L, C
D C
O C

The following discussion addresses water leakage onto the exterior surface of the Oyster Creek drywell shell. Part I, below, provides a historic overview of information about water leakage prior to the October 2006 outage. The discussion in Part II summarizes prior commitments made by AmerGen aimed at preventing leakage onto the shell, monitoring for such leakage and performing corrective actions if leakage occurs. Part III sets forth information discovered and analyzed as a result of the October 2006 outage. Overall conclusions about the drywell, AmerGen's performance of associated commitments, and continued drywell operability during the proposed twenty-year renewal term are summarized in Part IV.

I. Historical Background

Water leakage onto the exterior of the Oyster Creek drywell shell over a period of years, in combination with an historically degraded sand bed region drainage system, created a condition that was conducive to corrosion of the exterior surface of the drywell shell. The previous owner/operator of Oyster Creek conducted extensive troubleshooting and repairs to determine and address the leakage and the corrosive effects of that leakage onto the drywell shell. As part of its license renewal activities, AmerGen has reviewed previous actions and instituted new measures (see Section II below) to ensure that leakage will be minimized and monitored, and that ~~corrective actions~~ will be implemented to ensure the drywell continues to perform its intended functions throughout the proposed twenty-year period of extended plant operation.

In addition, drywell commitments for license renewal are embedded in a formal AmerGen tracking system that includes specific work tasks, thereby ensuring timely implementation of the commitments and effective management oversight. Therefore, AmerGen is confident that the measures put into place to prevent and monitor leakage, in conjunction with the implementation of drywell shell visual and ultrasonic testing aging management program activities, will protect the shell such that it continues to perform its intended functions throughout the proposed period of extended operation.

A. Chronology of Significant Events (Also see Timeline, Section 2)

- 1980 – Water was observed coming from the sand bed drains. As part of the original design, these drains had been filled with sand during plant construction. The sand was restrained at the outlet with a 100-mesh stainless steel screen (0.006 inch opening). The intent was to prevent loss of sand from the sand bed region through the drain lines, yet allow drainage of water.
- 1980, 1983 and 1986 refueling outages - Extensive investigations were performed to identify the source of water and the leakage path. Results of the investigations indicated that:
    - Leakage was observed (from the sand bed drains) during refueling outages;

B/9

- Leakage was not attributed to the reactor cavity metal trough drain line gasket or the refueling bellows seal (See Figure 6 of Section 3 of this Enclosure).

  The reactor cavity metal 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 gap between the drywell shell and reactor building concrete shield wall (i.e., drywell expansion gap). Any gasket leakage would be minor and would be collected in the concrete trough below the gasket. Also, 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 same concrete trough as would collect water from 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 drywell expansion gap (Ref [13], Attachment III).

- Leakage was attributed to through-wall cracks in the reactor cavity liner attributed to mechanical damage and to fatigue (Ref [13], Attachment III); and

- The leakage path was from the reactor cavity, to the concrete trough (later found to have been degraded – see Section C below) and through the drywell expansion gap down to the sandbed region within the reactor building (See Figure 6 of Section 3 of this Enclosure).

* Between 1988 and 1993, multiple mitigating actions were taken to address the corrosion problem. These actions included (Ref [32], page 9):

  - Cleared the former sand bed region drains of sand and corrosion products to improve drainage.

  - Replaced reactor cavity metal trough drain gasket, which was found to be leaking (See Figure 6 of Section 3 of this Enclosure).

  - Removed water from the sand bed region.

  - Installed a cathodic protection system in bays with greatest wall thinning. Subsequent UT thickness measurements in these bays showed that the system was not effective in reducing the rate of corrosion and the system was removed from service in 1992.

  - Removed sand from the sand bed region to break up the galvanic cell (Ref [46]).

  - Removed corrosion products from the external side of the drywell shell in the sand bed region.

- Upon sand removal, the sand bed concrete floor was found to be cratered and unfinished. The concrete floor was repaired, finished and coated to permit proper drainage of the sand bed region (Refer to Section 7 of this Enclosure for details).

- Applied an epoxy caulk seal at the junction of the drywell shell and the sand bed concrete floor to prevent intrusion of moisture into the drywell shell embedded in concrete (Refer to Section 6 of this Enclosure for details).

- Applied a multi-layered epoxy protective coating to the exterior surfaces of the drywell shell in the sand bed region (i.e., one pre-primer coat, and two top coats). (Refer to Section 6 of this Enclosure for details).

- Applied stainless steel type tape and strippable coating to the reactor cavity during refueling outages to seal cracks in the stainless steel liner, in order to limit leakage from the reactor cavity. (Note that the steel tape was applied to larger cavity liner cracks and then the strippable coating was applied over the entire liner surface that would be (otherwise) wetted.)

- Confirmed that the reactor cavity concrete trough drain line was not clogged (See Figure 6 of Section 3 of this Enclosure)

B. Discovery and Evaluation of Cavity Liner Defects

In 1987, defects in the reactor cavity liner were documented and evaluated in material nonconformance report MNCR 87-240 (Ref [49]). These defects consisted of through-wall and surface indications detected by non-destructive examination of the liner near weld joints. The purpose of the cavity liner is to facilitate filling the reactor cavity with water for refueling activities.

The defects do not pose problems except when the reactor cavity is filled with water during refueling outages. If no preventive action is taken, the defects allow water to leak behind the liner and run down into the reactor cavity concrete trough. If the flow rate exceeds the capacity of the two-inch trough drain, then water would back up into the drywell expansion gap and drain onto the outside of the drywell shell.

Safety Evaluation 328257-002 was generated in 1988 with the purpose of addressing the adequacy of the design and the safety impact of installation of a temporary barrier on the OC Reactor Cavity Pool to prevent leakage of water during refueling operation (Ref 6, pages 7 - 13). In it, two major options were considered – weld repair of the liner and a temporary barrier over the entire cavity liner. The weld repair option had the following drawbacks: (a) there were too many defects in the liner, (b) weld repair of these defects would produce large residual stresses and warping of the liner, and (c) if weld repairs were implemented, the repair areas would eventually fail due to the same mechanism, in the future. Therefore, the temporary barrier option of metal tape and strippable coating was chosen for the repair (Ref [6], page 6).

C. Reactor Cavity Concrete Trough Area Testing and Repairs

As a result of observations of water leaking from concrete biological shield penetrations and sand bed drain lines during refueling outages in the early 1980s, numerous troubleshooting and repair activities were implemented over several years. These included:

- Air and helium leak testing of the bellows seal in the bottom of the reactor cavity (no leakage detected) and cavity drain line (no significant leakage found),
- Leak testing and some minor repairs to reactor cavity liner welds,
- Further pressure testing of the bellows (no leakage detected) at a later outage,
- Liquid penetrant testing of the cavity "steps" upon which the cavity shield plugs are placed (no indications detected), and
- Air purge testing of the drain line that channels refueling cavity leakage away from the gap between the drywell shell and concrete drywell shield wall (drain line did not appear to be restricted).

During the 1986 refueling outage, the drain line from the refueling cavity metal trough was inspected and the drain line gasket was found to have leaks, and was replaced. Additional leak tests were performed on the bellows during the 1986 outage and no leaks were detected (Ref [1], Attachment 2, pages 2-1 and 2-2).

During the 1986 refueling outage, camera inspections identified that the lip of the reactor cavity concrete trough was not sufficient to assure that water would not enter the area between the concrete shield wall and drywell shell. (Ref [5], page 3). Prior to reactor cavity flooding for the 1988 refueling outage, repairs were made to the concrete trough to rectify the condition. These repairs were determined to be effective based on visual inspections for leakage during the 1988 outage.

As noted previously, the mitigating features described above were implemented between 1988 and 1993. For the strippable coating, a latex coating was used at first. This latex coating had (a) stringent surface preparation requirements; (b) long curing time; and (c) lack of strength to absorb mechanical abuse during refueling. Accordingly, it was not applied during the 1994 and 1996 refueling outages. Discontinuation was also prompted by the fact that sand had been removed from the sand bed region and drainage in the area was improved during the 1994 outage. However, the observed water leakage during the 1996 outage prompted investigation and use of a more durable barrier. InstaCote ML-2 coating barrier was effectively used on the reactor cavity during the 1998 outage. (Ref [28], page 6). Strippable coating has also been applied to the reactor cavity in all refueling outages since 1998.

II. Summary of IWE Program Elements Related to Water Leakage

The following is a summary of Oyster Creek's commitments related to preventing and monitoring for water leakage onto the exterior surface of the drywell shell. These are captured within the ASME Section XI, Subsection IWE Aging Management Program. These committed actions were performed during the 2006 refueling outage and will be performed during refueling outages in the future, including during the period of extended operation. For further details on these commitments, see Ref [39], Enclosure 2.

- Strippable coating, as discussed above in Section C, is applied to the reactor cavity liner surface prior to filling the reactor cavity with water for refueling activities.
- Periodic verification (once per refueling cycle) that the reactor cavity trough drain is functional (clear).
- Periodic monitoring (when reactor cavity is flooded) of reactor cavity trough drain for leakage.
- Daily visual monitoring of drywell sand bed drains for leakage during refueling outages when the reactor cavity is flooded. If leakage is detected, AmerGen will determine the source of leakage and investigate and address the impact of leakage on the drywell shell, including verification of the condition of the drywell shell coating and moisture barrier (seal) in the sand bed region and performance of UT examinations of the shell in the upper regions. UTs will also be performed on any areas in the sand bed region where visual inspection indicates the coating is damaged and corrosion has occurred. UT results will be evaluated per the existing program. Any degraded coating or moisture barrier will be repaired. These actions will be completed prior to exiting the associated outage.
- Quarterly visual monitoring of the sand bed drains for leakage during plant power operation. If leakage is identified, then the source of water will be investigated, corrective actions taken or planned as appropriate. In addition, if leakage is detected, the following items will be performed during the next refueling outage:
    - Inspection of the drywell shell coating and moisture barrier (seal) in the affected bays in the sand bed region
    - UTs of the upper drywell region consistent with the existing program
    - UTs will be performed on any areas in the sand bed region where visual inspection indicates the coating is damaged and corrosion has occurred
    - UT results will be evaluated per the existing program

Any degraded coating or moisture barrier will be repaired.

- When the sand bed region drywell shell coating inspection is performed, the seal at the junction between the sand bed region concrete and the embedded drywell shell will be inspected per the Protective Coatings Program.

Through these commitments, AmerGen will minimize any water leakage through the reactor cavity liner that may occur during refueling outages, and prevent or minimize water from reaching the external surface of the drywell shell. These commitments were made with the expectation that corrosion of the external surface of the drywell shell will be minimized, thus maximizing the margin remaining above the design-required thicknesses of the drywell shell.

III. Findings and Analysis from the 2006 Outage

During the 1R21 (October 2006) refueling outage, AmerGen implemented its commitments related to preventing water from reaching the outer surface of the drywell shell and monitoring for evidence of water leakage. The results of these activities were successful. Based on daily observations of sandbed drain water collection bottles and upon numerous visual reports from the sand bed region, no water leakage onto the exterior surface of the drywell shell during 1R21 was evident and no corrective actions related to water leakage onto the shell were required (Ref [47]).

The reactor cavity was coated with a strippable coating prior to flooding the cavity for refueling activities. A small amount of leakage (approximately 1 gallon per minute (GPM)) was observed coming from the cavity trough drain line during the time period when the refueling cavity was flooded. Daily observations of the cavity trough drainage confirmed a steady stream of approximately 1 GPM during this period. Because this small amount of leakage did not exceed the drainage capacity of the trough, no water would have leaked onto the exterior surface of the drywell shell. The minor leakage was discharged to the plant's radwaste system as designed.

Specifically, AmerGen performed the following actions during the October 2006 refueling outage to prevent or minimize water leakage onto the exterior of the drywell shell. These activities are consistent with commitments made in AmerGen Letter 2130-06-20358 (Ref [39]).

- Applied a strippable coating to the reactor cavity liner prior to flooding the cavity for refueling activities.
- Verified that the reactor cavity trough drain was clear prior to flooding the reactor cavity for refueling activities.
- Monitored the trough drain for leakage daily while the cavity was flooded with water. Documented results identified only a steady "pencil stream" of water coming from the trough drain, indicating, as expected, that the leakage was being handled by the cavity trough drain system, keeping water away from the drywell shell.

- Inspected the five sand bed drain lines to verify they were clear; removed some debris from two of the drain lines.
- Inspected the five poly collection bottles associated with the sand bed drains on a daily basis. Documented results identified no leakage observed coming from the sand bed drains.
- Verified no water on the concrete floor in any of the ten bays of the sand bed region through visual inspection.
- Inspected the seal at the junction between the sand bed region floor and drywell shell in all 10 bays. The inspection revealed the seal at this junction to be in good condition with no repairs required.

IV. Conclusion

Oyster Creek historically experienced water leakage onto the external surface of the drywell shell as described in Section I above. Various investigative and corrective activities have been performed to understand the issue and prevent water from continuing to drain onto the shell during refueling activities.

As part of the License Renewal process, AmerGen has established specific commitments within the formal Exelon Passport commitment tracking system to ensure license renewal commitments, including those addressing water leakage onto the drywell shell external surface (described in Section II above), are implemented. In addition, the recurring tasks, preventive maintenance activities, and surveillance procedures that are used to implement these commitments are annotated such that it is clear from looking at them that the subject actions are associated with commitments made to the NRC. In this way, there are formal controls to ensure awareness and oversight of the activities and to ensure that commitments are implemented.

The inspections performed during the 2006 refueling outage (1R21) confirm that the license renewal-related committed actions for leakage prevention and monitoring prevented water from reaching the external surface of the drywell shell. AmerGen has committed to perform these preventive/monitoring actions in future refueling outages, with the objective of preventing water leakage onto the drywell shell exterior. In addition, commitments are in place to investigate and address any leakage onto the shell exterior, should it occur.

This set of actions, aimed at preventing water from reaching the external surface of the drywell shell, serve as an additional level of assurance beyond that provided by performing and trending drywell shell thickness measurements and conducting visual inspections of the epoxy coating in the sand bed region (also part of the IWE Aging Management Program), that corrosion is not impacting the ability of the drywell to perform its design functions.