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10 CFR 50.90

February 15, 2019

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Peach Bottom Atomic Power Stations, Units 2 and 3
Renewed Facility Operating License Nos. DPR-44 and DPR-56
NRC Docket Nos. 50-277 and 50-278

Subject: Response to Request for Additional Information - License Amendment Request to Reduce High Pressure Service Water System Design Pressure and Revise Technical Specifications 3.6.2.3, 3.6.2.4, 3.6.2.5, and 3.7.1 for Temporary Extension of Completion Times

References:

1. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission – "*License Amendment Request to Reduce High Pressure Service Water System Design Pressure and Revise Technical Specifications 3.6.2.3, 3.6.2.4, 3.6.2.5, and 3.7.1 for Temporary Extension of Completion Times*," dated September 28, 2018 (ADAMS Accession No. ML18275A023)

2. Electronic mail message from Jennifer Tobin (U.S. Nuclear Regulatory Commission) to David Helker, Exelon Generation Company, LLC – "*Peach Bottom Units 2 and 3 - Request for Additional Information - High Pressure Service Water One Time TS Change (EPID L-2018-LLA-0265)*," dated January 16, 2019 (ADAMS Accession No. ML19017A047)

By letter dated September 28, 2018 (Reference 1), Exelon Generation Company, LLC (Exelon) requested amendments to Renewed Facility Operating License Nos. DPR-44 and DPR-56 for Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, respectively. The proposed changes revise the PBAPS, Units 2 and 3, design and licensing basis described in the Updated Final Safety Analysis Report (UFSAR) to reduce the design pressure rating of the High Pressure Service Water (HPSW) system. The proposed changes will provide additional corrosion margin in the HPSW system pipe wall thickness, increasing the margin of safety for the existing piping. The proposed changes will also temporarily revise the PBAPS, Units 2 and 3, Technical Specifications (TS) Sections 3.6.2.3, "Residual Heat Removal (RHR) Suppression Pool Cooling," TS 3.6.2.4, "Residual Heat Removal (RHR) Suppression Pool Spray," TS 3.6.2.5, "Residual Heat Removal (RHR) Drywell Spray," and TS 3.7.1, "High Pressure Service Water (HPSW) System," to allow sufficient time to perform physical modifications of the PBAPS, Units 2 and 3, HPSW systems and other supporting plant equipment.

The NRC reviewed the information provided in Reference 1 and indicated the need for additional information in order to complete its review and evaluation of the amendment request. In an electronic mail message dated January 7, 2019, the NRC issued a draft

Request for Additional Information (RAI). This draft RAI was the subject of further discussions during a teleconference on January 16, 2019, between Exelon and NRC representatives. The NRC then formally issued the RAI on January 16, 2019 (Reference 2) and requested that Exelon respond to the RAI by February 18, 2019.

The Attachment to this letter provides a restatement of the RAI questions cited in Reference 2 followed by Exelon's responses.

Exelon has reviewed the information supporting a finding of no significant hazards consideration, and the environmental consideration, that were previously provided to the NRC in the Reference 1 letter. Exelon has concluded that the information provided in this response does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92. In addition, Exelon has concluded that the information in this response does not affect the bases for concluding that neither an environmental impact statement nor an environmental assessment needs to be prepared in connection with the proposed amendment.

There are no new regulatory commitments in this response.

In accordance with 10 CFR 50.91, "Notice for public comment; State consultation," paragraph (b), Exelon is notifying the Commonwealth of Pennsylvania of this RAI response by transmitting a copy of this letter and its attachments to the designated State Official.

If you have any questions or require additional information, please contact Richard Gropp at 610-765-5557.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 15th day of February 2019.

Respectfully,

D. P. Helker

David P. Helker
Manager, Licensing and Regulatory Affairs
Exelon Generation Company, LLC

Attachment: Response to Request for Additional Information - License Amendment Request for High Pressure Service Water System Design Change and One-Time Technical Specifications Changes

cc: w/ Attachment
Regional Administrator – NRC Region I
U.S. NRC Senior Resident Inspector – Peach Bottom Atomic Power Station
U.S. NRC Project Manager, NRR – Peach Bottom Atomic Power Station
Director, Bureau of Radiation Protection – Pennsylvania Department of Environmental Protection
R. R. Janati, Pennsylvania Bureau of Radiation Protection
D. A. Tancabel, State of Maryland

ATTACHMENT

License Amendment Request

Peach Bottom Atomic Power Station, Units 2 and 3
Docket Nos. 50-277 and 50-278

Response to Request for Additional Information - License Amendment Request for High Pressure Service Water System Design Change and One-Time Technical Specifications Changes

Attachment

Response to Request for Additional Information – License Amendment Request for High Pressure Service System Design Change and One-Time Technical Specifications Changes

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The NRC reviewed the information provided in Reference 1 and indicated the need for additional information in order to complete its review and evaluation of the amendment request. In an electronic mail message dated January 7, 2019, the NRC issued a draft Request for Additional Information (RAI). This draft RAI was the subject of further discussions during a teleconference on January 16, 2019, between Exelon and NRC representatives. The NRC then formally issued the RAI on January 16, 2019 (Reference 2) and requested that Exelon respond to the RAI by February 18, 2019.

Below is a restatement of the two (2) questions cited in Reference 2 along with NRC's supporting regulatory analysis and background information. Exelon's response is provided after each of the questions.

Regulatory Analysis Basis

Title 10 of the Code of Federal Regulations (10 CFR) Part 50.67, "Accident Source Term," allows licensees to revise their current accident source term in the design basis radiological consequence analyses to apply for a license amendment under § 50.90. The application shall contain an evaluation of the consequences of applicable design basis accidents previously analyzed in the safety analysis report. Section 50.67(b)(2) requires that the licensee's analysis demonstrates with reasonable assurance that:

> *(i)* *An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, would not receive a radiation dose in excess of 0.25 Sv (25 rem) total effective dose equivalent (TEDE).*

(ii) *An individual located at any point on the outer boundary of the low population zone, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage), would not receive a radiation dose in excess of 0.25 Sv (25 rem) TEDE.*

(iii) *Adequate radiation protection is provided to permit access to and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 0.05 Sv (5 rem) TEDE for the duration of the accident.*

Background

In the license amendment request the licensee proposes to modify the HPSW system design, which will result in a reduction of the design pressure rating of the HPSW system to a value of approximately 200 psig. At this design pressure the HPSW system, when in operation, will no longer be maintained at a higher pressure than the RHR system. The RHR system injects water into the reactor vessel following a loss of coolant accident. After the proposed change to the HPSW system, if there is leakage at the RHR heat exchanger interface, during a loss of coolant accident this would allow the transport of radioactive material into the HPSW system and ultimately to the environment via the discharge canal.

In the licensee amendment request the licensee stated:

> *No changes are required to the UFSAR [updated final safety analysis report] Chapter 14 accident analyses. The calculated radiological consequences of analyzed accidents are unchanged because the design basis radiological analysis, as provided in Regulatory Guide 1.183, does not consider any liquid effluent release pathway through a heat exchanger interface. No new release pathway is introduced with the proposed change with respect to the design basis radiological analysis.*
>
> *Though not required per the station design basis, a technical evaluation was performed to consider the radiological impact of a post-LOCA [loss of coolant accident] plant release into the environment via a liquid release pathway from a RHR heat exchanger leaking into HPSW. There is no regulatory guidance for a post-LOCA liquid release pathway and it is considered to be outside of the design bases. The most limiting dose consequence from RHR heat exchanger leakage into HPSW is that associated with post-LOCA control room dose due to airborne iodine release fraction. Based on a conservative analysis and maximum allowable RHR heat exchanger leak rate, the post-LOCA control room 30-day dose remains below the regulatory limit (5 rem TEDE). In addition, the evaluation considered the dose consequence from RHR heat exchanger leakage into HPSW at the nearest potable water sources and concluded that the 30-day dose to the public remains below the 25 rem TEDE limit at the Exclusion Area Boundary (EAB) and the Low Population Zone (LPZ).*
>
> *An evaluation was also performed to consider the radiological impact due to a potential increase in RHR heat exchanger leakage during normal operations resulting from periods of operation in which HPSW pressure may be less than*

> *RHR pressure. A parametric study was conducted, using conservative RHR heat exchanger leakage rates, and concluded that the Offsite Dose Calculation Manual (ODCM) limits would not be exceeded.*

Regulatory guide 1.183 revision 0, Appendix A, regulatory position 5 states:

> *ESF [engineered safety features] systems that recirculate sump water outside of the primary containment are assumed to leak during their intended operation. This release source includes leakage through valve packing glands, pump shaft seals, flanged connections, and other similar components ... The radiological consequences from the postulated leakage should be analyzed and combined with consequences postulated for other fission product release paths to determine the total calculated radiological consequences from the LOCA. The following assumptions are acceptable for evaluating the consequences of leakage from ESF components outside the primary containment for BWRs [boiling water reactors] and PWRs [pressurized water reactors].*

The intent of regulatory position 5 of regulatory guide 1.183 is to analyze the radiological consequences for all possible leakage pathways from ESF systems. The ESF leakage pathways stated in regulatory position 5 is not a complete list of all possible pathways. For Peach Bottom Atomic Power Station, RHR heat exchanger leakage was not included in the loss of coolant accident radiological consequence analysis because the HPSW system was operated at a higher pressure than the RHR system thus preventing any outward leakage from the RHR system; because of this, it wasn't necessary to evaluate this RHR leakage pathway. However, the proposed change no longer prevents RHR leakage through the heat exchanger interface to the HPSW system and it allows any RHR leakage to reach the environment via the HPSW system to the discharge canal.

In order for the NRC staff to be able to state that there is reasonable assurance that the regulatory limits stated in 10 CFR 50.67 continue to be met at Peach Bottom Atomic Power Station for the LOCA, the licensee's evaluation of the dose consequences from RHR leakage through the RHR heat exchanger interface must be reviewed.

RAI-1

Therefore, please provide additional information describing the assumptions, inputs, methodology, and results of the aforementioned RHR leakage dose consequence analysis.

Response:

The RHR heat exchanger leakage dose consequence analysis, discussed in the LAR (Reference 1), was performed to provide further assurance that there would be minimal increase in dose to the public, such that the overall accident dose to the public would remain well below regulatory limits, were an accident to occur after a RHR heat exchanger leak had developed. The intent of the dose consequence analysis is not to imply that RHR heat exchanger leakage is acceptable, nor is it to establish an allowable design basis limit for RHR leakage. The analysis is not intended to establish a new methodology for evaluating liquid release pathways for a design basis LOCA analysis.

The assumptions, inputs, methodology, and results for the RHR heat exchanger leakage dose consequence analysis are summarized below.

Summary of Dose Analysis for RHR Heat Exchanger Leakage during Normal Operations

The Offsite Dose Calculation Manual (ODCM) calculates the normal operation liquid dose at the canal discharge into the river (i.e., the site boundary). Currently, under normal operations, PBAPS classifies leakage across an RHR heat exchanger or heat exchangers as an abnormal occurrence, and quantifies the dose impact of this pathway. This pathway is then added to the station liquid release pathways as part of the Annual Radioactive Effluent Release Reports (ARERRs). The ARERRs show dose assessments substantially below ODCM limits.

A parametric study was performed utilizing the method described in the ODCM and ARERR. The study postulated a number of leakage rates across the RHR heat exchanger(s) (i.e., 1 – 10 gpm) for two (2) source terms (i.e., torus water cooling and reactor water cooling) based on Unit 3 water sampling and gamma scan results. The two cases evaluated the dose from a leak over a 30-day period with dilution provided by the operation of one (1) HPSW pump and one (1) to three (3) Circulating Water (CW) Pumps, with the design HPSW pump flow rate of 4,500 gpm and a CW pump flow rate of 200,000 gpm. The associated dose rates were evaluated against the requirements for maintaining compliance with the ODCM limits (i.e., for non-accident or normal operating conditions) and were well below ODCM limits.

The bounding case analyzed was for a 10 gpm leak, with the reactor coolant source term, and only one (1) HPSW pump and one (1) CW pump in operation. The total body dose for this case was 0.192 mrem and the maximum organ dose for this case was 1.09 mrem. These dose results are substantially less than the ODCM limits of a total body quarterly dose of 3 mrem and annual dose of 6 mrem, and maximum organ quarterly dose of 10 mrem and annual dose of 20 mrem.

Summary of Dose Analysis for RHR Heat Exchanger Leakage during Accident Conditions

Background

The current accident dose analysis of record evaluates post-LOCA doses using alternative source terms and follows the guidance in Regulatory Guide (RG) 1.183 for the treatment of ESF leakage. There are no postulated post-LOCA liquid release pathways to the environment in this analysis. The computer program, RADTRAD, Version 3.03, is used to calculate post-LOCA dose consequences in the Main Control Room (MCR), at the Exclusion Area Boundary (EAB) and at the Low Population Zone (LPZ). This program uses only airborne release pathways in the analysis. There are no program options to calculate doses for post-LOCA liquid releases to the environment.

With the current HPSW design, if any leakage through an RHR heat exchanger into HPSW were present following a LOCA, the leakage could migrate into the idle HPSW loops. However, the heat exchanger outlet valves would remain closed in the idle HPSW loops and radiation would be contained. After 10 minutes, a minimum of one HPSW loop is operated for post-LOCA containment cooling. If any RHR heat exchanger leakage into HPSW were present in the operated HPSW loops, that leakage would be terminated after approximately 10 minutes when

the HPSW pump is started and any radioactivity associated with that leakage would be discharged to the canal. With the proposed change to reduce HPSW operating pressure to below the RHR pressure, any leakage through an RHR heat exchanger into HPSW would occur for the duration of the event, which is evaluated for 30 days. The RHR heat exchanger leakage dose consequence analysis models post-LOCA HPSW discharge into the Susquehanna River with associated dose consequences at potable water source locations and models an airborne iodine release with associated dose consequences.

<u>Assumptions</u>

	Airborne Iodine Release
1	The release from the HPSW discharge pipe is assumed to be a ground level release.
2	Unit 2 X/Qs and associated ESF leakage dose results from the analysis of record are used (because the inputs are more conservative than those for Unit 3).
3	Assumed a 1 gpm leak rate from the RHR heat exchanger to HPSW and directly to the discharge canal in order to allow for simple scaling of dose results with respect to leak rate.
4	For the dose analysis, the radioiodine that is postulated to be available for release to the environment due to ESF leakage is assumed to be 97% elemental and 3% organic (consistent with the analysis of record and guidance in RG 1.183).
5	For calculation of iodine evaporation release fraction at the HPSW discharge, all iodine releases are assumed to be in the elemental form (I_2).
6	The HPSW discharge pipe is assumed to be exposed above the water surface which exposes the discharged water to air (otherwise the airborne release would be negligible). Note that the discharge pipe is at least partially submerged most of the year, depending on the canal water level, and that it is conservative to assume that the pipe is exposed.
7	The fraction of HPSW inventory lost to the environment through evaporation and drift from the HPSW flow stream exiting the HPSW discharge pipe is based on the inventory lost for a spray pond. Applying the design basis inventory loss fractions for another BWR plant with a spray pond (for the maximum water loss case) to the PBAPS HPSW discharge flow stream is conservative because the small spray particles are more susceptible to evaporation. Drift losses from the example plant spray pond were also used as a surrogate for PBAPS to further increase conservatism.
	HPSW Liquid Release
1	Assumed a 1 gpm leak rate from the RHR heat exchanger to HPSW and directly to the discharge canal in order to allow for simple scaling of dose results with respect to leak rate.
2	Assumed a 30-day release.
3	Assumed 1 HPSW pump provided dilution (at the design flow of 4500 gpm or 10.03 cu. ft. per sec. (cfs))
4	Assumed average river flow of 33823.33 cfs. (River flow was assumed to be an average value from the last 5 years of monthly river flow based on USGS National Water Information Service; Monitoring Site 01576000, Susquehanna River at Marietta, PA; http://waterdata.usgs.gov/nwis; Accessed April 25, 2018.)
5	Usage factors and travel times provided in PBAPS Original Dose Assessment Report from December 1976 (also used in the ARERR) are applicable.

Inputs

	Source Term
1	Time-dependent radionuclide activities in the torus water were obtained by rerunning the RADTRAD file of the analysis of record. (The plant scenario file in RADTRAD, Version 3.03, was modified by selecting the "Detailed Output" option for the torus compartment and by adding additional time steps for the output with no flow rate changes made.)
2	In Excel, the time-dependent torus activity is divided by the minimum torus water volume from the RADTRAD model and analysis of record, 122,900 ft^3, with the appropriate unit conversions, to yield isotopic activity concentrations (in units of µCi/cc). Note that Sb-129 was not used in the LADTAP II analysis, as no dose factors existed for this isotope in LADTAP. This is an acceptable deviation, as the activity contribution of Sb-129 is only 0.029% of the total activity released during the LOCA.
3	Separate RADTRAD computer code runs were made to determine the MCR dose contribution in the analysis of record for each different X/Q time interval.
	Airborne Iodine Release Dose Analysis
1	Distances used to calculate new X/Qs are 208 meters from the discharge pipe to the control room intake, 622 meters from the discharge pipe to the EAB and 7100 meters from the discharge pipe to the LPZ.
2	ESF leakage is 10 gpm per the analysis of record and is calculated consistent with RG 1.183.
3	The iodine release fraction (or flashing fraction) for ESF leakage is 10% in the analysis of record, consistent with the guidance in RG 1.183.
4	The maximum drift loss for the example BWR spray pond is 1.17E+05 gallons over 30 days post-accident, which equates to a drift loss fraction of 5.11E+05.
5	The maximum evaporation losses from the example BWR spray pond are 11.72E+06 gallons (evaporation from plant heat load) and 2.81E+06 gallons (natural evaporation) over 30 days post-accident, which equates to an evaporation loss fraction of 0.00635 (or 0.635%).
6	An average HPSW discharge temperature of 125°F, based on 24 hours post-accident, was applied for 30 days.
7	Vapor pressure of I_2 and water at 125°F are 2.3 mmHg and 100 mmHg, respectively.
	HPSW Liquid Release – LADTAP II Analysis
1	LADTAP II default values for population fraction were used (i.e., Adult = 0.71, Teen = 0.11, Child = 0.18, Source Term Multiplier = 1 and 50-mile population = 1).
2	Site specific (receptor location) usage and travel time information is as follows: Conowingo Dam – 25-hour travel time and a dilution factor of 7.7. Chester Water Intake – 11-hour travel time and a dilution factor of 5.9.
3	Consistent with Assumption 5 for HPSW Liquid Release, the consumption rates for drinking water (e.g., 730 L/yr for an adult) at all real locations evaluated except Chester Water Authority (CWA) are those listed in Table A-2, RG 1.109, Revision 0. The values used for CWA were 10% of those listed above because approximately 10% of the system's source of water is from Conowingo Pond.

Methodology for Airborne Iodine Release and Dose Analysis

In addition to the post-LOCA radionuclide activity within the HPSW discharge that is released to the discharge canal into the river, it is conservatively postulated that there is an iodine release to the atmosphere (via evaporation) from the HPSW discharge liquid effluent prior to entering the discharge canal. Additional dose contributions from this evaporation pathway are calculated at the MCR, EAB and the LPZ using a scaling approach.

The new X/Qs calculated in the RHR heat exchanger leakage dose consequence analysis are based on the methodology described in RG 1.194, Revision 0, for the MCR and RG 1.145, Revision 1, for the EAB and LPZ for meteorological stability Class F and a wind speed of one (1) meter/second, which is a conservative combination of stability class and wind speed leading to conservative non-sector directional X/Qs. Note that, using the guidance of RG 1.194, the time-independent X/Q for the MCR is adjusted for wind speed and wind direction.

The increase in dose at the MCR, the EAB, and the LPZ is dependent on the ratio of the ESF and the RHR-to-HPSW leak rates, the X/Q ratio, and the ratio of the iodine evaporation fraction calculated for the HPSW discharge pipe to the flashing fraction of the ESF leakages as described in the analysis of record (i.e., 10%). The calculated dose results for the MCR, EAB, and LPZ for ESF leakage from the analysis of record are used as bases for the additional dose calculated from the variations in X/Q and the evaporation fraction related to the HPSW discharge. (Note that reductions in ESF activity by dilution and holdup in the Reactor Building or by removal of iodine activity by Standby Gas Treatment filtration are not credited in the analysis of record. Therefore, adjustment factors are not required to account for these effects.)

As an example, the additional dose contribution from the HPSW discharge pipe is calculated in the following manner for the Main Control Room:

$$\text{Additional MCR dose} = \frac{1}{10}\sum_{t}\left(ESF\ Dose(t) \times \frac{\frac{X}{Q}^{ADJ}(t)}{\frac{X}{Q}^{TD}(t)} \times \frac{\text{EVAP. FRACTION}}{0.1}\right)$$

Where:

- 1/10 is the ratio of the assumed 1 gpm leak rate from the HPSW discharge pipe to the 10 gpm ESF leak rate value in the analysis of record;
- ESF Dose(t) is the time-dependent dose (based on the analysis of record) in the MCR due to the iodine activity that enters the MCR during the time period over which the X/Q is constant and the time-dependent dose accounts for residual iodine activity within the MCR during subsequent X/Q time periods;
- (X/Q^{ADJ} / X/Q^{TD}) is ratio of the new adjusted time-dependent X/Q, based on RG 1.194, to the time-dependent X/Q from the analysis of record;
- EVAP.FRACTION is the calculated HPSW discharge pipe iodine evaporation fraction (i.e., 2.0E-04); and,
- (0.1 or 10%) is the ESF iodine flashing fraction from the analysis of record, consistent with the guidance in RG 1.183.

The total additional MCR dose due to airborne iodine release from the HPSW discharge is the sum over all X/Q time periods.

The fraction of radioiodine in the RHR heat exchanger leakage that becomes airborne is related to the amount of evaporation at the point where the HPSW discharge enters the canal leading to the Susquehanna River. Potential drift losses are also conservatively included.

The halogen (i.e., iodine) airborne release fractions are calculated based on partial pressures of iodine and discharge temperature. The liquid stream is treated as an ideal solution and Raoult's Law and Dalton's Law are used to calculate the vapor composition of the cooling water effluent. Then the vapor composition and evaporation fraction are used to compute the rate of I_2 released to the atmosphere, based on the vapor pressure of I_2 and mole fraction of I_2 in the liquid and vapor phases. Further evaporation off the canal and river surfaces is considered to be negligible and enveloped by the calculated evaporation loss at the HPSW pipe discharge, as HPSW becomes diluted and cooled as it mixes with colder, much larger water bodies downstream. The distance from the discharge pipe to the control room intake is the shortest distance and entails the maximum activity due to initial evaporation.

Note that Section 5.5 of Appendix A to RG 1.183 states that if the temperature of leakage is less than 212°F or the calculated flashing fraction is less than 10%, the amount of iodine that becomes airborne should be assumed to be 10% of the total iodine activity in the leaked fluid, unless a smaller amount can be justified. HPSW discharged to the canal is significantly below 212°F. Application of the evaporation rate as the iodine release fraction, as discussed above, does not account for the volatility of organic iodine (i.e., the dose analysis assumes the fraction of both organic and elemental iodine in HPSW that is released to the environment is equal to the elemental iodine evaporation fraction). This is acceptable for this analysis because:

(1) the fraction of organic iodine expected to be in the HPSW is much less than 3% (i.e., since the containment pH is greater than 7, according to NUREG-1465, the percentage of organic iodine in containment would be no greater than 0.15%);

(2) the iodine activity in the ESF water that is available for release to the environment is already accounted for in containment atmosphere leakage since 100% of the iodine released from the reactor core is simultaneously assumed to be released to the containment atmosphere and into the torus water; and,

(3) the calculated evaporation rate is conservative since it is based on a spray discharge which has greater evaporation than an open-ended pipe discharge.

The additional dose estimates from the airborne pathway are added to the doses tabulated in the analysis of record to show that MCR, EAB and LPZ LOCA doses remain below regulatory limits when combined with doses currently presented in the analysis of record.

Results for Airborne Iodine Releases and Dose to the MCR, EAB, and LPZ

For a total 1 gpm leak across the RHR heat exchangers, the additional dose contribution to the control room is 1.764E-01 rem TEDE and the total dose would remain below the regulatory limit of 5 rem TEDE. The additional contribution to the control room dose is proportional to the RHR heat exchanger leak rate. The results of the MCR dose analysis are summarized in the following table:

Control Room Dose Addition Due To Post-LOCA RHR-to-HPSW Leakage (Assumed 1 gpm RHR-to-HPSW Leak Rate)					
Time Period (hrs)	Time Dependent X/Q (Per Analysis of Record) (sec/m^3)	Time Independent X/Q From Discharge to the MCR Intake (sec/m^3)	Time Dependent X/Q From the Discharge to the MCR Intake Adjusted for Wind Speed and Direction (sec/m^3)	Time Dependent Delta Dose (Per Analysis of Record) (rem TEDE)	Additional Dose to MCR from HPSW Discharge (rem TEDE)
0 - .05	1.18E-03	3.12E-03	3.12E-03	1.24E-02	6.57E-06
0.05 - 2	3.31E-06	3.12E-03	3.12E-03	4.00E-02	7.54E-03
2 - 8	1.00E-15	3.12E-03	3.12E-03	4.88E-11	3.04E-02
8 - 24	1.00E-15	3.12E-03	1.84E-03	1.13E-10	4.14E-02
24 - 96	1.64E-08	3.12E-03	1.17E-03	3.74E-03	5.34E-02
96 - 720	4.54E-09	3.12E-03	5.15E-04	1.92E-03	4.36E-02
				Total Additional Dose	**1.764E-01**

The EAB and LPZ dose results are less significant and, therefore, the MCR dose is the most limiting. For a total 1 gpm leak across the RHR heat exchangers, the additional dose contribution to the EAB (for a 2-hour period) is 2.20E-02 rem TEDE. Similarly, the additional dose contribution to the LPZ (for a 30-day period) is 1.44E-01 rem TEDE. For both the EAB and LPZ, the total doses would remain below the 25 rem TEDE limit.

Use of Conservative X/Qs

Note that the hand calculated X/Q values used in the RHR heat exchanger leakage dose consequence analysis are very conservative. As part of the review for this analysis, the X/Q values for the MCR were compared against more realistic values calculated in ARCON96 (similar to how they were calculated for the analysis of record). The results of this comparison indicate the hand calculated X/Qs, and therefore the associated additional dose to the MCR, are conservative by more than an order of magnitude.

Methodology for HPSW Liquid Release and Dose Consequences for Potable Water Sources

RG 1.183 does not provide guidance or acceptance criteria for evaluating a liquid release to the environment. The following approach is based on an accepted methodology using LADTAP II to evaluate effluent releases. The 30-day cumulative post-LOCA HPSW activity (in units of Curies) is postulated to be released into the river as an annual release. Using the computer program LADTAP II (see NRC NUREG/CR-1276 and NUREG/CR-4013 for further information), the dose at various points of interest are evaluated, accounting for dilution and decay based on average river flow. For this evaluation, two potable water sources of interest (i.e., drinking water pathways) are identified, the Chester Water Authority (CWA) and the Conowingo Dam. Other pathways that are part of the LADTAP II results (e.g., recreation related activities) are not relevant to this evaluation and were not considered for the purposes of this analysis.

The dose results of LADTAP II are annual average doses (in terms of mrem dose to a critical organ) resulting from the postulated 30-day cumulative activity release into the river. These results are used as 30-day results and are converted using the TEDE factors provided in Federal Guidance Report 11 for comparison to the RG 1.183 TEDE limits.

Results for HPSW Liquid Releases and Dose Consequences for Potable Water Sources

The Conowingo Dam is 49,500 feet (15,087 meters) SE downstream from the HPSW discharge point into the Susquehanna River. The annual dose, conservatively treated as a 30-day dose, is 2.62E-01 rem TEDE. The Chester Water Authority is 13,300 feet (4,053 meters) ESE downstream from the HPSW discharge point into the Susquehanna River. The annual dose, conservatively treated as a 30-day dose, is 3.48E-02 rem TEDE. Doses are directly proportional to the RHR-to-HPSW leak rate. These doses are not included in the LOCA analysis of record, which follows the guidance in RG 1.183 for ESF leakage. RG 1.183 does not provide guidance or acceptance criteria for evaluating a liquid release to the environment. However, for comparison purposes only, these doses are substantially less than the 10 CFR 50.67(b)(2)(ii) limit of 25 rem TEDE for an individual located at any point on the outer boundary of the LPZ (approximately 7100 meters from the HPSW discharge point into the Susquehanna River).

Further Actions to Minimize Post-LOCA RHR Heat Exchanger Leakage

The RHR operating mode with the highest pressure at the heat exchanger is the containment spray mode. After the proposed change to reduce HPSW system pressure, only in the containment spray mode would there be a significant difference in pressure between RHR and HPSW at the heat exchanger. In other containment cooling modes, HPSW is expected to operate at a similar or higher pressure than RHR at the heat exchanger interface, depending on the HPSW pump alignment and associated flow rates.

Operator actions to isolate or minimize RHR heat exchanger leakage into the HPSW system were not credited as part of the dose consequence analysis. If an actual event were to occur coincident with RHR heat exchanger leakage, there are several actions which could be taken to minimize the dose consequences and prevent a prolonged release (i.e., 30 days). The analysis of record currently requires two RHR heat exchangers and the system cross-tie to be in operation one hour after a design basis LOCA in order to remove decay heat and sensible heat; however, the amount of decay heat quickly decreases with time after shutdown. After sufficient time has passed, well before 30 days, only one heat exchanger would be required to reject the heat load, thereby allowing the leaking heat exchanger to be isolated. Alternatively, additional actions could be taken to reduce the RHR / HPSW system pressure differential to reduce the leak rate after the event. Additionally, although not currently credited for the design basis LOCA, PBAPS has a unit cross-tie which could be credited in order to isolate a leaking heat exchanger post-LOCA.

Conclusion

The RHR heat exchanger leakage dose consequence analysis was performed to provide further assurance that there would be minimal increase in dose to the public, such that the overall accident dose to the public would remain well below regulatory limits, were an accident to occur after a RHR heat exchanger leak had developed. The intent of the dose consequence analysis

is not to imply that RHR heat exchanger leakage is acceptable, nor is it to establish an allowable design basis limit for RHR leakage, and the analysis is not intended to establish a new methodology for evaluating liquid release pathways for a design basis LOCA analysis. The RHR heat exchanger leakage dose consequence analysis does not affect the analysis of record; however, the results could be used as input to support future operability evaluations.

Based on the RHR heat exchanger leakage dose consequence analysis, the most limiting dose consequences are associated with post-LOCA Control Room dose from airborne release due to evaporation at the outlet of the HPSW pipe at the discharge canal. This is due to the limited margin between the regulatory limit and the conservatively calculated accident dose in the analysis of record. A bounding total leak rate of approximately 1 gpm for all RHR heat exchangers on a given unit (because an accident is only postulated for one unit at a time) was calculated for accident conditions based on the regulatory limit of 5 rem TEDE for control room operator dose. The impacts on EAB and LPZ doses are not significant and there is considerable margin to regulatory limits. A HPSW liquid release would not have a significant effect on doses to the public and should not be included in the analysis of record.

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In addition please provide the basis for why any increase in the calculated dose from this new pathway (previously precluded by pressure differential) should not be included in the design basis LOCA analysis of record.

<u>Response:</u>

The current design basis is that the PBAPS RHR heat exchangers are designed and were tested to be free from leakage and this will be maintained. The design basis does not allow RHR heat exchanger leakage and requires monitoring to identify and respond to leakage. Therefore, internal RHR heat exchanger leakage from the RHR system to the HPSW system should be excluded from the design basis calculations.

The proposed change to reduce HPSW system pressure does not increase the likelihood of RHR heat exchanger leakage. It is recognized that reducing the HPSW system pressure to be less than the RHR pressure during HPSW operation is a reduction in the level of defense-in-depth associated with minimizing RHR system leakage outside of containment. As discussed in Section 4.2 of the license amendment request (LAR), dated September 28, 2018 (included in Reference 1), there is precedent for operating the service water system at a pressure below that of the RHR system at other BWR plants. Note that no precedent was identified for evaluating a liquid release pathway to the environment as part of the design basis LOCA analysis. Additionally, no precedent was identified for including RHR heat exchanger leakage to the environment in the ESF leakage for design basis accident analyses. The reason this liquid release pathway was not previously analyzed was because the design basis for the RHR heat exchangers does not allow for leakage (i.e., the heat exchangers were designed and hydrostatically tested to demonstrate there is no internal leakage).

Section 10.7.5 of the PBAPS UFSAR (see markups in Attachment 4 of the LAR, included in Reference 1, for information only) describes the current licensing basis for the HPSW system

and explains that, under certain circumstances, it is possible for a RHR heat exchanger leak to allow RHR water to migrate into the HPSW system and into the river. For example, during normal standby conditions the RHR system is maintained at a stay-full pressure of at least 140 psig, as verified in operator rounds, whereas the HPSW pressure is approximately 0 psig. This pressure differential would force RHR water to enter the HPSW side of the heat exchanger, and this RHR water in the HPSW system would subsequently be flushed out during shutdown cooling operations. Similarly, under the current licensing basis, if a design basis LOCA were to occur while a RHR heat exchanger is considered to be operable but degraded due to leakage, there is a short period of time (approximately 10 minutes) before the HPSW system is at operating pressure in which RHR water could be released to the environment.

Section 10.7.5 of the PBAPS UFSAR also explains that, in order to limit the release of RHR water to the Susquehanna River from this potential release path, signals from the radiation monitors in the sample system, which samples the HPSW upstream and downstream of the RHR heat exchangers, initiate an alarm in the control room at a predetermined radiation level. These alarms and established Operations and Chemistry procedures are utilized to identify and respond to any RHR / HPSW system leakage issues. As discussed in the LAR, if RHR heat exchanger leakage is detected, the leakage is monitored and included in the ARERR and the heat exchanger is repaired.

The intent of the RHR leakage dose consequence analysis is not to imply that RHR heat exchanger leakage is acceptable, nor is it to establish an allowable design basis limit for RHR leakage. The analysis is not intended to establish a new methodology for evaluating liquid release pathways for a design basis LOCA analysis. RHR system leakage is still required to be minimized consistent with the PBAPS procedures, technical specifications, and the licensing basis.

In conclusion, the current design basis is that the PBAPS RHR heat exchangers are designed and were tested to be free from leakage; the heat exchangers are further monitored to identify leakage and ensure the heat exchangers are repaired after leakage is detected. This design basis will be maintained. Postulated RHR heat exchanger leakage into HPSW due to lower relative HPSW system pressure is not included in the analysis of record, consistent with industry precedent. The proposed change to lower HPSW system pressure would result in a slight decrease in defense-in-depth associated with minimizing RHR leakage to the environment. However, a dose consequence analysis has determined that there would be minimal increase in dose to the public, such that the overall accident dose to the public would remain well below regulatory limits, were an accident to occur after a RHR heat exchanger leak had developed. Therefore, it is not necessary to add a new release pathway to the design basis LOCA analysis of record.

<u>References:</u>

1. Letter from David P. Helker (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission – *"License Amendment Request to Reduce High Pressure Service Water System Design Pressure and Revise Technical Specifications 3.6.2.3, 3.6.2.4, 3.6.2.5, and 3.7.1 for Temporary Extension of Completion Times,"* dated September 28, 2018 (ADAMS Accession No. ML18275A023)

2. Electronic mail message from Jennifer Tobin (U.S. Nuclear Regulatory Commission) to David Helker, Exelon Generation Company, LLC – *"Peach Bottom Units 2 and 3 - Request for Additional Information – High Pressure Service Water License Amendment One Time TS Change (EPID L-2018-LLA-0265),"* dated January 16, 2019 (ADAMS Accession No. ML19017A047)