UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 11, 2019

Mr. Bryan C. Hanson
Senior Vice President
Exelon Generation Company, LLC
President and Chief Nuclear Officer
Exelon Nuclear
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: OYSTER CREEK NUCLEAR GENERATING STATION – REISSUANCE WITH REVISED EFFECTIVE DATE OF EXEMPTIONS FROM CERTAIN EMERGENCY PLANNING REQUIREMENTS (EPID L-2018-LLA-0305)

Dear Mr. Hanson:

The U.S. Nuclear Regulatory Commission (NRC) has reissued the enclosed exemptions from specific requirements of Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, Section 50.47, "Emergency plans," and 10 CFR Part 50, Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities," based on the permanently shutdown and defueled status of the Oyster Creek Nuclear Generating Station. This action is in response to your submittal dated November 6, 2018, as supplemented by letter dated February 13, 2019, that requested exemptions from certain emergency planning requirements with a modified effective date of 285 days after permanent cessation of operations.

A copy of the NRC staff's safety evaluation for the revised effective date is also enclosed. The exemptions are being forwarded to the Office of the Federal Register for publication.

Sincerely,

/RA/
Amy M. Snyder, Senior Project Manager
Reactor Decommissioning Branch
Division of Decommissioning, Uranium Recovery and Waste Programs
Office of Nuclear Material Safety and Safeguards

Docket No. 50-219

Enclosures:
1. Safety Evaluation
2. Exemption

cc: Listserv

SUBJECT: OYSTER CREEK NUCLEAR GENERATING STATION – REISSUANCE WITH REVISED EFFECTIVE DATE OF EXEMPTIONS FROM CERTAIN EMERGENCY PLANNING REQUIREMENTS (EPID L-2018-LLA-0305)
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ADAMS Accession Nos.: Pckage: ML19095A997 LTR: ML19095A873
Exemption FRN: ML19095A872 Exemption: ML19095A870

*via email **via memo

OFFICE	NRR/DORL/LPL2-1/PM	NRR/DORL/LSPB/LA	NSIR/DPR/RLB/BC*	NRR/DSS/SCPB/BC**
NAME	JLamb	JBurkhardt	JAnderson	SAnderson
DATE	4/8/19	4/8/19	5/7/19	5/3/19
OFFICE	OGC – NLO*	NMSS/DUWP/RDB/BC	NMSS/DUWP/D	NMSS/DUWP/RDB/PM
NAME	JScro	BWatson	JTappert	ASnyder
DATE	5/21/19	5 / 22 /19	5 / 22 /19	6/11/19

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ENCLOSURE 1

SAFETY EVALUATION RELATED TO

EXELON GENERATION COMPANY, LLC

OYSTER CREEK NUCLEAR GENERATION STATION

REQUEST FOR EXEMPTIONS FROM PORTIONS OF

10 CFR 50.47 AND 10 CFR PART 50, APPENDIX E

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REVISED MINIMUM DECAY TIME FOR IMPLEMENTATION OF DEFUELED EMERGENCY PLAN AND SUPPORTING EXEMPTION

EXELON GENERATION COMPANY

OYSTER CREEK NUCLEAR GENERATION STATION

DOCKET NO. 50-219

1.0 INTRODUCTION

By letter dated October 17, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18221A400), the U.S. Nuclear Regulatory Commission (NRC) granted Exelon Generation Company, LLC (Exelon, the licensee) a license amendment approving relaxation in the emergency plan and associated emergency action level scheme commensurate with the reduced likelihood of significant radiological events presented by the permanently defueled condition of the reactor and low decay heat rate of the stored fuel at Oyster Creek Nuclear Generating Station (OCNGS). This license amendment was supported by exemptions from certain emergency planning (EP) requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.47 and Appendix E to 10 CFR Part 50, in accordance with 10 CFR 50.12, "Specific exemptions." By letter dated October 16, 2018 (ADAMS Accession No. ML18220A980), the NRC staff notified Exelon that the Commission had granted the requested exemptions allowing Exelon to modify the OCNGS emergency plan (hereinafter the EP exemptions). The exemptions were to become effective no earlier than 12 months (365 days) after permanent cessation of power operations at OCNGS.

By letter dated January 7, 2011 (ADAMS Accession No. ML110070507), pursuant to 10 CFR 50.82(a)(1)(i), Exelon provided formal notification to the NRC that it planned to permanently cease operations at OCNGS no later than December 31, 2019. By letter dated February 14, 2018 (ML18045A084), Exelon subsequently notified the NRC of its plans to permanently cease operations at OCNGS no later than October 31, 2018. Exelon permanently ceased power operations at OCNGS on September 17, 2018. By letter dated September 25, 2018 (ADAMS Accession No. ML18268A258), Exelon certified the permanent removal of fuel from the OCNGS reactor vessel. Since the docketing of the certifications for permanent cessation of operations and permanent removal of fuel from the reactor vessel, as specified in 10 CFR 50.82(a)(2), has been completed, the 10 CFR Part 50 license for OCNGS no longer authorizes operation of the reactor or emplacement or retention of fuel into the reactor vessel.

By letter dated October 22, 2018 (ADAMS Accession No. ML18295A384), Exelon requested a change in the effective date of a previously approved permanently defueled emergency plan license amendment from 12 months (365 days) to 9.38 months (285 days) after permanent cessation of power operations. By letter dated November 6, 2018 (ADAMS Accession No. ML18310A306), Exelon separately requested to modify the effective date of the EP exemptions to 9.38 months (285 days) after permanent cessation of power operations.

In response to the NRC staff's request for additional information (RAI) dated February 13, 2019 (ADAMS Accession No. ML19044A643), Exelon submitted a revised adiabatic calculation

(Revision 2) in support of the requested effective date change. Revision 2 of the calculation replaces, in its entirety, the previous revision of the calculation (Revision 1) submitted in the October 22, 2018, letter (ADAMS Accession No. ML18295A384). The NRC staff's detailed review and technical basis for the approval of the EP exemptions are provided in the associated safety evaluation (hereinafter the October 2018, SE) (ADAMS Accession No. ML18220A980). Apart from the impact of the effective date, which is evaluated in this safety evaluation, the October 2018, SE remains valid. To provide a complete record of the NRC staff's analysis for the exemptions, the NRC reissued the EP exemptions originally granted on October 16, 2018, with the revised effective date of 285 days after the permanent cessation of power operations.

2.0 **REGULATORY EVALUATION**

2.1 BACKGROUND

Spent fuel is currently stored onsite in the OCNGS spent fuel pool (SFP) and a dry cask independent spent fuel storage installation (ISFSI) at the OCNGS facility. The OCNGS SFP, located within the Reactor Building, is a reinforced concrete structure, completely lined with seam welded stainless steel sheets. The SFP consists of thick reinforced concrete walls and reinforced concrete floor slab supported by reinforced concrete beams. To avoid unintentional draining of the pool, there are no penetrations that would permit the pool to be drained below one foot above the active fuel. All lines extending below this level are equipped with suitable valving to prevent backflow. A cask handling area is located within the SFP to provide for removal of irradiated fuel, and cask handling activities are supported by an upgraded single failure-proof crane to minimize the potential for a handling accident. The passage between the fuel storage pool and the refueling cavity above the reactor vessel is provided with two double sealed gates with a monitored drain between the gates.

The NRC staff has long recognized that the potential for a large radiological release at a decommissioning power reactor storing irradiated fuel in a SFP is lower than the potential for a large offsite radiological release at an operating reactor. The NRC staff evaluated the potential for large releases caused by Beyond-Design-Basis events affecting SFP storage in the 1980s (NUREG-1353, "Regulatory Analysis for the Resolution of Generic Issue 82',"Beyond Design Basis Accidents in Spent Fuel Pools'," issued April 1989 (ADAMS Accession No. ML082330232), and determined the risk was acceptably low, largely as a result of the low frequency of events that could challenge the integrity of the SFP structure. Subsequently, the NRC staff completed a detailed study of decommissioning risk, which is documented in NUREG-1738, "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," issued February 2001 (ADAMS Accession No. ML010430066). For spent fuel aged one year, the NRC staff estimated the frequency of fuel uncovery to range from 5.8×10^{-7} to 2.4×10^{-6} per year for the plants studied. The frequency of fuel uncovery was used as a simplifying and conservative surrogate for the overall frequency of severe fuel damage resulting from inadequate cooling following a loss of coolant inventory. Consistent with NUREG 1353, beyond design basis seismic initiating events dominate the fuel uncovery frequency estimates. Because the configuration of the fuel, the storage racks, and the pool structure could be affected in unpredictable ways by a major seismic event or cask drop, the associated consequence evaluation could not rule-out conditions where air cooling would be inadequate, even after many years of decay. To assess the available time for response measures, the analysis considered both situations where the heat of oxidation affected heat-up rate in air-cooled configurations and adiabatic heat-up in configurations where air cooling would be precluded.

Following removal of spent fuel from the reactor vessel, the principal radiological risks are associated with the storage of spent fuel onsite. Generally, a few months after the reactor has been permanently shutdown, there are no possible design-basis events that could result in a radiological release exceeding the U.S. Environmental Protection Agency (EPA) early phase protective action guides (PAGs) limit of one roentgen equivalent man (rem) at the exclusion area boundary. The only potential accident that might lead to a significant radiological release at a decommissioning reactor is a zirconium cladding fire. The zirconium cladding fire scenario is a postulated, but highly unlikely, beyond-design-basis accident scenario that involves a major loss of water inventory from the SFP, resulting in a significant heat-up of the spent fuel and culminating in substantial zirconium cladding oxidation and fuel damage. The significance of a spent fuel heat-up scenario that might result in a zirconium cladding fire depends on the decay heat of the irradiated fuel stored in the SFP. The amount of decay heat in the spent fuel is directly associated with the amount of time since the reactor permanently ceased operations. Therefore, the probability of a zirconium cladding fire scenario continues to decrease as a function of the time that the decommissioning reactor has been permanently shutdown.

The NRC staff believes based on past studies that for all but the most unlikely events, any offsite protective actions would be taken by governmental officials as a precautionary measure. On this basis, the NRC granted exemptions from radiological emergency planning requirements at many decommissioning reactors once an analysis performed by the licensee demonstrates that after a complete loss of SFP water inventory with no heat loss (adiabatic heat-up), a minimum of 10 hours is available before any fuel cladding temperature reaches 900 degrees Celsius (°C) from the time all cooling is lost. In the unlikely event of a beyond design-basis accident resulting in a loss of the SFP water inventory, there would be time to initiate appropriate SFP mitigating actions. If State or local governmental officials determine that offsite protective actions are warranted, then sufficient time and capability would also be available for offsite response organizations to implement these measures using a Comprehensive Emergency Management Program, "all-hazards," approach.

2.2 PROPOSED CHANGE

Exelon reanalyzed the site-specific Zirconium Fire Analysis, associated with an adiabatic heatup, to support an implementation date for the permanently defueled emergency plan and the supporting EP exemptions of 9.38 months (285 days) after permanent shutdown, instead of the 12 months, previously approved by the Commission. The licensee's analysis determined that there would be a sufficient decay time such that the hottest fuel assembly in the SFP would not reach the zirconium ignition temperature (900°C) in fewer than 10 hours. This reanalysis modeled an increased heat capacity of the fuel assembly by incorporating variations in specific heat with temperature and an additional fuel assembly component to compensate for higher decay heat rates at the reduced decay time.

Exelon requested that all other aspects of the NRC-approved EP exemptions, dated October 16, 2018, remain unchanged.

2.3 REGULATORY GUIDANCE

In accordance with 10 CFR 50.12, "Specific exemptions," the Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of 10 CFR Part 50 when: (1) the exemptions are authorized by law, will not present an undue risk to public health or safety, and are consistent with the common defense and security; and (2) any of the special circumstances listed in 10 CFR 50.12(a)(2) are present.

These special circumstances include, among other things, that the application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule.

As discussed in 10 CFR 50.47(a), "Emergency Plans," the NRC will grant an initial operating license only when the NRC finds reasonable assurance that protective measures can and will be taken in the event of a radiological emergency. As supported by numerous precedent exemptions and NSIR/DPR-ISG-02, "Interim Staff Guidance: Emergency Planning Exemption Requests for Decommissioning Nuclear Power Plants," May 11, 2015 (ADAMS Accession No. ML14106A057), the NRC has concluded that 10 hours provides sufficient time to meet the underlying purpose of the regulation by supporting implementation of the existing all-hazard emergency plans on an ad hoc basis instead of maintaining a specific radiological emergency plan.

3.0 **TECHNICAL EVALUATION**

3.1 Design-Basis Accidents and other Events

In Section 5.2 of Attachment 1 to its submittal in support of the EP exemptions, Exelon provided a summary of event analyses relevant to OCNGS in its permanently shutdown and defueled condition. After the permanent cessation of reactor operation and permanent removal of fuel from the reactor vessel, most of the initial conditions of accident and transient analyses included in the safety analysis report are no longer possible. The licensee identified the fuel handling accident (FHA) in the Reactor Building where the SFP is located as the only design-basis accident scenario with the potential to result in a radiological release in the permanently shutdown and defueled state of OCNGS. An analysis based on the FHA was performed to determine the dose to operators in the control room and the public at the Exclusion Area Boundary (EAB or Site Boundary) as a function of time after shutdown.

As described in the licensee supplement dated November 6, 2018 (ADAMS Accession No. ML18310A306), Exelon provided an analysis in support of the modified effective date for the EP exemptions that demonstrated that, as of 33 days after permanent cessation of operations, the radiological consequences of the only remaining design-basis accident (DBA) with potential for offsite radiological release (i.e., a FHA in the Reactor Building) will not exceed the limits of the EPA early phase PAGs to the public beyond the exclusion area boundary. Exelon stated that this analysis remains unchanged. Because the requested effective date of the exemptions is 285 days following permanent cessation of power operations, the 33-day decay necessary for the FHA dose to decrease within the EPA PAGs remains bounded.

3.2 Beyond-Design-Basis Accidents

The NRC staff evaluates the ability to mitigate beyond design basis events considering the time available to implement measures to maintain the fuel cool or, if necessary, implement an appropriate emergency response. The NRC staff uses an assessment of the adiabatic heat-up to determine the available time because it is generally limiting. The NRC staff uses a time of greater than 10 hours to support a finding of special circumstances related to the emergency planning regulation exemptions. The heat-up time calculated the time to reach temperature 900 degrees Celsius, which correlated to 1652 °F, as the temperature where "runaway oxidation" (zirconium fire) is expected to occur, as defined in NUREG-1738.

By letter dated October 22, 2018 (ADAMS Accession No. ML18295A384), Exelon requested a change in the effective date for the previously approved permanently defueled emergency plan license amendment from 12 months (365 days) to 9.38 months (285 days) after permanent cessation of power operations. By letter dated November 6, 2018 (ADAMS Accession No. ML18310A306), Exelon separately requested to modify the effective date of the EP exemptions supporting the emergency plan change to 9.38 months (285 days) after permanent cessation of power operations. The licensee justified the earlier effective date for when Exelon can implement the approved permanently defueled emergency plan amendment by re-evaluating the decay time necessary to ensure a 10-hour heat-up time from normal fuel temperatures to the temperature associated with runaway zirconium oxidation. The changes in the calculation involved a decreased decay heat rate for the limiting fuel assembly and a change in the heat capacity of the fuel assembly by assuming that additional components of the fuel assembly would heat-up uniformly with the fuel. The NRC staff determined that an effective heat transfer path would be necessary to allow the additional components to heat uniformly and requested additional information justifying the uniform heat-up.

In response to the NRC staff's request for additional information justifying the assumption of uniform temperatures within the analysis boundary, Exelon provided a revised calculation in Attachment 2 to the letter dated February 13, 2019 (ADAMS Accession No. ML19044A643). This revised calculation limited the additional components that would heat-up uniformly, with the fuel to the fuel assembly channel box assembly, in the region of the fuel at elevated temperatures, where radiative heat transfer would be effective and decreased conservatisms in the calculated heat capacity by modeling the change in specific heat of fuel assembly materials as temperatures increase.

To demonstrate a 9.38-month decay would be adequate to reduce the heat rate from the limiting spent fuel bundle, the licensee presented an evaluation of the length of time (in hour increments) it would take for uncovered spent fuel assemblies in the SFP to reach the temperature at which the zirconium fire could result. The calculation used an assumed initial temperature, calculated specific heat values as a function of temperature within the heated length of the assembly, and calculated a decay heat rate for the hottest fuel assembly. From this information, the licensee determined the time to reach 900 °C, which corresponds to runaway cladding oxidation and the potential for a large radiological release.

The initial fuel assembly temperature for the heat-up analysis is assumed to be uniform and 125 degrees Fahrenheit, which is the maximum initial pool temperature shown in OCNGS Technical Specification 5.3.1. The heat-up time is assumed to start when the spent fuel pool has been completely drained, which is conservative relative to the actual conditions following a rare and challenging event that could lead to a loss of SFP water. For these events, water would be expected to be present for a significant time, considering the large volume of water initially in the pool, and absorb much of the decay heat generated during that time. The adiabatic assumption assumes there is no air cooling of the assemblies, because natural circulation flow paths are not credited and assumed blocked. These assumptions eliminate other mechanisms in which decay heat would be transferred away from the fuel bundle either by convective heat transfer or by the boiling of spent fuel pool water. The analysis also conservatively does not credit the full mass of material found in the bundle as the thicker corners of the fuel channel are not included in the calculation of the channel mass. Also, the mass of the upper and lower stainless-steel tie plates is not included but could provide a conductive heat pathway for some of the decay heat.

The licensee's heat up analysis was performed with a spreadsheet to calculate the time to reach 900 degrees Celsius, which correlated to 1652 °F. For this analysis, the specific heat for uranium dioxide and the Zircaloy-2 cladding mass were calculated at fixed time intervals (or time steps), as assembly temperature increases. The calculation determines the increase in temperature over sequential time steps of 0.025 Hours. The specific heat capacity is based on the temperature determined after the previous time step. The specific heat capacity values increase with temperature over the range from 300K (80 °F) to 1,173K (900 °C). These specific heat capacities at various temperatures of Zircaloy-2 were determined by interpolating values developed in NUREG/CR-6150, Volume 5, Revision 2, "SCDAP/RELAP/MOD3.3 Code Manual: Assessment of Modeling of Reactor Core Behavior During Severe Accidents," dated January 2001 (ADAMS Accession No. ML010310397). The uranium dioxide specific heat values were calculated using the approach found in NUREG/CR-7024, "Material Property Correlations: Comparisons between FRAPCON-3.4, FRAPTRAN 1.4 and MATPRO," dated March 2011 (ADAMS Accession No. ML11101A012). The NRC staff reviewed the licensee's correlation of specific heat values to fuel assembly temperature and compared it to other industry information specific to zircaloy and uranium dioxide. The NRC staff found the values reasonable.

In the calculation, the licensee assumed an adiabatic envelope around the active fuel region of the assembly, where all components heat-up uniformly with the fuel pellets and cladding. Only the masses within the active fuel region (fuel pellets, cladding, water rods, and pin spacers) were initially modeled. When the bulk temperature reaches 580 degrees Fahrenheit, the licensee incorporated the fuel assembly channel heat capacity in the model by adding its mass to that of other zircaloy components. Because radiative heat transfer between the fuel rods and the channel is a function of the difference between the fourth power of the absolute temperatures of the involved components, the elevated temperature helps ensure the channel temperature would increase uniformly with the components in the fuel region. At this temperature, substantial heat may be radiatively transferred to the channel with a relatively small temperature difference. Therefore, the analysis assumption that the components heat uniformly would be reasonably satisfied. Heat absorbed by the channel at lower temperatures was neglected because the radiative heat transfer path requires a substantial temperature difference at those lower temperatures and no other credible heat transfer path to the channel is available.

The thermal capacity of the fuel assembly was calculated based on the dimensions and materials used for GNF2 fuel assembly design. The licensee described that the final cycle 26 contains a full core of GNF2 fuel. As specified in the analysis, the worst-case (hottest) bundle was defined as the assembly with the maximum calculated burnup, minimum initial enrichment, and maximum inventory of uranium. The decay heat was evaluated using the ORIGEN-ARP code for the hottest bundle discharged at the end of Cycle 26 for cooling times from 9 months to five years. Fuel properties are assumed to be those of Uranium dioxide fuel pellets and the Zircaloy-2 cladding.

The NRC staff concluded after 9.38 months (285 days) decay, more than 10 hours would be available before any fuel cladding temperature reaches 900 degrees Celsius from ther time all cooling is lost, thus satisfying Criterion 2 of NSIR/DPR-ISG-02 (Section 5.0).

The NRC staff's evaluation of all other aspects of the NRC-approved exemptions, dated October 16, 2018, remains valid.

3.3 Conclusion

As explained above, on October 16, 2018, the Commission determined that the licensee's requested exemptions from certain requirements of 10 CFR 50.47(b), 10 CFR 50.47(c), and Appendix E to 10 CFR Part 50, as specified in the October 2018, SE, satisfied the criteria in 10 CFR 50.12. These EP exemptions originally had an effective date of 12 months (365 days) from permanent cessation of power operations. Subsequently, the licensee requested that the EP exemptions be effective at 9.38 months (285 days) after the permanent cessation of power operations, as opposed to 12 months (365 days).

The NRC staff previously evaluated the safety impacts of the EP exemptions in the associated October 2018 SE. The NRC staff's evaluation in the October 2018, SE of all other aspects of the EP exemptions, apart from the new effective date, remain valid.

To address the impact of the revised effective date of the EP exemptions, the NRC staff reviewed the calculation to verify that important physical properties of materials were within acceptable ranges and that the results were accurate. The NRC staff determined that physical properties were appropriate. Therefore, the NRC staff found that after 9.38 months (285 days), more than 10 hours would be available before any fuel cladding temperature reaches 900 °C from the time all cooling is lost. As such, the NRC staff concluded that the adiabatic heat-up calculation provided an acceptable method for determining the minimum time available for deployment of mitigation equipment and, if necessary, for offsite governmental officials to implement measures under a comprehensive emergency management plan, or "all-hazards," approach.

Accordingly, the Commission has determined that, pursuant to 10 CFR 50.12, reissuing the EP exemptions originally granted on October 16, 2018, with the revised effective date of 285 days after the permanent cessation of power operations at Oyster Creek will not present an undue risk to the public health and safety, and is consistent with the common defense and security. Also, special circumstances are present. Specifically, the NRC staff finds that with the licensee's requested exemptions meet the underlying purpose of the planning standards in 10 CFR 50.47 and requirements in Appendix E to 10 CFR Part 50 in view of the reduced risk of offsite radiological consequences associated with a permanently shutdown and defueled condition at Oyster Creek and, therefore, satisfy the special circumstances in 10 CFR 50.12(a)(2)(ii) and can be implemented at 9.38 months (285 days) after permanent cessation of power operations.

Principal Contributors: S. Jones, NRR
G. Curran, NRR

Date: June 11, 2019

ENCLOSURE 2

EXEMPTIONS

EXELON GENERATION COMPANY, LLC

OYSTER CREEK NUCLEAR GENERATION STATION

REQUEST FOR EXEMPTIONS FROM PORTIONS OF

10 CFR 50.47 AND 10 CFR PART 50, APPENDIX E