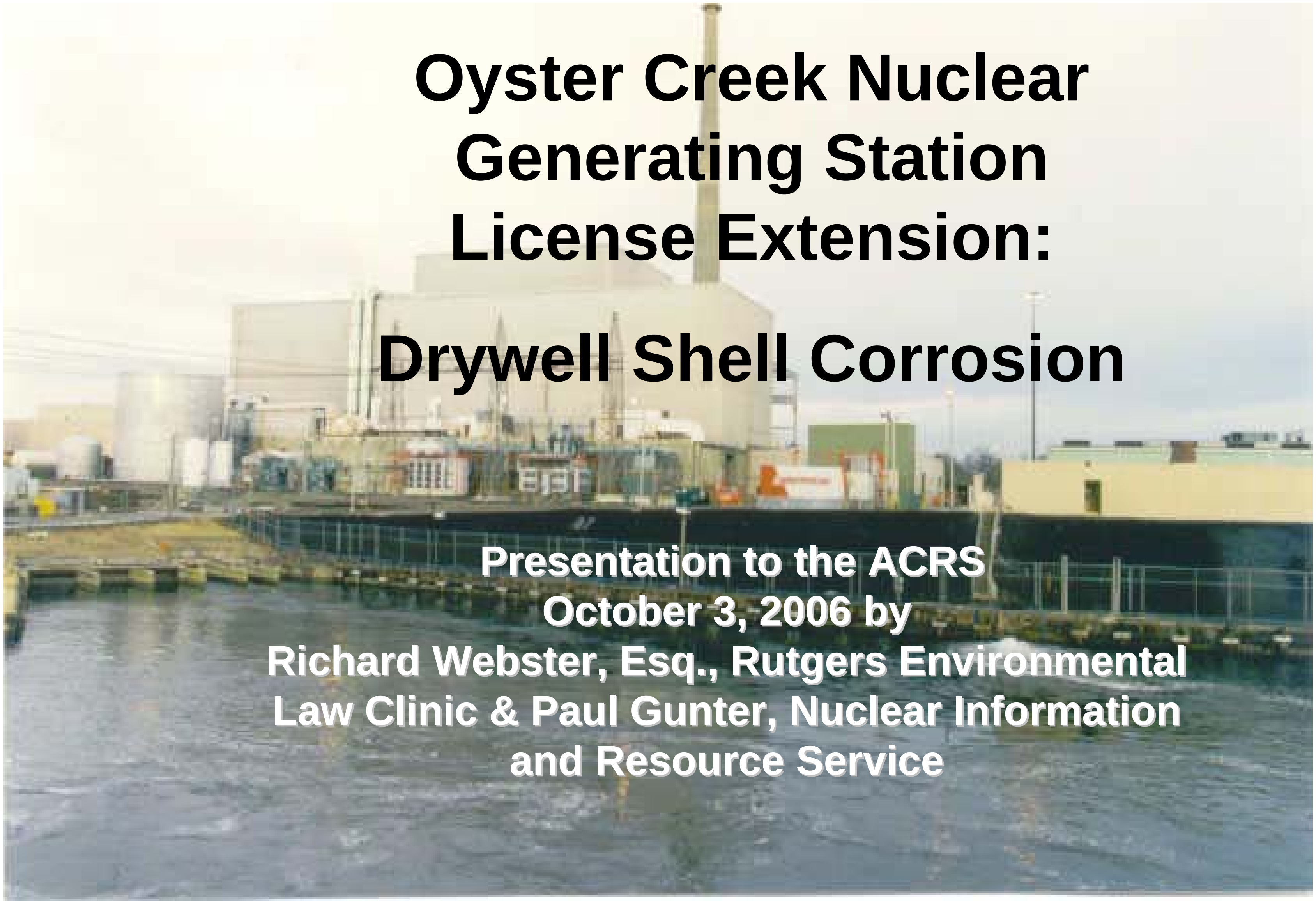
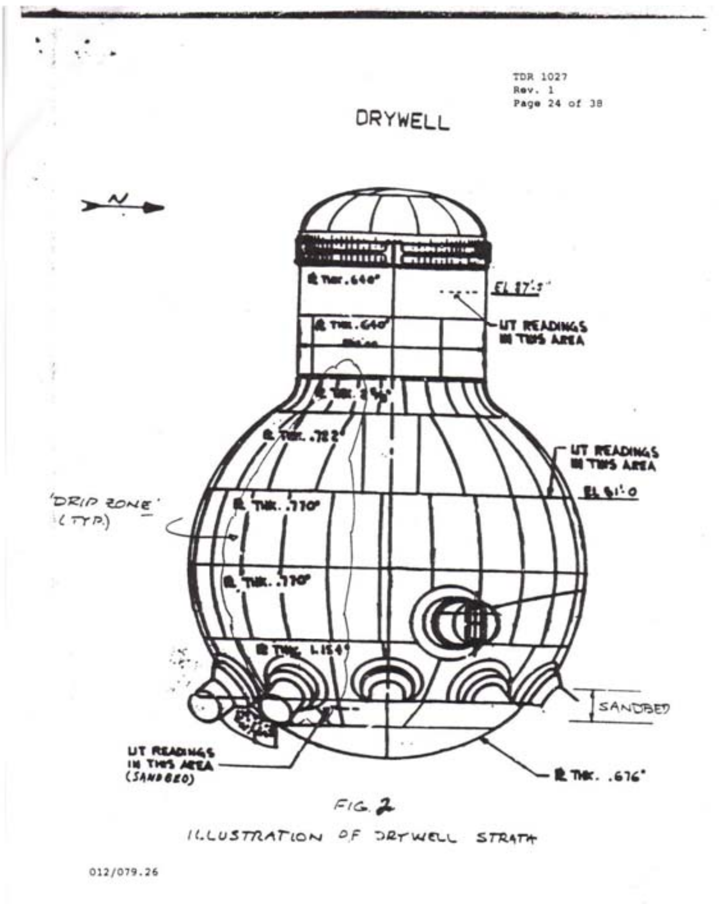


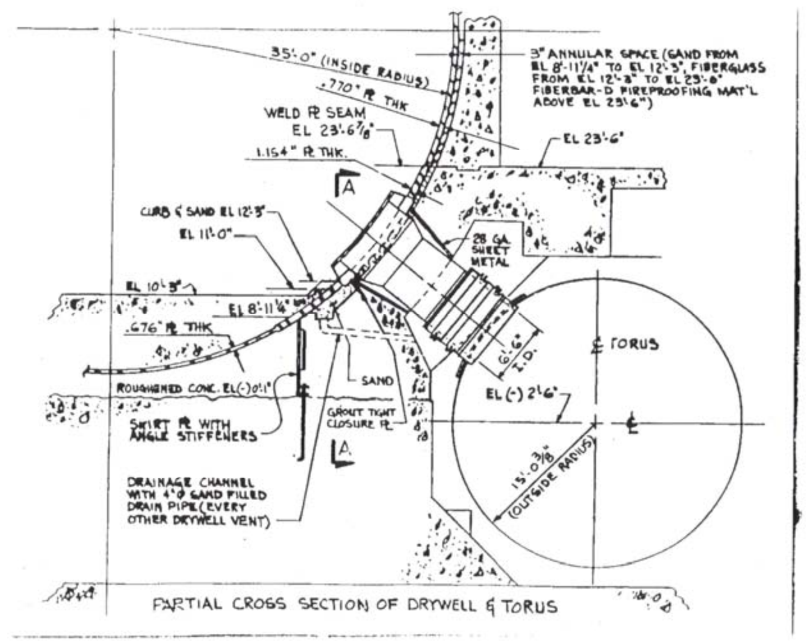
Oyster Creek Nuclear Generating Station License Extension:

Drywell Shell Corrosion

Presentation to the ACRS
October 3, 2006 by
Richard Webster, Esq., Rutgers Environmental Law Clinic & Paul Gunter, Nuclear Information and Resource Service

Oyster Creek
Containment Corrosion





Oyster Creek
Containment Corrosion

SUMMARY OF 14R OUTAGE UT THICKNESS MEASUREMENTS

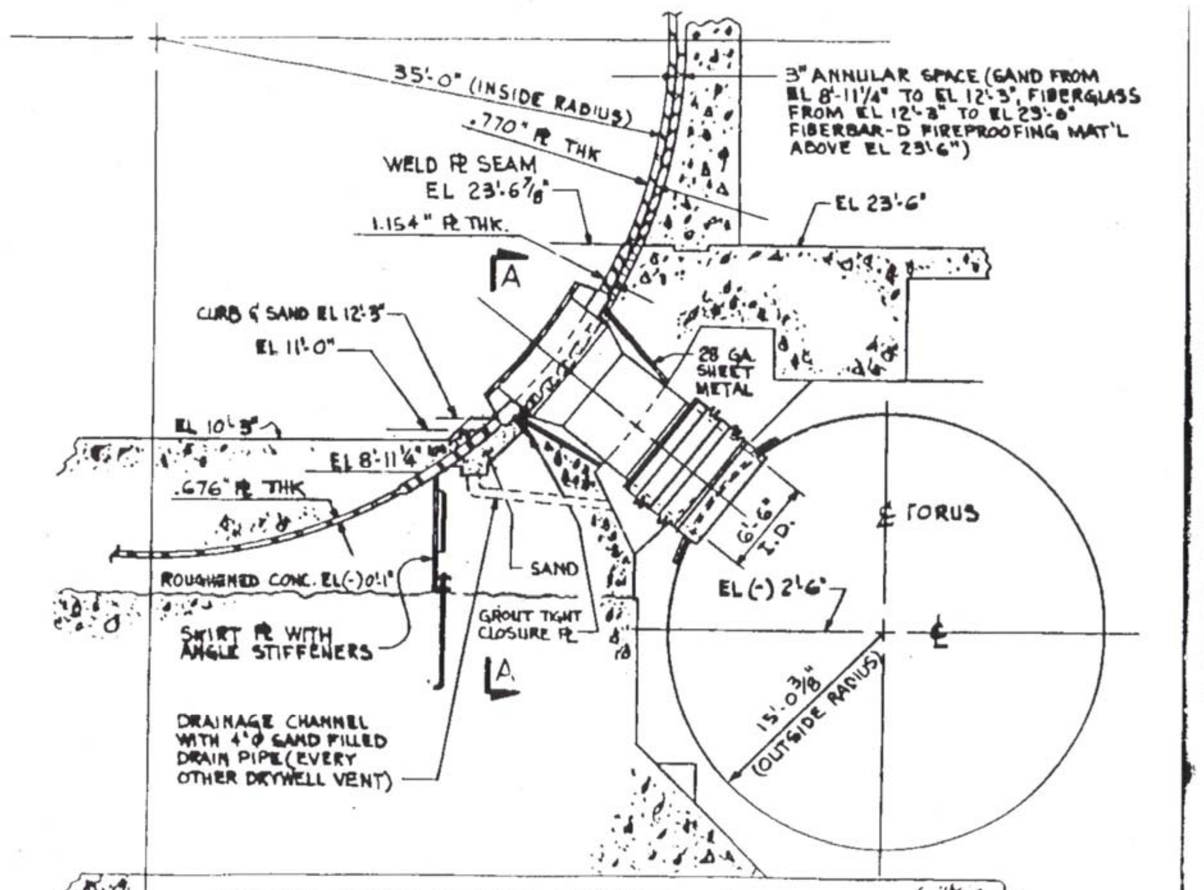
(TAKEN FROM INSIDE DRYWELL)

	Vessel Thickness (inches)			
Drywell Region	As Designed (inches)	Minimum Required at 1.1 Smc (inches)	Current Thinnest (12/92) (inches)	Previous Thinnest (7/91) (inches)
Cylinder	0.640	0.580	0.614	0.612
Upper Sphere (El. 51' to 65')	0.722	0.650	0.691	0.695
Middle Sphere (El. 23' to 51')	0.770	0.670	0.743	0.745
Sand Bed	1.154	0.736	0.800	0.803

Identified Concerns

- Possible corrosion in the embedded region
  - concern covers both current safety and potential for future undetected degradation
- Sandbed region
  - whether the drywell liner meets safety margins now; and, if so
  - whether any significant degradation in the future would be detected before safety margins are violated – subject of contention

Oyster Creek Containment Corrosion



PARTIAL CROSS SECTION OF DRYWELL & TORUS

Embedded Region in 1992

- When sand was removed in 1992 the sand bed floor was unfinished, water had ponded on the floor, and the floor had deep craters, probably due to corrosion of rebar
- Until 1992 no seal was present between the shell and the concrete to reduce penetration of water into gaps
- Moisture from groundwater has not been ruled out

Corrosion Possible

- Conditions in the embedded region from the early 60s through to 1992 were favorable for crevice corrosion, which could then self-accelerate
- Since 1992, it has been assumed, but not verified that the elastomer seal has kept the embedded region dry
- Assumption of dry conditions since 1992 not valid because seal could be leaking and water could be coming from below

Effect of Sand Removal

- Removal of sand could have accelerated corrosion in the embedded region because of differential aeration, if wet conditions persisted
- Corrosion rates in the sandbed region do not bound corrosion rates in the embedded region
- Steel thickness in the lower embedded region was nominally 0.676 inches and corrosion rates could be up to 0.33 inches per year

Necessary Actions

- Comprehensively check current thickness of metal in the embedded region
- Monitor for wet conditions in the embedded region using electronic detectors
- If water is present, must sample and trace source
- Need to establish acceptance criteria and an adequate aging management program, need objective data where experts disagree

Sandbed Established Safety-based Acceptance Criteria

- Most critical constraint is buckling
- Uniform criterion - 0.736” wall thickness
- Single point criterion - no point should be less than 0.49 inches
- Small area criterion - one square foot per bay may be less than 0.736 inches, but must be greater than 0.536 inches
- All based on modeling of 36 degree slices of shell that inherently assumed axial symmetry and spherical shape.

Problems With Established Criteria

- Sandbed is far from uniform, some bays were much more corroded than others with a dimpled “golf ball” surface
- Symmetry assumption prevented model simulating anti-symmetric buckling
- Assumption of spherical shape not justified – shell was welded together in situ in the 1960s, could be far from spherical
- Derivation of the small area criterion was not rigorous – did not see if shapes other than a square could be more critical – e.g. horizontal gash

Measured Shell Thickness

- Last UT measurements taken with procedures that are not in question were carried out in 1992
- Results taken from both inside and outside
- Smallest measured result was 0.603 inches from inside and 0.618 inches from the outside
- Area that is less than 0.736 inches recently estimated at 0.68 ft. sq., but no account taken of uncertainty or failure to measure all thin areas
- Each measurement is uncertain by 0.03 inches. AmerGen accepted results that showed up to 0.05 inches increase in thickness

AmerGen Accepted "Anomalous" UT Measurements

- May 3, 2006, Dr. Rudolf Hausler:

  The AMGT (average minimal general thickness) for each grid decreases from 1992 to 1994, but then ***increases*** in 1996. "This is of course physically impossible; metal simply does not spontaneously get thicker."
- Hausler, "I interpret this as a systematic error in the UT methodology employed."
- June 20, 2006, AmerGen admits that 1996 UT results were anomalous. "In at least one case, the increase is as much as 50 mils in a two year period."
- 1994 results not validated – were similar problems with procedures
- AmerGen relied in part on the 1994 and 1996 results to claim corrosion in sandbed was zero

Margins Established in 1992

- Single point margin overestimated at 0.11 inches by operator
- Single point margin estimated by Dr. Hausler at around 0.06 inches
- Small areas margin overestimated at 0.07 inches by operator
- Small areas margin estimated at around 0.03 inches by Dr. Hausler based on possible expansion of area thinner than 0.736 inches

Inadequate Spatial Scope

- **Hausler, June 23, 2006 – Much of sandbed is inaccessible from inside:**
  - **Initial investigations before sand removed measured shell from the inside shell "at lowest accessible locations"**
  - **Interior concrete floor & curb 2 ft. higher than exterior floor leaving about 2/3 of sandbed region not tested.**
  - **Interior floor removed in 2 bays & found similar thinning below floor level confirming area should not be omitted from UT**
- **Both Hausler and Stress believe much more spatially comprehensive UT thickness measurements are needed to accurately represent current state of vessel**

Simplistic Treatment of Acceptance

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Current Margins Unknown

- Acceptance criteria not updated yet
- Recently discovered that water has been draining from the sandbed over the last eight years
- Visual monitoring of epoxy coat is inadequate to detect small pinholes, coat could mask corrosion, and coat is beyond its anticipated life
- UT measured area was not adaptive to thin areas at edges, not representative, is only 3 sq. ft. out of 300 sq. ft., and misses known areas less than 0.736 inches
- Single UT measurement uncertainty is very close to margins, but operator failed to fully account for uncertainty
- Insufficient data to calculate area below 0.736 inches

Predictions About The Future

- Present situation very poorly defined
- Predictions about the future are therefore highly uncertain
- To determine appropriate monitoring for the future in terms of spatial scope and required accuracy need to know current margin to a high degree of certainty – must use most accurate techniques as proposed by Stress
- To determine monitoring frequency need to adequately monitor conditions, estimate worst-case corrosion rate, and account for uncertainty

Proposed UT Program Is Inadequate

- **Spatial scope too small - areas of the shell less than 0.736 inches thick would not be systematically identified and tested**
- **Statistical techniques used in data analysis are flawed**
- **Coating integrity not adequately maintained**
- **Monitoring for water is inadequate**
- **Initial UT monitoring frequency is too low if corrosive conditions are present**
- **Must build in fail-safe checks**

Inadequate Spatial Scope

Hausler, June 23, 2006:

- **AmerGen proposes to measure the same locations measured in 1992, 1994, 1996**
- **Many areas below 0.736 inches are not proposed to be monitored at all**
- **AmerGen must devise a systematic approach to identify and measure all areas thinner than 0.736 inches**

Proposed Statistical Techniques Are Flawed

- Potential for future corrosion not estimated when no corrosion measured
- Erroneous assumption of linearity over time. Even under constant conditions pit corrosion can accelerate
- Erroneous assumption of unchanged conditions
- Use of 95% confidence interval - no justification for the assumption that failing to detect violation of safety margins 1 in 20 times is adequate – must do analysis of safety significance
- Erroneous use of normal statistics and data filtering
- Failed to look systematically at uncertainties in measurements
- Unable to estimate worst-case corrosion rate due to lack of data

Maintaining Coating Integrity

- Visual examination may miss small holidays and pinholes
- Visual examination must be augmented by industry standard objective measurements
- When wet conditions prevail, monitoring frequency must increase to at least quarterly until more certainty prevails
- Response to coating failure must be complete renewal of coating and comprehensive UT measurements within one quarter

Monitoring For Water Is Inadequate

- Recent announcement that operator failed to monitor sandbed drains for 8 years and then dumped collected water without testing dramatically illustrates problems with a purely visual approach
- Now no way of knowing when the leakage occurred, exactly which areas of the shell were wet, or where the water came from
- Having moisture monitored electronically provides verifiable records that show moisture variation in space and time
- Detection of water must trigger comprehensive checks of coating integrity within a quarter

UT Monitoring Frequency

- Cannot decide on UT monitoring frequency until safety margins and worst case corrosion rates are known
- Must make conservative assumptions, and assume other programs are missing something
- Recent experience shows that we cannot rely only on committed inspections alone to drive UT monitoring. Must have fail safe intervals.

Second Possible Failure Mechanism

Hausler, June 23, 2006 points out:

- Chloride induced fatigue cracking is possible
- It will be necessary to examine both the corroded areas and susceptible areas for the existence of stress corrosion cracks in the drywell liner
- Nothing yet proposed to resolve this issue

Conclusions

- Not even a current reasonable assurance of safety
- Know that the proposed monitoring program is inadequate
- More measurements are currently scheduled this month. If they were comprehensive, many of the current safety questions could be answered
- At best, conclusions about future safety of the shell in the SER and the inspection report were premature
- Need to discard all the invalid assumptions that have accumulated and conduct an analysis that is as rigorous and quantitative as possible based on comprehensive data and careful consideration of uncertainty