Citizens Exhibits 17

RAS 14327

U.S. NUCLEAR REGULATORY COMMISSION
In the Matter of AmerGen Energy Co., LLC
Docket No. 50-0219-LR Official Exhibit No. Citizens Exh. 17
OFFERED by: Applicant/Licensee Intervenor
NRC Staff
IDENTIFIED on 9/25/07 NH
Action Taken: ADMITTED REJECTED WITHDRAWN
Reporter/Clerk PW

From: Hutchins, Steven P <steven.hutchins@exeloncorp.com>
Sent: Monday, September 18, 2006 4:51 PM
To: Hufnagel Jr, John G <u000jgh@ucm.com>; O'Rourke, John F. <t925jfo@ucm.com>
Subject: FW: DW WHITE PAPERS
Attach: MAM writeup.doc; Drywell Corrosion Fact Sheet.pdf

-----Original Message-----
From: Tamburro, Peter
Sent: Tuesday, September 12, 2006 2:07 PM
To: Hutchins, Steven P
Subject: DW WHITE PAPERS

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DOCKETED
USNRC

October 1, 2007 (10:45am)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

Template=SECY-028

OCLR00013714

SECY-02

1) Summary:

Beginning in 1980, conditions were identified at the Oyster Creek plant indicating episodic intrusion of water into spacing between the outer steel surface of the drywell portion of the primary containment and the surrounding reactor building concrete. The potential for corrosion of the outer surface of the drywell was recognized, with potential adverse effects on the ability of the drywell to perform its intended design functions. The presence of corrosion was subsequently confirmed and the degree and extent of the corrosion quantified through extensive inspection and testing. An initial assessment determined that the drywell structure remained capable of performing its design requirements.

Corrective actions were directed at assuring that the drywell would continue to satisfy its design requirements over the projected life of the plant. These have included but are not limited to: actions to minimize the potential for water intrusion into the affected area; actions to effect removal of any water that might intrude into the affected area; removal of material (sand) in the lower sand bed region external to the drywell shell that might contribute to drywell shell corrosion; application of a protective coating to the steel drywell external surface in the sand bed region; and determination of a plant specific drywell design pressure for Oyster Creek, establishing a conservative corrosion allowance for the upper region of the drywell. Corrective actions undertaken also include monitoring through periodic inspection activities of the condition of the drywell shell, assessment of the effectiveness of the various mitigating activities, and continuing assessment of the adequacy of the drywell to meet its design functions through the end of plant life.

Corrosion assessment results demonstrate that corrective actions taken at Oyster Creek have been effective in reducing the rate of corrosion in the upper regions of the drywell. The corrective actions also have been effective in arresting corrosion of the drywell shell in the sand bed region. Analysis performed following 2004 UT inspections show that the drywell shell will not corrode to less than minimum required thickness before the year 2029. UT measurements taken in 1992, 1994, and 1996 confirmed that the sandbed region coating has effectively mitigated corrosion of the drywell shell in the sand bed region. Continued implementation of corrective actions described below and as described in "ASME Section XI, Subsection IWE" program, "Protective Coating Monitoring and Maintenance Program", and in the "Drywell Corrosion" time-limited aging analyses, will provide reasonable assurance that loss of material of the drywell shell will be detected before a loss of the containment drywell intended function, assuring the capability of the drywell to perform its intended design functions throughout the License Renewal extended period of operation.

2) Background:

a) Containment Design

The Oyster Creek primary containment is a General Electric Mark I design and consists of a drywell, a pressure suppression chamber, and a vent system connecting the drywell and the suppression chamber. The primary containment is a safety related structure, required to control the release of fission products to the secondary containment in the event of a design basis loss-of-coolant accident (LOCA) so that off site consequences are within acceptable limits. The primary containment was originally rated for a maximum internal pressure of 62 psig, consistent with generic GE Mark I containment design.

The drywell houses the reactor vessel, the reactor coolant recirculation loops, and other components associated with the reactor system. The drywell structure is a steel pressure vessel in the shape of an inverted light bulb, consisting of a 70 ft diameter spherical lower section with a 33 ft diameter by 23 ft high upper cylindrical section, topped by a removable, semi-elliptical dome.. The spherical section of the drywell is partially embedded in reinforced concrete, from a lower invert at elevation 2'-3" to elevation 8'-11 1/4", and transitions into the non-embedded section through a sand bed region extending to elevation 12'- 3". The non-embedded portion of the drywell is enclosed by a reinforced concrete shield wall, separated from the steel drywell structure by a nominal fifteen inch gap in the sand bed region and a nominal three inch gap above the sand bed region, designed to allow for expansion of the drywell shell (See Figure 1 detail "B").

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(Figure to be revised to show steel trough drain line and gasket)

The gap in the sand bed region was originally sand-filled with dry sand as specified in ASTM 633 to smooth the transition of the drywell shell from a condition of fully restrained in the embedded region to a free standing condition above the embedded region. Drains provided in the concrete surface beneath the sand bed were designed to remove any water that might intrude into the gap between the concrete shield wall and the drywell shell. The concrete surface beneath the sand bed was designed to be finished and shaped to direct any water intrusion to the sand bed drains.

The drywell shell is fabricated from ASTM A-212-61T Gr. B welded steel plates varying in nominal design thickness:

- Embedded shell below the sand bed region : 0.676 inches
- Sand bed region shell : 1.154 inches
- Spherical region El 23' to El. 51' : 0.770 inches
- Spherical region El. 51' to El. 65' : 0.722 inches
- Transition from spherical to cylindrical region: 2.625 inches
- Cylindrical region : 0.640 inches

The internal surface of the drywell steel shell is coated with Carboline Carbo-Zinc 11 paint. The external surface of the drywell steel shell above the embedded region was originally coated with red lead base paint identified as TT-P-86C Type I. Internally, the bottom of the drywell is filled with concrete to a nominal elevation of 10'-3".

b) Cause of Corrosion

The potential for corrosion of the drywell vessel was first recognized when water was noticed coming from the sandbed drains in 1980. Water leakage from the sandbed drains created the potential for a moist environment to exist in contact with the exterior surface of the drywell shell. Extensive investigations to identify the source of water and the leakage path were undertaken during the 1980, 1983, and 1986 refueling outages. Results of the investigations indicated that:

- Leakage was observed during refueling outages;

- Leakage was not attributed to the reactor cavity steel trough drain line gasket or the refueling bellows seal (See Figure 1 detail "A").

  The reactor cavity steel trough drain line gasket leak was ruled out as the primary source of water observed in the sand bed drains because there was no clear leakage path to the seismic gap. Minor gasket leakage would be collected in the concrete trough below the gasket. The concrete trough is equipped with a drain line that would direct any leakage to the reactor building equipment drain tank and prevent it from entering the seismic gap.

  Inspections concluded that the refueling bellows (seals) were not the source of water leakage. The bellows were repeatedly tested using helium (external) and air (internal) without any indication of leakage. Furthermore, any minor leakage from the refueling bellows would be collected in the concrete trough below the bellows. The concrete trough is equipped with a drain line that would direct any leakage to the reactor building equipment drain tank and prevent it from entering the seismic gap.

- Leakage was attributed to through wall cracks in the reactor cavity liner; and

- The leakage path was through the seismic/expansion gap between the drywell and the reactor building, down to the sandbed region within the reactor building.

c) Initial Corrosion Monitoring

To determine if water leakage had an adverse effect on the drywell shell, a series of ultrasonic thickness (UT) measurements of the drywell shell were taken during refueling outages and outages of opportunity between 1986 and 1989 to establish and characterize the extent of corrosion of the drywell shell. Approximately 1000 UT measurements were taken to identify the thinnest areas. In addition, core samples of the drywell shell were taken at seven locations, believed to be representative of general wastage, to confirm the UT results. Results of the UT measurements confirmed that:

- Corrosion was occurring in the sandbed region and, to a lesser extent, in the upper regions of the drywell;
- The most severe corrosion rate found in the sandbed region was 39.1±3.4 mils/year; and
- The highest corrosion rate above the sandbed region was 4.6±1.6 mils/year.

As a result of these inspections, it was concluded that a long term monitoring program would be established. This program included periodic UT inspections at critical locations, the performance of calculations to track corrosion rates, and the projection of vessel thickness based on conservative corrosion rates to demonstrate that the minimum required vessel thickness is maintained. The continued presence of water in the sandbed region raised concerns about corrosion at higher elevations and, consequently, periodic UT measurements in the upper spherical region (elevation 50'-2" and 51'-10") and in the cylindrical region (elevation 87'-5") were eventually added to the long term monitoring program.

Based upon the differing drywell shell plate thicknesses in the different regions of the drywell, coupled with the different observed corrosion rates and postulated corrosion mechanisms for these regions, different mitigative actions were undertaken for the upper regions of the drywell and the sand bed region, as discussed below.

3) Mitigative Actions:

a) Strippable Coating:

A strippable coating was applied to the reactor cavity liner to prevent water intrusion into the gap between the drywell shield wall and the drywell shell during periods when the reactor cavity is flooded.

b) Sandbed Region:

i) Sand Bed Region Drains

The sand bed region drains were cleared to improve drainage.

ii) Modifications:

(1) Cathodic Protection System:

In 1988, based upon assessment that the higher observed rate of corrosion in the sand bed region was largely galvanic in nature, the first extensive corrective action, i.e., the installation of a cathodic protection system, was taken. The cathodic protection system was comprised of rectifiers, anodes, reference electrodes and system performance monitoring equipment. The cathodic protection system was an impressed current system, which relied on an electrolyte to pass current from the anodes to the "protected" structure. The design of the cathodic protection system assumed that the pre-existing leakage of moisture into the sandbed region would not be abated and would provide an adequate electrolyte for the impressed current system. However, several modifications and/or maintenance activities were performed that eliminated or reduced the leakage into the sandbed, including, the application of a strippable coating to the reactor cavity liner during refueling outages (subsequently made a commitment for the extended period of operation) and the monitoring of leakage from the sandbed region drains. The "drying" of the sandbed reduced the systems performance and the cathodic protection system was subsequently deemed ineffective. The system was removed in 1992.

(2) Sand Removal:

In 1992, a modification was implemented to remove the sand from the sandbed region. Modification activities in the sandbed region also included the removal of rust and old paint from the drywell exterior and the application of a protective epoxy coating on the drywell exterior surface. The concrete surface below the sand was intended to be shaped to promote flow toward each of the five sand bed drains. However once the sand was removed it was discovered that the floor was not properly finished and shaped as required to permit proper drainage. There were low points, craters, and rough surfaces that could allow moisture to pool instead of flowing smoothly toward the drains. These concrete surfaces were refurbished to fill in low areas, smooth rough surfaces, and coated with an epoxy coating to promote improved drainage. The drywell shell at the juncture of the concrete floor was sealed with an elastomer to prevent water intrusion into the embedded drywell shell.

(3) Protective Coating:

The coating of the exterior surface of the drywell in the sandbed region is considered to be a non-safety-related Service Level II application, as defined by ANSI N101.4. The coating procedure invoked surface preparation in accordance with Steel Structures Painting Council standards SSPC SP-2, Hand Tool Cleaning, and SP-3, Power Tool Cleaning. It also provided requirements for the application of a three-coat Devoe epoxy coating system, consisting of one coat of Preprime 167 and two coats of Devran 184 epoxy coating. Devmat 142S caulk was specified to seal crevices, and the new coatings were required to overlap the existing sound coatings, which permitted a continuous film to be established in the recoated area. Each coat was visually examined and dry film thickness measurements were taken to assure proper coating thickness was achieved. Devran 184 is a two-part, 100 percent solids epoxy coating, which is less susceptible to degradation in moist environments than solvent-based coatings because there are no microscopic pores remaining as a result of solvent release to serve as entry points for moisture intrusion. Instead, the two components cross-link chemically to form a dense solid film. The primer assures that good bonding is achieved with the substrate, and the application of two coats assures that full coverage is attained. Therefore, this coating system was an excellent choice for this application.

The coatings system was qualified inside a sandbed mockup with lighting conditions and space constraints similar to those in the actual sandbed region to assure that the specified coating application methods and thickness requirements were adequate to produce a sound coating film over the rough surface. Personnel performing the qualification tests wore anti-contamination clothing and respirators to simulate working conditions in the actual sandbed region. Representative coating qualification test panels were prepared and coated in accordance with the coating procedure and were visually examined and inspected using a low-voltage wet sponge holiday test in accordance with ASTM G62 to detect any pinholes or discontinuities. This type of testing is normally specified to qualify immersion service coating applications, such as tank linings.

Following the application of the coating system in the sandbed region, the coating in all ten bays (the ten bays are numbered only using odd numbers from 1 – 19) was visually examined to the same visual standards used for the procedure qualification and coating thickness was measured. Since the initial coating application and inspection in 1992, the coating applied to the sandbed region of the drywell shell exterior has been visually examined for chips/scratches, rust spots, blisters, spalling, peeling, cracking, delamination, flaking and any other types of visible coating defects or distress in the coatings. These examinations have been performed on a sample basis during refueling outages, with two bays being examined every other refueling outage. A total of five of the ten bays have been inspected to-date, in the following sequence: 1994 – Bays 11 and 3; 1996 – Bays 11 and 17; 2000 – Bays 1 and 13; 2004 Bays 1 and 13. All coating inspection results to-date have been satisfactory, with no deficiencies noted in any of these inspections. The five remaining bays (5, 7, 9, 15, and 19) have not been re-inspected since the original coating application inspection. Prior to the period of extended operation, Oyster Creek will perform additional visual inspections of the epoxy coating that was applied to the exterior surface of the Drywell shell in the sand bed region, such that the coated surfaces in all 10 Drywell bays will have been inspected at least once. In addition, the Protective Coating Monitoring and Maintenance program will be enhanced to require inspection of 100% of the epoxy coating every 10 years during the period of extended operation. Performance of the inspections will be staggered such that at least three bays will be examined every other refueling outage.

Visual inspection of the containment drywell shell, conducted in accordance with ASME Section XI, Subsection IWE, is credited for aging management of accessible areas of the containment drywell shell. Typically this inspection is for internal surfaces of the drywell. The exterior surfaces of the drywell shell in the sand bed region for Mark I containments is considered inaccessible by ASME Section XI, Subsection IWE, thus visual inspection of the sand bed region was not possible at Oyster Creek before the sand was removed. After removal of the sand, the region was made accessible during refueling outages for periodic inspection of the coating. Subsequently, Oyster Creek performed periodic visual inspection of the coating in accordance with an NRC current licensing basis commitment. This commitment was implemented prior to implementation of ASME Section XI, Subsection IWE. For the period of extended operation, Oyster Creek has committed to monitor the protective coating on the exterior surfaces of the drywell in the sand bed region in accordance with the requirements of ASME Section XI, Subsection IWE through the implementation of the Protective Coating Monitoring and Maintenance Program. Sand bed Region external coating inspections will be per Examination Category E-C (augmented examination) and will require VT-1 visual examinations per IWE-3412.1.

- The inspected area shall be examined (as a minimum) for evidence of flaking, blistering, peeling, discoloration, and other signs of distress.

- Areas that are suspect shall be dispositioned by engineering evaluation or corrected by repair or replacement in accordance with IWE-3122.

- Supplemental examinations in accordance with IWE-3200 shall be performed when specified as a result of engineering evaluation."

c) Drywell Upper Elevation:

i) Revised Drywell Design Pressure:

The upper regions of the drywell vessel, above the sandbed, were handled separately from the sandbed region because of the significant difference in corrosion rate and physical difference in design. As part of the overall mitigation strategy addressing Oyster Creek drywell corrosion, a decision was made to establish a corrosion allowance by demonstrating, through analysis, that the original drywell design pressure was conservative. The original primary containment design pressure of 62 psig was generic to GE Mark I containment design and was based upon simulation tests to confirm the design adequacy of the Bodega Bay Plant. The value was established by adding 10 psig to the estimated 52 psig peak containment pressure for Bodega Bay. The 10 psig was added for margin and conservatism. The resulting generic value was considered bounding for the Oyster Creek containment design. A comparison of the Oyster Creek and Bodega Bay containment design features indicated that the Oyster Creek drywell pressure would be significantly less than that for Bodega bay.

Analyses were performed to reevaluate the drywell design pressure and to establish an appropriate plant specific design pressure and corresponding temperature for the Oyster Creek drywell. Analysis demonstrated that following a worst-case design basis loss of coolant accident (DBLOCA), the peak drywell pressure will not exceed 38.1 psig, with a corresponding saturation temperature of 285° F. Applying a 15% (nominal) margin establishes an appropriate design pressure for the Oyster Creek drywell of 44 psig at a corresponding saturation pressure of 292° F. In accordance with the provisions of 10CFR50.90, Oyster Creek requested a change to Appendix A of the Facility Operating License, reducing the drywell design pressure from 62 psig to 44 psig at a corresponding coincident drywell temperature of 292° F. These changes were approved as Amendment 165 to the Oyster Creek Technical Specifications.

Establishment of an appropriate, plant specific design pressure for the Oyster Creek drywell and subsequent evaluation of observed drywell shell thickness in the upper drywell region demonstrates adequate existing and projected wall thickness for this, the thinnest portion of the drywell shell.

Given that 1) mitigation measures for the sand bed region (including application of a protective coating to the outer drywell shell in the region) have resulted in arresting the corrosion that was occurring in the sand bed area, and 2) the metal in the upper drywell is directly exposed to any potential water spillage into the expansion gap, while wetting of the metal in the sand bed region is precluded by the applied protective coating, monitoring the condition of the upper drywell shell is considered a conservative means of assessing corrosion effects on the overall drywell structure. Periodic UT measurements in the sand bed region were discontinued for a time, with upper drywell UT measurements combined with periodic inspection of the sand bed region protective coating providing adequate drywell shell corrosion monitoring. Periodic UT measurements in the sand bed region will be reinstituted, however, to provide additional assurance that drywell corrosion effects are adequately monitored during the period of extended operation.

4) Corrosion Monitoring:

a) Sand Bed Region

After the sand was removed in 1992, and prior to coating the shell, thickness measurements were taken in each of the 10 bays, from outside the drywell, to establish the minimum general and local thickness of the thinned shell. The measurements from inside the drywell showed that the minimum general thickness of the sand bed region was 0.800 inches, and the minimum local thickness was 0.618 inches. The measurements from outside the drywell in the sand bed region showed that the minimum general thickness was generally greater