October 18, 2002

Mr. John L. Skolds, President
and Chief Nuclear Officer
Exelon Nuclear
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: OYSTER CREEK NUCLEAR GENERATING STATION - ALTERNATIVE REPAIR OF CONTROL ROD DRIVE HOUSING INTERFACE WITH REACTOR VESSEL (TAC NO. MB5700)

Dear Mr. Skolds:

Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(g), requires that nuclear power facility components must meet the requirements contained in specific editions of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, for Inservice Inspection and Repair and Replacement Programs. Specifically, ASME Code, Section XI, IWA-4000, describes the Code repair process and requires the removal of the flaw and a subsequent weld repair.

By letter dated July 26, 2002, as supplemented on October 4, 2002, AmerGen Energy Company, LLC (AmerGen) requested approval of an alternative repair under 50.55a(a)(3)(i) of the control rod drive (CRD) housing penetrations at Oyster Creek Nuclear Generating Station (OCNGS). This request was for approval of an alternative to a Code repair of any additional CRD housing penetrations that exhibit leakage during future inspections until expiration of OCNGS's operating license on April 9, 2009. The Nuclear Regulatory Commission (NRC) staff reviewed the referenced submittals (see enclosed safety evaluation) and found AmerGen's proposed alternative will provide reasonable assurance of the integrity of the CRD housings to the reactor pressure vessel, and concluded that the proposed alternative will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the proposed alternative is authorized until the next refueling outage (i.e., RFO 20). If AmerGen intends to use this alternative as a permanent repair, the NRC staff recommends that AmerGen pursue this with the ASME Code Committee to accept this as a permanent repair through a code case.

Sincerely,

**/RA/**

Richard J. Laufer, Chief, Section 1
Project Directorate 1
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-219

Enclosure: Safety Evaluation

cc w/encl: See next page

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Sincerely,

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Docket No. 50-219
Enclosure: Safety Evaluation
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<u>Distribution:</u>

| | | | | |
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| PUBLIC | PDI-1 Reading | S. Richards | R. Laufer | ACRS |
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVE REPAIR OF CONTROL ROD DRIVE (CRD) HOUSING INTERFACE

WITH REACTOR VESSEL

AMERGEN ENERGY COMPANY, LLC

OYSTER CREEK NUCLEAR GENERATING STATION

DOCKET NO. 50-219

## 1.0 INTRODUCTION

By letter dated July 26, 2002, as supplemented on October 4, 2002, AmerGen Energy Company, LLC (AmerGen or the licensee), requested approval of an alternative to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(g), for Oyster Creek Nuclear Generating Station (OCNGS). The alternative consists of roll-expansion repairs to CRD housing penetrations at OCNGS. This request is similar to the November 10, 2000, request submitted by AmerGen for OCNGS which was approved by the Nuclear Regulatory Commission (NRC) staff by letter dated November 16, 2000. NRC approval was for roll-expansion repair for one cycle, from refueling outage (RFO) 18 up to the next refueling outage (RFO 19).

## 2.0 REGULATORY EVALUATION

Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(g), requires that nuclear power facility components must meet the requirements contained in specific editions of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), Section XI, for Inservice Inspection and Repair and Replacement Programs. Specifically, ASME Code, Section XI, IWA-4000, describes the Code repair process and requires the removal of the flaw and a subsequent weld repair. ASME Code, Section XI, IWA-5250 requires that the source of leakage detected during the conduct of a pressure test on a system be located and evaluated for corrective measures and repair. Pursuant to 10 CFR 50.55a(a)(3), proposed alternatives to the requirements of paragraphs 10 CFR 50.55a(c) - (h) may be used provided the applicant demonstrates (i) that the proposed alternatives would provide an acceptable level of quality and safety, or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

AmerGen's July 26, 2002, letter requested approval of an alternative repair under 50.55a(a)(3)(i) of the CRD housing penetrations at OCNGS. This request was for approval of an alternative to a Code repair of CRD housing penetrations that exhibit leakage during future inspections until expiration of OCNGS's operating license on April 9, 2009. The CRD housings and stub tubes are considered ASME Section XI Code Class 1 components.

Enclosure

3.0 TECHNICAL EVALUATION

As an alternative to the Code repair, AmerGen proposed to follow repair techniques and criteria stated in the Boiling Water Reactor (BWR) Vessel and Internals Project (BWRVIP) Report, “Roll/Expansion Repair of Control Rod Drive and In-Core Instrument Penetrations in BWR Vessels (BWRVIP-17).” AmerGen proposed to employ the roll-expansion repair technique as described in BWRVIP-17, as was used in the fall 2000 repair of the two penetrations, for repair of any additional penetrations that may exhibit leakage until expiration of OCNGS’s operating license on April 9, 2009. A weld repair according to BWRVIP-58, “BWR Vessel and Internals Project, CRD Internal Access Weld Repair,” or an equivalent Code repair, will be employed if roll-expanded penetrations do not meet the leakage limits in BWRVIP-17 or more than five CRD penetrations continue to leak after roll-expansion repairs.

BWRVIP provides the technical basis and criteria for performing a non-Code repair to an ASME Code component, including leakage criteria, design objectives, qualification criteria, and pre-repair and post-repair inspections. The licensee stated that the alternative provides a commensurate level of safety that would allow a repair to be deferred if insufficient time exists to perform a Code repair.

3.1 Historical Background

The NRC staff’s safety evaluation dated November 16, 2000, provides a detailed description of the history of the CRD penetration leaks at OCNGS. During the OCNGS 18R refueling outage, visual inspections performed during the reactor pressure vessel (RPV) leak test identified water leaking from the under-vessel area at the mirror insulation in the vicinity of CRD housings 42-43 and 46-39. Further inspection determined that the leakage originated at the interface of the RPV lower head and CRD housing.

The licensee has not determined the exact origin of the leak; however several possibilities exist which include the stub tube, the stub tube-housing weld, or the RPV-to-stub tube weld. The licensee will remove a control rod guide tube during refueling outage 19R, which commenced on October 4, 2002, to gain access to the lower plenum of the RPV. An examination of the bottom head in the area of the stub tubes associated with CRD housings 42-43 and 46-39 will be performed with a remote observation vehicle to support the root cause determination of the leakage. The licensee is requested to submit the results of the root cause evaluation within 90 days.

The penetrations were roll-expansion-repaired in accordance with BWRVIP-17. The BWRVIP-17 report referenced three licensee requests for an alternative under 10 CFR 50.55a(a)(3), including one from Nine Mile Point Nuclear Station, Unit No 1 (NMP1). By letter dated March 25, 1987, the NRC staff provided an evaluation of the NMP1 request. The NRC staff’s evaluation granted approval to the NMP1 licensee based on a number of conditions and ongoing licensee activities, including the absence of cracks in the J-weld, leakage inspections, development of a prototype mechanical seal, and associated tooling and investigation of methods of weld repair. The approval was based on the specific locations of the cracks at NMP1, the change to the plant’s Technical Specifications (TSs) to limit leakage, as well as the development of a permanent repair that corrects the degradation to the reactor coolant system pressure boundary. The NRC staff did not approve the roll/expansion process as a permanent repair for NMP1 in lieu of meeting the ASME Code repair criteria, but rather as a temporary repair until such time as a permanent repair could be implemented.

3.2 NRC Evaluation of the BWRVIP-17 Report

In a letter dated March 13, 1998, the NRC staff completed its review of the BWRVIP-17 Report. The NRC staff's position is that the corrective action required by the ASME Code, upon discovery of a flaw in a Class 1 pressure retaining boundary component, is either to repair the flaw or replace the flawed component in order to return it to a condition of Code compliance. An ASME Code-acceptable repair of a crack in a CRD stub tube or in-core penetration would require a weld repair. Although the roll/expansion method may, for some time period, control the symptom of the flaw (leakage), it does not repair the flaw; therefore, it does not meet the criteria or the intent of a permanent repair method. The NRC staff determined that the BWRVIP-17 report does not provide a sufficient basis for authorizing a permanent alternative pursuant to 10 CFR 50.55a(a)(3). As such, the NRC staff denied the BWRVIP-17 generic application in a letter dated March 13, 1998.

3.3 ASME Code Requirements

The ASME Code, Section XI, for Inservice Inspection and Repair and Replacement Programs, IWA-4000, describes the Code-repair process. A Code repair requires the removal of the flaw and a subsequent weld repair. Additionally, ASME Code, Section XI, IWA-5250, requires that the source of leakage detected during the conduct of a pressure test on a system be located and evaluated for corrective measures and repair. The CRD housings and stub tubes are considered ASME Code, Section XI, Class 1 components.

3.4 The Licensee's Proposed Alternative Repair

3.4.1 Specific Description of the Repair

The licensee's proposed alternative is to follow repair techniques and criteria stated in BWRVIP-17 which provides the technical basis and criteria for performing a non-Code repair to an ASME Code component. These include leakage criteria, design objectives, qualification criteria, and pre-repair and post-repair inspections.

During RFO 18, the repair activity involved a roll expansion of CRD housings 42-43 and 46-39 that were plastically expanded into the bore region of the RPV lower head. This roll expansion process was utilized to repair RPV lower head housings at NMP-1, which employs a CRD housing design similar to that of OCNGS. In a safety evaluation (SE) dated March 25, 1987, the NRC staff approved the roll expansion process for NMP1 as a temporary repair until such time as a permanent Code repair could be completed. In an SE dated November 10, 2000, the NRC staff, as stated above, approved the roll expansion process for OCNGS for one cycle, as a temporary repair, until such time as a permanent Code repair could be completed.

The licensee implemented the methodology and tooling that was developed for the NMP1 roll-expansion repair for OCNGS's CRD housings 42-43 and 46-39. AmerGen stated that the roll expansion repair mitigated leakage from the cracking of: (1) the stub tube, (2) the stub-tube-to-housing weld, or (3) the RPV-to-stub-tube weld.

3.4.2 Design Objectives

To date, the licensee indicated that the roll expansion process eliminated leakage from CRD housings 42-43 and 46-39. Similar results in eliminating CRD housing penetration leakage are expected for any future roll-expansion repairs. The housings were plastically expanded within the RPV lower head bore to create a radial contact pressure between the housing and the vessel bore. Proper contact pressure was achieved by controlling the radial expansion of the housing and by utilizing additional passes to increase the contact length. The licensee stated that the process will have no harmful effects on affected CRD housings.

3.4.3 Design Criteria

CRD housings 42-43 and 46-39 were diametrically expanded to ensure that the contact pressure at the housing to RPV lower head bore was about three to five times the RPV system pressure (i.e., 3000 psi - 5000 psi). During the rolling process, the CRD housing expands locally along the rolled interfaces. Because the yield strength of the RPV lower head is greater than that of the CRD housing, the net effect is plastic deformation and wall thinning of the CRD housing. Wall thinning of 3- to 5-percent in the housing thickness is required to achieve a continuous contact pressure between the housing and the vessel bore. Experience has shown that a roll length between 4.5 to 5.5 inches combined with wall thinning in the range of 3%-5% is effective in mitigating leakage. The diameter of the CRD housing is increased by 0.070 inches ± 0.006 inches. The roll expansion process, equipment, and personnel are qualified on a mockup to ensure that process parameters are maintained during in-plant application.

The actual CRD housing wall thinning was in the range of 5.8% for CRD 42-43 and 6% for CRD 46-39. AmerGen provided a discussion regarding these wall thinning results by letter dated November 14, 2000. The report concluded that, while greater than the nominal range for a typical initial roll, the wall thinning achieved for CRDs 42-43 and 46-39 was within design parameters and there were no negative impacts.

3.4.4 Penetration Leakage Acceptance Limits

The licensee stated that the leakage that can be generated through all possible locations is not considered safety significant since allowable total unidentified leakage is limited to 5 gallons per minute (gpm) and the allowable increase in unidentified leakage within any 24-hour period of steady-state operation is limited to 2 gpm per the OCNGS TSs. Additionally, acceptable leakage limits, as documented in the BWRVIP-17 Report, will be followed. These leakage limits are similar to those approved for NMP1 in the NRC staff's SE dated March 25, 1987. The leakage limits reflect whether the inspection for leakage occurs during a short (<7 days) or extended (>7 days) outage. In accordance with the NRC's approval of NMP1 leakage limits, the maximum number of leaking housings or stub tubes will not exceed five.

3.4.5 Repair Evaluation and Qualification

The licensee stated that the roll repair will meet the qualification criteria in Section 3 of the BWRVIP-17 Report as it applies to OCNGS, without exception.

3.4.6 Pre-Repair and Post-Repair Inspection

Before performing the repair, the housing will be ultrasonically tested (UT) to verify its structural integrity in the area to be rolled and at the location of the CRD housing to stub-tube weld (including the portion of the housing above and below the weld with coverage of the heat-affected zone). The examinations will be performed in accordance with an intergranular-stress-corrosion cracking (IGSCC)-qualified procedure. Dimensional inspections will be performed, as appropriate, to determine the pre-rolled inside diameter (ID) of the CRD housing. Additionally, all repaired CRDs will be stroke-timed and scram-tested before returning to service.

Following repair and before plant restart, the UT will be repeated and dimensional examinations performed. The purpose of the follow-up UT examination is to confirm that no cracks developed during rolling. The purpose of the dimensional inspection is to determine the as-rolled ID of the housing so that the wall thinning can be verified. An ASME Code, Section XI, inservice leak test and post-repair pressure test will be performed to determine the extent, if any, of remaining leakage.

A VT-2 visual examination will be performed during the pressure test to satisfy the requirements of ASME Code, Section XI, IWA-5246. The examinations will be performed at the nominal operating pressure of the Class 1 boundary, based on ASME Code, Section XI, IWA-4000, requirements for pressure testing the installation of mechanical joints.

During subsequent RFOs, UT examination of the housing will be performed when normal CRD maintenance activities make access to the housing ID available.

3.5 <u>Safety Evaluation</u>

3.5.1 Component Failure Analysis

Because the leakage location is indeterminate, a Code-compliant weld repair could not be specified by the licensee. Although the exact origination of the leak was not determined, several possibilities exist, which include: 1) the stub tube, 2) the stub-tube-to-housing weld or 3) the RPV-to-stub-tube weld. All of these components are constructed of stainless steel. The leaking stub tubes were sensitized during stress relief when the reactor vessel was under construction. It should be noted that stub tubes were cracked prior to operation perhaps by the chlorides in the seaside environment. The sensitized stub tubes were repaired and clad with 308L stainless steel and weld material 182 to limit the likelihood of cracking while in service.

The most likely cause of leakage of a stainless steel weld in this service is crack growth resulting from IGSCC, which is well understood and bounded. All industry experience related to stainless steel cracking has shown ample time to react from the time of significant leakage to failure. In addition, prior to performing the repair, the CRD housing will be ultrasonically examined to verify its structural integrity in the area to be rolled and at the location of the CRD housing-to-stub-tube weld. This examination will include that portion of the housing above and below the stub-tube-to-RPV weld.

3.5.2 Safety Analysis for the Repaired Penetration

The licensee evaluated the proposed alternative repair in accordance with 10 CFR 50.59. The NRC staff reviewed the evaluation and added information as appropriate. The following areas were addressed:

(1) Leakage from the housing to stub-tube welds, stub-tube-to-vessel welds, or through-wall leakage in the stub tube.

The leakage that can be generated through any and all of these locations is not considered safety significant since any leakage will be measured as part of the unidentified leak rate, which has a TS limit of 5 gpm. Additionally, the existing TSs limit the increase in unidentified leakage within any 24-hour period of steady state operation to 2 gpm. Any leakage will be well within plant system make-up capabilities. Therefore, leakage is controlled.

(2) Rod ejection due to total stub-tube failure

Rod ejection from total stub-tube-to-housing failure is not a credible scenario because the weld nugget attached to the CRDM housing would not allow the housing to eject if the stub tube was completely cracked.

In the extremely unlikely event that rod ejection occurs, the system design includes the CRD shoot-out steel installed under the vessel, which will limit rod ejection such that total ejection and/or missile generation is not possible. Leakage from a rod housing total displacement has been determined to be about 150 gpm. The core spray system is designed for a large-break loss-of-coolant accident event. Therefore, the leakage associated with a rod ejection is well within the capability of the core spray system. Additionally, the shoot-out steel is positioned below the CRDs and designed for the maximum force that could be imposed by a ruptured CRD housing, so that axial motion would be prohibited or limited.

The ability of the collet fingers to stop rod ejection has been investigated using dynamic drop tests. Free fall drop tests of weights equal to the rod weight were conducted to simulate index tube impact on the collet. Height of the free fall was varied to cover a range of impact velocities from zero to 15 feet per second (maximum possible rod ejection velocity in the CRD is calculated to be 10 feet per second). In each test, the ability of the collet to stop the ejection and hold the index tube was demonstrated. Thus, even in the event of a housing failure, the control rod would not be ejected from the core (OCNGS Final Safety Analysis Report 3.9.4.4).

(3) Loads during scram

Loads on the housing that result from a scram (CRD deceleration) could lift the housing relative to the head. The upward force is from the inertia of the drive and the control blade as its upward velocity is stopped at the end of the insertion (or scram) stroke. The possibility of upward motion of a housing at the end of the scram has been investigated.

Vessel pressure above 372 psi results in a downward force on the housing that is sufficient to resist motion caused by the end of scram force (including a suddenly applied load factor of 2). If the scram occurs below 372 psi, the insertion function of the drive will already have been accomplished.

(4) CRD misalignment such that rod insertion is affected

CRD misalignment can only occur with a 360° through-wall crack in the CRD housing-to-stub-tube weld, stub-tube-to-vessel weld, or rod ejection. Misalignment will be minimized, should it occur, by the roll repair. Testing will be performed to verify drive operability. Rod movement is verified periodically, and any potential problems will be identified by normal, required surveillance testing.

(5) CRD housing displacement

The roll expansion repair can cause the top end of the CRD housing to be displaced relative to the lower flange in the horizontal direction, which could potentially cause misalignment of the control rod blade within the reactor core and create difficulties in control rod blade insertion. As discussed in the NRC SE for NMP1 (dated June 29, 1984), the effect of CRD housing misalignment with respect to the reactor core was evaluated by General Electric. Test results indicate that there is no significant increase in scram time for a 1-inch displacement of the CRD housing. The maximum displacement of the NMP1 CRD housing was 0.35 inches; therefore, the functional requirement of the CRD to insert the control rod blades will not be adversely affected by the roll expansion repair. Additionally, scram time testing will be performed on all drives that will undergo the rolling process.

(6) Structural loads

Stress analysis performed by Combustion Engineering for NMP1 has shown that the load carrying capacity of the rolled area exceeds that of the weld; therefore, the load carrying capacity will not be compromised by rolling. Furthermore, the fatigue usage factors were found to remain essentially the same after implementation of the roll expansion repair. After implementation of the roll expansion repair, the CRD housing and RPV lower head will continue to meet plant design fatigue requirements.

3.6 <u>NRC Staff Evaluation of the Proposed Alternative</u>

Based on industry experience, roll expanding of the CRD housing to the RPV has been identified as an appropriate alternative repair for use at OCNGS. To date, the roll expansion process has been successful in eliminating leakage from CRD housings 42-43 and 46-39. The housings were plastically expanded within the RPV lower head bore to create a radial contact pressure between the housing and the vessel bore. Proper contact pressure is achieved by controlling the radial expansion of the housing and by utilizing additional passes to increase the contact length. The process will have no harmful effects on CRD housing 42-43 and 46-39 stub tubes or the reactor vessel. Potential failures, which could occur as a result of this repair, have been evaluated.

The roll repair will meet the qualification criteria in Section 3 of the BWRVIP-17 Report as it applies to OCNGS, without exception, and the nominal 3- to 5-percent minimum thinning to achieve continuous contact. Additionally, the alternative provides for the pre-repair and post-repair inspections to ensure the adequacy of this proposed repair. Thus, the proposed alternative will provide assurance of structural integrity for the approval period requested. Because use of the alternative repair in BWRVIP-17 until RFO 20 will provide adequate assurance of structural integrity, the staff finds that the proposed alternative would provide an acceptable level of quality and safety.

The licensee, in its submittal of November 10, 2000, committed to reevaluate previous hydrogen water chemistry (HWC) electro-chemical potential (ECP). By its October 4, 2002, letter the licensee indicated that as a result of the HWC ECP reevaluation, the hydrogen water chemistry injection was increased midcyle (RFO 18) from 0.3 parts-per-million (ppm) to 0.5 ppm. The licensee also indicated that for RFO 19, noble metal chemistry addition will be implemented. The NRC staff acknowledges that the licensee is taking measures that should improve resistance to IGSCC.

The NRC staff has evaluated the licensee's proposed alternative for OCNGS. The NRC staff finds that the proposed roll expansion repair, as described above, and any re-roll repairs required for CRD housings 42-43 and 46-39, are acceptable until RFO 20. The NRC staff requests that the licensee provide, within 90 days, the RFO 19 inspection results of the CRD housing penetrations. In addition, the NRC staff requests that the licensee submit, within 90 days, an evaluation of the existing leakage and include a determination of why and where the leakage occurred given that specific measures were taken to prevent cracking, i.e., application of Inconel cladding to the stub tubes at original construction and application of HWC in 1995. The implementation of the alternative is subject to inspection by the NRC.

The NRC staff does not approve the roll-expansion process as a permanent repair for OCNGS in lieu of meeting the ASME Code repair criteria. The NRC staff recommends that if the licensee intends to use this alternative as a permanent repair, it should pursue this alternative repair of the CRD housings with the Code Committee to accept this as a permanent repair through a Code Case on an expedited basis. Should this prove to be not successful, the NRC staff recommends that the licensee follow up with a schedule for a permanent Code repair.

## 4.0 CONCLUSION

The proposed alternative repair will ensure the continued integrity of the CRD housings and reactor vessel, and ensure that the associated components perform their intended safety function. The alternative includes controls over repair processes that have been established to ensure that the repair will be performed in a safe and effective manner.

Because the licensee's proposed alternative will provide reasonable assurance of the integrity of the CRD housings to the RPV, the NRC staff concludes that the proposed alternative will provide an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the proposed alternative is authorized until RFO 20.

Principal Contributor: Meena Khanna

Date: October 18, 2002

Chief Operating Officer
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

Senior Vice President - Nuclear Services
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

Vice President - Mid-Atlantic Operations Support
Exelon Generation Company, LLC
200 Exelon Way, KSA 3-N
Kennett Square, PA 19348

Senior Vice President -
Mid Atlantic Regional Operating Group
Exelon Generation Company, LLC
200 Exelon Way, KSA 3-N
Kennett Square, PA 19348

Kevin P. Gallen, Esquire
Morgan, Lewis, & Bockius LLP
1800 M Street, NW
Washington, DC 20036-5869

Kent Tosch, Chief
New Jersey Department of
Environmental Protection
Bureau of Nuclear Engineering
CN 415
Trenton, NJ 08625

Vice President -
Licensing and Regulatory Affairs
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

Site Vice President
Oyster Creek Nuclear Generating Station
AmerGen Energy Company, LLC
PO Box 388
Forked River, NJ 08731

H. J. Miller
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406-1415

Mayor of Lacey Township
818 West Lacey Road
Forked River, NJ 08731

Senior Resident Inspector
U.S. Nuclear Regulatory Commission
P.O. Box 445
Forked River, NJ 08731

Director - Licensing
Exelon Generation Company, LLC
Correspondence Control Desk
P.O. Box 160
Kennett Square, PA 19348

Oyster Creek Generating Station Plant Manager
AmerGen Energy Company, LLC
P.O. Box 388
Forked River, NJ 08731

Regulatory Assurance Manager
Oyster Creek Nuclear Generating Station
AmerGen Energy Company, LLC
P.O. Box 388
Forked River, NJ 08731

Vice President, General Counsel and Secretary
Exelon Generation Company, LLC
300 Exelon Way
Kennett Square, PA 19348

J. Rogge, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406-1415

Manager Licensing - Oyster Creek and Three Mile Island
Exelon Generation Company, LLC
Nuclear Group Headquarters
Correspondence Control
P.O. Box 160
Kennett Square, PA 19348

Correspondence Control Desk
Exelon Generation Company, LLC
200 Exelon Way, KSA 1-N-1
Kennett Square, PA 19348