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RS-15-129

10 CFR 50.90

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

Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. 50-373 and 50-374

Subject: Response to Request for Additional Information Regarding Request for a License Amendment to Braidwood Station, Units 1 and 2, Technical Specification 3.7.9, "Ultimate Heat Sink"

References:

1) Letter from D. M. Gullott (Exelon Generation Company, LLC) to U. S. Nuclear Regulatory Commission, "Request for a License Amendment to Braidwood Station, Units 1 and 2, Technical Specification 3.7.9, 'Ultimate Heat Sink,'" dated August 19, 2014 (ML14231A902)

2) Email from J. Wiebe (NRC) to J. Krejcie (Exelon Generation Company, LLC) Preliminary RAIs for LAR Regarding Braidwood Station Technical Specification, "Ultimate Heat Sink" dated February 5, 2015 (ML15036A431)

3) Email from J. Wiebe (NRC) to J. Krejcie (Exelon Generation Company, LLC) Preliminary RAIs for LAR Regarding Braidwood Station Technical Specification, "Ultimate Heat Sink" dated March 9, 2015 (ML15069A004)

4) Email from J. Wiebe (NRC) to J. Krejcie (Exelon Generation Company, LLC) Revised Preliminary RAIs for LAR Regarding Braidwood Station Technical Specification, "Ultimate Heat Sink" dated March 24, 2015 (ML15084A018)

In Reference 1, Exelon Generation Company, LLC, (EGC) requested an amendment to the Technical Specifications (TS) of Facility Operating License Nos. NPF-72 and NPF-77 for Braidwood Station, Units 1 and 2. The proposed amendment would modify TS 3.7.9, "Ultimate Heat Sink (UHS)," by changing the maximum allowable temperature of the UHS from 100 °F to a maximum UHS temperature of 102 °F.

In Reference 2, the U. S. Nuclear Regulatory Commission (NRC) requested additional information related to its review of Reference 1. In Reference 3, the NRC provided additional preliminary RAIs from the Containment and Ventilation Branch. In Reference 4, the NRC clarified the questions provided in Reference 2 and indicated that certain questions originally transmitted in Reference 2 had been eliminated and no longer required a response (i.e., RAIs 2, 3 and 4).

EGC has reviewed the information supporting a finding of no significant hazards consideration that was previously provided to the NRC in Attachment 1 of Reference 1. The additional information provided in this submittal does not affect the bases for concluding that the proposed license amendments do not involve a significant hazards consideration.

In accordance with 10 CFR 50.91, "Notice for public comment; State consultation," paragraph (b), a copy of this letter and its attachments are being provided to the designated State of Illinois official.

Should you have any questions concerning this letter, please contact Ms. Jessica Krejcie at (630) 657-2816.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 30th day of April 2015.

Respectfully,

David M. Gullott
Manager – Licensing
Exelon Generation Company, LLC

Attachments:

1) Response to Request for Additional Information
2) Westinghouse Report CCE-15-27, "Braidwood Units 1 and 2- Responses to NRC Request for Additional Information (RAI) Regarding Ultimate Heat Sink Temperature Increase License Amendment Request" April 2015

cc: NRC Regional Administrator, Region III
NRC Senior Resident Inspector, Braidwood Station
Illinois Emergency Management Agency – Division of Nuclear Safety

ATTACHMENT 1

Response to Request for Additional Information

ATTACHMENT 1
Response to Request for Additional Information

By letter dated August 19, 2014 (ADAMS Accession No. ML14231A902), Exelon submitted a license amendment request to raise the Braidwood Station, Unit 1 and Unit 2, Ultimate Heat Sink (UHS) technical specification 3.7.9.2 temperature limit of 100°F to 102°F (Reference 1). During review of the submittal, the Nuclear Regulatory Commission (NRC) identified information that is needed to support their review. In Reference 2, the NRC staff requested additional information related to its review of Reference 1. In Reference 3, the NRC provided additional preliminary RAIs from the Containment and Ventilation Branch (SCVB). In Reference 4, the NRC clarified the questions provided in Reference 2 and indicated that certain questions originally transmitted in Reference 2 had been eliminated and no longer required a response (i.e., RAIs 2, 3 and 4).

A response to the clarified questions provided in Reference 4 as originally transmitted in Reference 2 is provided below:

NRC RAI 5:

Provide justification that demonstrates that the LakeT-PC model accurately represents the effective essential cooling pond volume and surface area with sufficient accuracy and within the margin of error for the temperature of cooling water that supplies the safety related loads.

EGC Response to NRC RAI 5:

The Braidwood Station UHS has been modeled in Sargent and Lundy's computer program LakeT-PC. Attachment A of the LAR (Reference 1) is the detailed calculation that assesses the thermal performance of the UHS during a postulated LOCA event. In support of this LAR, the UHS initial temperature for all design cases is set to the proposed technical specification limit of 102°F. In addition to the initial UHS temperature, the information below describes other inputs and assumptions that have been used in the Reference 1 Attachment A LakeT-PC model, including the effective essential cooling pond volume and surface area, along with additional clarification to describe how the LakeT-PC model accurately represents the Braidwood Station UHS.

1. Main assumptions/inputs in the model

The following are the main assumptions and inputs (not related to UHS size or shape, plant heat load, Essential Service Water (SX) flow, or weather) in the UHS analysis:

Water Properties - The density and specific heat of water in the UHS is assumed to be 62.4 lb/ft^3 and 1 Btu/lb-°F, respectively. The density varies from 62.4 lb/ft^3 at 60°F to 61.9 lb/ft^3 at 105°F which correspond to ~0.7% change. The specific heat varies from 1 Btu/lb-°F at 60°F to 0.998 Btu/lb-°F at 105°F which correspond to ~0.2% change. These changes are acceptable since they are very small and have negligible impact on the results of analysis.

Makeup, Blowdown, Runoff, etc. - It is assumed that there is no makeup, blowdown, runoff, or dam spill in the UHS.

Seepage Rate - The seepage rate is 0.8 ft^3/s

Wind Gradients - LAKET-PC models wind gradients (as a function of the elevation above ground level) per the following equation:

$$WNDCOR = 1.15\left[\frac{mph}{knots}\right]\cdot\left(6.56/WINDZ\right)^{0.3}$$

where:

WNDCOR	= wind correction factor to 2m above ground level
WINDZ	= measurement elevation above ground level [ft]
1.15	= conversion factor from knots to mph

The wind speed extrapolation is a power law equation correcting the wind speed to an elevation of 2 meters (6.56 ft) above the ground level. There are a variety of exponential factors that have been used over the years in the power law equation, LAKET-PC uses a conservatively bounding value of 0.3 for the exponent. The conservative high exponent of 0.3 was validated by similar work performed for LaSalle County Station as docketed in Reference 9.

2. UHS size, volume, and effectiveness

Area/Volume Data - The normal UHS elevation is 590 ft and is used as the initial UHS elevation. The drawdown curve for the UHS given in the table below was based on the Revised Area Capacity Curve for UHS calculation.

Table 1: UHS Drawdown Curve

Elevation (ft)	Gross Area (acres)	Gross Volume (acre-ft)	Effective Area* (acres)	Effective Volume* (acre-ft)
590.0	95.6	555.8	78.7	457.4
589.0	94.5	460.0	77.8	378.6
588.0	93.5	370.0	77.0	304.5
587.0	92.5	276.0	76.1	227.1
586.0	91.5	185.0	75.3	152.3
585.0	90.5	90.0	74.5	74.1

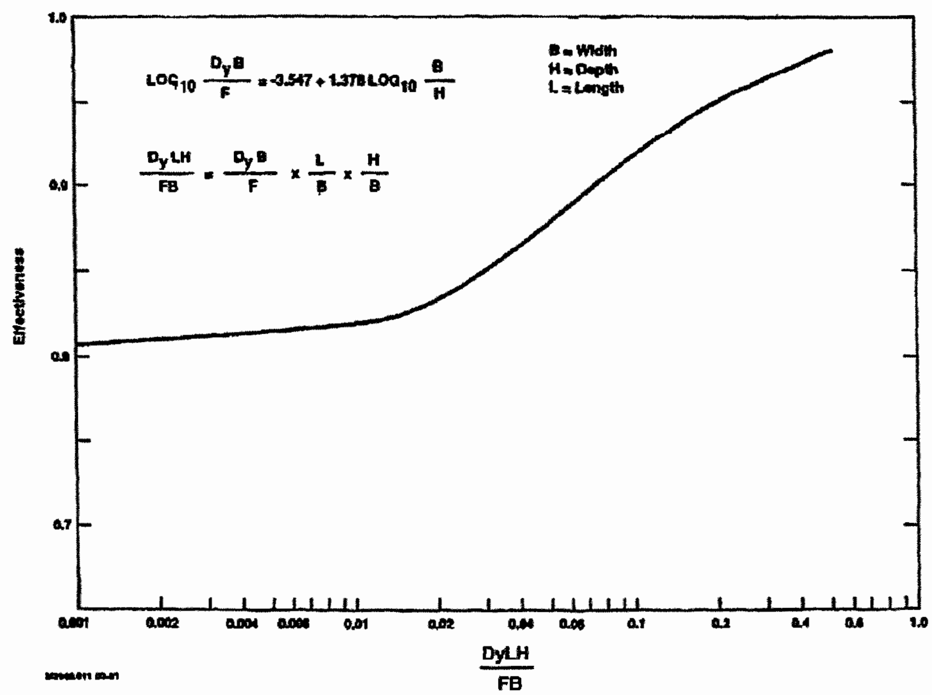
*Effective Area and Volume are 82.3% of Gross values

The actual gross area at 589.4 ft is 101.4 acres based on the recent DLZ Survey results representing approximately 6.1% margin over the analyzed value. Additionally, the actual gross volume at 590 ft is 591.5 acre-ft based on the recent DLZ Survey results representing approximately 6.4% margin over the analyzed value. Therefore the volume input to the LakeT-PC model calculation is conservative relative to the recent actual UHS measurements.

Effectiveness - Effective Area and Volume were calculated to be 82.3% of gross values. Effectiveness of the UHS was determined in Calculation MAD 83-0239. The methodology utilized for calculation of the Braidwood UHS effectiveness has subsequently been documented in S&L Engineering Guideline MES-11.1. The main inputs for lake effectiveness are the lake

size/shape and water flow. Based on figure MES-11.1-02 , presented below and as included in a response to an NRC RAI received for the LaSalle UHS temperature increase request (Reference 9), the effectiveness of the main channel varies from approximately 81 to 98%. Therefore, the value of 82.3% calculated in MAD 83-0239 is conservatively on the lower side of the curve. Note that the Braidwood UHS is a man-made rectangular shape lake without any side arms or odd shapes.

RATIO OF EFFECTIVE TO CROSS AREA FOR LAKES OF VARIOUS LENGTH TO WIDTH AND DEPTH TO WIDTH RATIOS
Figure MES-11.1-02



3. The number of plugs used in the model

Number of plugs in the LakeT-PC model depends on the SX flow, the time step, and the effective volume of the UHS. Each plug represents the volume of water that is pumped by SX pumps in one time step (i.e., 3 hours, for Braidwood UHS model). This is not a value that is entered as an input to the model, the number of plugs is determined by the program based on the abovementioned parameters.

The following table represents the number of plugs at the beginning of the UHS transient.

Table 2: Number of plugs used in the UHS model

# of SX pumps in operation	# of plugs
2	17
3	12
4	8

In summary, the following are conservatisms included in the Braidwood Station specific model of LakeT-PC.

Area/Volume Data - The actual gross area at 589.4 feet is approximately 6.1% larger than modeled in the UHS analysis. The actual gross volume at 590 feet is approximately 6.4% larger than modeled in the UHS analysis.

Wind Speed Adjustment - The wind speed is adjusted from the measurement elevation to an elevation of 2m (6.56 ft) by using conservatively bounding value of 0.3 for the exponent of the equation. The conservative high exponent of 0.3 was validated by similar work as documented in Reference 9.

Constant Initial Temperature - The UHS initial temperature for all design cases is set to the proposed technical specification limit of 102°F. This is conservative since for the limiting case (i.e., with 3 SX pumps operating) where the maximum plant inlet temperature is calculated to be 105.2°F the transient starts at 3 AM. However, based on observation of plant data, the early morning SX inlet temperatures are lower than the afternoon peak values. Actual plant data from July 7, 2012 was reviewed when the UHS temperature exceeded 100°F. The actual UHS temperature in the morning was approximately 2°F lower at 6AM and approximately 1.8°F lower at 3AM than the peak temperature of 100°F.

NRC RAI 6/7:

Describe how the temperature instrument uncertainty of 0.07°F was confirmed. In addition, describe the controls imposed to ensure the uncertainty doesn't increase as a result of configuration, procedure, and instrument changes. Include in the above descriptions, consideration of the complete instrument system, as appropriate, such as the thermocouple well that constitutes the interface between the system fluid and thermocouple, the wires between the thermocouple and the instrument (including the connections at both ends of the wires), the instrument used, and the ambient temperature effects on: the thermocouple well (is it required to be capped to exclude ambient air), wires, connections, and instrument.

EGC Response to NRC RAI 6/7:

The surveillance procedures for the UHS temperature (References 5-8) require using precision temperature instrumentation if the SX temperature on the discharge of any operating SX pump exceeds 97°F.

The precision instrumentation consists of a handheld Hart Scientific digital thermometer (model 1521) and a Secondary Reference Thermistor Probe (Model 5610-9). The Thermistor Probe is inserted in existing "spare" thermowells located on the discharge side of its associated SX pump and strainer.

There are two sets of the high precision instrumentation available consisting of the digital thermometer and secondary reference thermistor probe. The instruments are located in the Measurement and Test Equipment (M&TE) tool room; this room is under the control of the

Instrument Maintenance Department (IMD). If the instrumentation is needed during off-hours periods, Operations Shift personnel have access.

The surveillance procedures require operators to:

- Obtain the precision temperature instrument
- Verify calibration is current
- Record the instrument serial number on the surveillance Data Sheets
- Locally obtain the discharge temperature for the running pump from the spare thermowell locations.

As part of the implementation activities for the UHS LAR, the References 5 through 8 surveillance procedures will be updated to include the specific model number and identification number for the precision instrumentation.

When needed, the thermistor Probe connector end is inserted into the handheld thermometer. The Probe bead (measuring end) is then fully inserted into the spare thermowell until it makes contact. The temperature reading on the thermometer is allowed to stabilize and is then recorded. After the temperature measurement has been recorded, the probe is removed from the spare thermowell. The reading from the precision instrument does not have to be plugged into another plant instrumentation loop to obtain the temperature readout.

Determining the overall uncertainty of the instrumentation involves two components, (1) the handheld thermometer and (2) the secondary reference thermistor probe. The uncertainty is calculated in accordance with Exelon Standard BES-EIC-20.04, and it follows the methodology for M&TE. It has been determined that the M&TE uncertainty for the Hart Scientific Thermometer Model 1521 with Secondary Reference Probe model 5610-9 using the spare thermowells has an overall uncertainty of 0.07°F. The calculated accuracy is applicable for ambient temperatures between 41°F and 113°F; the thermowell does not need to be capped while the reading is taken.

The calibration of the instrumentation is performed by Exelon Power Labs. Exelon PowerLabs, LLC, a corporate entity within Exelon Generation, is dedicated to providing calibration, failure analysis and testing services in accordance with 10 CFR 50, Appendix B for the nuclear industry. The calibration frequency is annual; this frequency is set by Power Labs and is tracked in the Braidwood IMD PowerTrackR data base.

If the M&TE became obsolete, a request would be sent by IMD to Power Labs for a replacement. If the replacement unit were not the same as the original unit, an Engineering Change Request would be generated to evaluate the replacement for use in the specific application. This includes evaluating compliance with the stringent requirements.

ATTACHMENT 1
Response to Request for Additional Information

The below responses are provided for the Reference 3 SCVB RAIs.

NRC SCVB-RAI-1

Section 3.5.8 refers to NRC Generic Letter (GL) 96-06 "Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions," Section 3.5.8 addresses GL 96-06 concerns for possible water hammer events following either a Loss-Of-Coolant Accident or a Main Steam Line Break concurrent with a Loss Of Offsite Power in the first few minutes post-accident, while the pumps and fans are restarting following load shed.

a) Provide a description of how and where the postulated water hammer events can take place following the first few minutes post-accident.

b) What is the gas and how does it cause the voiding described in Section 3.5.8? Describe how this voiding is prevented?

c) Provide a description of the analysis that determined that an increase in the cooling water temperature from 102°F to 104°F will not cause water hammer events in the system piping considered under GL 96-06.

EGC Response to NRC SCVB-RAI 1:

(a) Provide a description of how and where the postulated water hammer events can take place following the first few minutes post-accident.

The Braidwood Station resolution to the GL 96-06, "Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions" is documented in a series of correspondence to the NRC culminating in the issuance of the NRC letter documenting satisfaction of resolution for the Braidwood Station response to Generic Letter 96-06 (Reference 10). All Braidwood Station submittals related to GL 96-06 are listed in Reference 10.

In Generic Letter 96-06, the NRC identified concerns for possible water hammer events following either a Loss of Coolant Accident (LOCA) or a Main Steam Line Break (MSLB) concurrent with a Loss of Offsite Power (LOOP). Under this scenario, the pumps that supply cooling water to the Reactor Containment Fan Coolers (RCFCs) and fans that supply airflow to the RCFCs will temporarily lose power. Cooling water flow will stop and boiling may occur in the RCFCs tubes, causing steam bubbles to form in the cooling tubes within the RCFCs and expand to the attached SX piping, creating steam voids. As the SX pumps restart and the water column accelerates, accumulated steam in the fan coolers tubes and piping will condense which could result in a water hammer when the void closes. Hydrodynamic loads that are introduced by this water hammer event could challenge the integrity and function of the RCFCs and associated cooling water system components, as well as pose a potential challenge to containment integrity.

A Braidwood Unit 1 specific analysis of this event models the hydraulics of the affected systems using RELAP5 up to the point of void collapse and determines the resulting flow and pressures, and then calculates water hammer forces using either the EPRI methodology or a method of characteristics-based program, such as HYTRAN. The RELAP5 analysis is used to obtain pressures and flows immediately prior to void collapse. These parameters are then modeled in

HYTRAN to complete the void collapse and determine loads on affected piping. The HYTRAN program generates force time-histories along each leg in the model.

The specific Braidwood RELAP5 analysis identified three (3) void collapses of interest in the SX piping. The specific locations are:

1. Collapse in the 4-inch discharge line from A RCFC
2. Collapse in the 14-inch discharge line between coolers A and C RCFC
3. Collapse in the buried suction piping upstream of pump B SX Pump (Note 1)

Note 1- During the transient, a pressure spike is observed in the suction piping to the SX pumps. The SX pump and fluid in the suction pipe come to a complete stop approximately 15 seconds after the SX pump trips. When power to the SX pump returns, the pump reaches full speed prior to the fluid in the suction piping reaching full speed. This disparity causes the fluid in the suction pipe to depressurize and a void forms due to the fluid in the suction pipe depressurizing to the vapor pressure of water. When the inertia of the water in the long length of pipe is overcome, the void collapses.

All loads that are generated by the evaluated transient have been found to be acceptable. All three cases produce loads that are lower than would be experienced during a seismic event.

The Braidwood analysis was done specifically for the Unit 1 configuration. The RCFC Unit 2 piping analyses are based on the Unit 1 RCFC piping analytical models, with unit specific differences reconciled during original construction. Unit specific RCFC piping differences that are applicable to the 96-06 analysis will be reconciled as part of Regulatory Commitment #1 of Reference 1, prior to the implementation of the UHS LAR.

(b) What is the gas and how does it cause the voiding described in section 3.5.8? Describe how this voiding is prevented?

Under the scenario described above, the pumps that supply cooling water to the RCFCs and fans that supply air to the RCFCs will temporarily lose power. Cooling water flow will stop. Boiling may occur in the RCFCs tubes, causing steam bubbles to form in the RCFCs and expand to the attached SX piping, creating steam voids.

Voiding in this event is not prevented. The water hammers resulting from the event have been evaluated and have been found to not affect the integrity of the affected piping and components.

(c) Provide a description of the analysis that determined that an increase in the cooling water temperature from 102 °F to 104 °F will not cause water hammer events in the system piping considered under GL 96-06.

The analysis for the GL 96-06 event has been completed for an SX water temperature of 100°F. This analysis states that a small increase (about 2°F) in the fluid temperature will have a negligible impact on the results since voiding in the RCFCs is caused by the increase in temperature surrounding the RCFCs. A slight increase in the fluid temperature entering the coils will not result in significant changes to the amount of voiding in the coils. Void formation combined with the pump restart results in void collapse which forces the water columns in the

RCFCs to come together. Small variations in fluid temperature will have a negligible impact on fluid velocities at the void collapse and will not significantly impact the results of the analysis. The initial temperature for the UHS is 102°F. The period of interest for the NRC GL 96-06 concern of water hammer is the first few minutes post-accident, while the pumps and fans are restarting following load shed. During this time, as shown in the temperature profile in Figure 1, of Reference 1, the actual UHS temperature is below 102°F, thus the temperature of the cooling water to the RCFCs, will be less than 102 °F. The discussion in the analysis for a small fluid temperature change is therefore applicable.

In line with the analysis for GL 96-06, the evaluation determined the forces resulting from water hammer events and concludes that the affected piping maintains its integrity.

NRC SCVB-RAI-2:

Section 3.6.1 identifies changes to the Mass and Energy (M&E) release by correcting the Steam Generator tube material density and specific heat as discussed in Westinghouse Nuclear Safety Advisory Letter (NSAL)-14-2. However, the LAR does not mention M&E release corrections discussed in NSAL-06-6 and NSAL-11-5. Describe changes in the following containment analyses results using the corrected methodology that incorporates corrections listed in the above three NSALs, (a) containment peak pressure, (b) containment peak gas temperature for Environment Equipment Qualification (EEQ), (c) containment peak wall temperature, (d) containment sump peak water temperature, (e) pump Net Positive Suction Head (NPSH) Available (NPSHA) for the pumps that draw water from the containment sump during recirculation mode of safety injection and containment cooling, and (f) containment minimum pressure analysis for Emergency Core Cooling System performance capability.

EGC Response to NRC SCVB-RAI-2:

Please see Attachment 2 for responses to parts (a), (b), (c) and (e). The response to part (d) is below.

Part (d):

The Braidwood Design Basis Net Positive Suction Head analysis determines the Net Positive Suction Head Available (NPSHA) and margin to NPSH Required (NPSHR) for the Containment Spray (CS) and Residual Heat Removal (RHR) pumps during the post-LOCA recirculation mode of operation. In addition to the NPSH margin determination, the suction path to the pumps (from the suction pipe intake at the containment recirculation sump) is reviewed for intermediate points of water flashing and air evolution versus acceptable limits for pump performance.

The sump water temperature that is calculated in the Containment Response Analysis in support of the UHS LAR (Reference 1)is an input to the NPSH analysis. The minimum LOCA containment pressure as a function of containment recirculation sump temperature is used in the water flashing and air evolution calculations. The minimum LOCA containment pressure maximizes the water flashing and air evolution. The bounding (minimum) containment pressure profile is determined using the double ended pump suction break with minimum safeguards.

The NPSH analysis results using the UHS temperature of 100°F are given in Table 3:

TABLE 3				
Sump T (°F)	**Limiting Margin RHR Pumps (ft)**	**Limiting Margin CS Pumps (ft)**	**Void Fraction at RHR Pump Inlet (%)**	**Void Fraction at CS Pump Inlet (%)**
258.1	2.8	0.7	0.11	0.02
250.6	2.3	0.6	0.16	0.02
242.5	2.2	0.6	0.16	0.02
230.0	2.6	0.7	0.12	0.02
210.0	2.7	0.6	0.10	0.02
203.9	2.7	0.6	0.10	0.02
200.0	2.8	0.6	0.10	0.02
195.0	6.7	4.5	0.20	0.11
175.0	11.0	11.0	0.39	0.28
155.0	10.8	10.8	0.52	0.39
135.0	10.2	10.2	0.67	0.52
120.001	9.4	9.4	0.85	0.65
119.999	9.4	9.4	1.02	0.78
95.0	8.3	8.3	1.13	0.87
73.4	7.3	7.3	1.24	0.95

The NPSH analysis results using the UHS temperature of 102°F are given in Table 4:

TABLE 4				
Sump T (°F)	**Limiting Margin RHR Pumps (ft)**	**Limiting Margin CS Pumps (ft)**	**Void Fraction at RHR Pump Inlet (%)**	**Void Fraction at CS Pump Inlet (%)**
258.1	3.2	1.5	0.10	0.04
248.4	2.6	1.3	0.17	0.06
236.2	2.7	1.4	0.15	0.05
230.0	2.9	1.5	0.13	0.04
210.0	3.1	1.5	0.10	0.04
203.9	3.1	1.5	0.10	0.04
200.0	3.1	1.5	0.10	0.04
195.0	7.1	5.4	0.20	0.13
175.0	11.0	11.0	0.41	0.31
155.0	10.8	10.8	0.57	0.45
135.0	10.2	10.2	0.67	0.54
125.2	10.2	10.2	0.86	0.68
120.0	9.4	9.4	1.03	0.81
95.0	8.3	8.3	1.14	0.90
73.4	7.3	7.3	1.25	0.99

Note – An increase in margin was recorded in the values listed in Table 4 due to a reduction in head loss in the suction piping to the RHR and CS pumps. This head loss reduction is due to a change in modeling for elbows. The previous analysis modeled elbows as standard fittings while the revised analysis models them as Long Radius bends which reduced some of the loss factors.

<u>SCVB-RAI-3</u>

Section 3.6.1 states:

"However, the SX temperature change coupled with the other changes described above resulted in peak pressure values similar to the current design analysis."

For each of the "other changes", provide a summary whether the change resulted in an increase or decrease in released mass, and an increase or decrease in the released energy.

<u>EGC Response to NRC SCVB-RAI-3:</u>

Please see Attachment 2 for responses to SCVB-RAI-3.

<u>SCVB-RAI-4</u>

Section 3.6.1 states:

"The Braidwood Station Units were reanalyzed to assess an increase in the water temperature of the UHS to 104°F"

a) Describe the methodology used for performing the proposed short and long term M&E release reanalysis and how does it differ from the current licensing basis analysis methodology.

b) Describe the methodology used for performing the proposed short and long term containment pressure analysis for peak pressure, containment peak temperature analysis for EEQ, sump water temperature analysis for pump NPSH. How does the methodology for the proposed analysis differ from the current licensing basis analysis methodology?

c) Provide a comparison of the inputs and assumptions in the proposed analysis that were changed from the current analysis. Provide justification for those inputs and assumptions in which the conservatism in the proposed analysis is reduced.

d) Provide the resulting graphs for the most limiting LOCA peak pressure analysis for the double ended hot leg break and double ended pump suction break for both units.

EGC Response to NRC SCVB-RAI-4:

Please see Attachment 2 for responses to SCVB-RAI-4.

SCVB-RAI-5

Refer to Sections 3.6.2.1 and 3.6.2.2; what methodology is used for the proposed MSLB analysis compared to the current analysis, and is the methodology up to date with all errors corrected?

EGC Response to NRC SCVB-RAI-5:

Please see Attachment 2 for responses to SCVB-RAI-5.

SCVB-RAI-6

Refer to Section 3.6.2.1; for both units, provide the following information:

a) Describe the MSLB cases analyzed for containment peak temperature, and provide their comparison with the cases analyzed in the current analysis.
b) If other than the currently analyzed cases were selected, provide basis for their selection.
c) Provide a comparison of the inputs and assumptions in the proposed analysis that were changed from the current analysis. Provide justification for those inputs and assumptions in which the conservatism in the proposed analysis is reduced.
d) Explain why the peak containment temperatures are less in the proposed analysis than in the current analysis.
e) Provide the graph of the most limiting MSLB peak temperature profile case.

EGC Response to NRC SCVB-RAI-6:

Please see Attachment 2 for responses to SCVB-RAI-6.

SCVB-RAI-7

Refer to Section 3.6.2.2; for both units, provide the following information:

a) Describe the MSLB cases analyzed for containment peak pressure, and provide their comparison with the cases analyzed in the current analysis.
b) Describe the cases in the proposed and the current analysis that resulted in the maximum peak pressures.
c) If other than the currently analyzed cases were selected, provide basis for their selection.

d) Provide a comparison of the inputs and assumptions in the proposed analysis that were changed from the current analysis. Provide justification for those inputs and assumptions in which the conservatism in the proposed analysis is reduced.

e) Provide the graph of the most limiting MSLB peak pressure profile case.

EGC Response to NRC SCVB-RAI-7:

Please see Attachment 2 for responses to SCVB-RAI-7.

SCVB-RAI-8

NUREG-0800, Standard Review Plan (SRP) Revision 2, July 1981, 6.2.1.5 provides NRC staff review guidance for the minimum containment pressure analysis for emergency core cooling system (ECCS) performance capability. Branch Technical Position CSB 6-1 provides guidance for complying with 10 CFR Part 50, Appendix K, paragraph I.D.2 when calculating the containment pressure response used for evaluating cooling effectiveness during the post-blowdown phase of a LOCA. The Branch Technical Position states that the minimum containment pressure should be calculated by including the effects of containment heat sinks and operation of all pressure-reducing systems. Provide the results of the re-analysis for the minimum containment pressure with the proposed change in the cooling water temperature, including the corrections and revisions to analyses described in your letter dated August 19, 2014.

Alternatively, provide justification why the proposed change in the cooling water temperature, including the corrections and revisions to analyses described in your letter dated August 19, 2014, does not impact the minimum containment pressure analysis.

EGC Response to NRC SCVB-RAI-8:

Please see Attachment 2 for responses to SCVB-RAI-8.

SCVB-RAI-9

Section 3.4.3 states:

"The long term containment analysis was re-performed and it was demonstrated that the containment pressures and temperatures have been significantly reduced from the calculated peak value at 36 hours after the event. At 36 hours the containment pressure is approximately 30 psi lower than the calculated peak and the containment atmosphere temperature is approximately 80°F lower than the calculated peak. Therefore, the increase in the UHS temperature above 104°F post 36 hours will not result in exceeding any design criteria related to post-LOCA containment requirements."

Describe the analysis performed that demonstrated that an increase in the UHS temperature to 105.2°F at 36 hours post-accident will not result in exceeding the containment design pressure and temperature.

EGC Response to NRC SCVB-RAI-9:

The containment peak temperatures and pressures, and the time they occur, calculated to support this LAR, are shown in the table below. As stated in Section 3.4.3 of Reference 1, these values were calculated based on a UHS temperature of 104°F.

Table 5

	Peak Pressure (psig)		Peak Temperature (°F)	
	Braidwood U-1	**Braidwood U-2**	**Braidwood U-1**	**Braidwood U-2**
Double Ended Hot Leg Break	42.1 (at 21.54 sec)	37.7 (at 19.73 sec)	263.5 (at 21.54 sec)	256.5 (at 19.73 sec)
Double Ended Pump Suction Break	42.1 (at 716.36 sec)	38.4 (at 592.2 sec)	262.6 (at 716.36 sec)	256.7 (at 592.2 sec)

The limiting curve for the UHS temperature shows that the temperature rises post-LOCA and exceeds 104°F after about 36 hours (129,600 seconds) into the event (see Figure 1 of Reference 1). This higher UHS temperature persists for a maximum of 6 hours (i.e. 36 to 42 hours) and reaches a maximum of 105.2°F.

After 36 hours into the event the containment pressure is about 30 psi lower than the calculated peak pressure and the containment atmosphere temperature is more than 80 °F lower when compared to the calculated peak temperature. For both Braidwood Units 1 and 2 the containment conditions at about 36 hours (129,600 sec) into the event are:

- Pressure < 9 psig
- Temperature < 170°F

The UHS temperature increase of 1.2°F (from 104°F to 105.2°F) could increase the containment temperature by 1.2°F and potentially increase the containment pressure by 0.16 psi (temperature increase from 170°F to 171.2°F, based on saturated steam conditions). The actual effect will be lower due to the cooling provided by the containment fan coolers. Conservatively adding the 1.2°F containment temperature increase and a 0.16 psi containment pressure increase to the post-LOCA conditions, 36 hours into the event, does not alter the conclusions of the analyses and will not result in exceeding any design criteria or Technical Specification related to post-LOCA containment requirements. Therefore, the increase of 1.2°F in the UHS temperature above the analyzed 104°F between 36 and 42 hours post-LOCA will have no significant effect on the LOCA results and the analyses supporting this LAR remain bounding.

SCVB-RAI-10

Section 3.5.4 states that the engineering evaluation of the main control room chiller condensers was performed for the increased UHS temperature of 105.2°F using design heat loads, design SX cooling flow rates and existing tube plugging values and used reduced fouling factor based on the as-found fouling factors of other heat exchangers in the NRC GL 89-13 program.

a) Provide a detailed justification for using a reduced fouling factor for proposed evaluation of the main control room chiller condenser.

b) What was the as-found value of the main control room chiller condenser fouling factor used in the current licensing basis analysis and the value of the fouling factor used in the proposed engineering evaluation.

c) Provide results of the control room chiller condenser heat transfer performance in the current licensing basis analysis and in the proposed analysis.

EGC Response to NRC SCVB-RAI-10:

Part (a):

The design fouling factor for the Main Control Room (MCR) Chiller condenser and Component Cooling (CC) heat exchangers is 0.0015 hr-ft^2- °F/Btu for SX tubeside fouling.

The MCR Chillers are cleaned in accordance with the station Generic Letter (GL) 89-13 program in a similar manner to the CC heat exchangers. The GL 89-13 program has established the following thermal performance testing and maintenance inspection frequencies for the MCR Chillers and CC heat exchangers.

Table 6: GL 89-13 Program

	A&B MCR Chillers	**CC Heat exchangers**
Clean and Inspect Frequency	Condenser- Every 3 years	0CC01A - Every 3 years
	Evaporator - Every 6 years	1CC01A - Every 4 years
		2CC01A - Every 3 years
Thermal Performance Testing	N/A	0CC01A - Every 2 outages
		1CC01A - Every outage
		2CC01A - Every outage

The results of the last thermal performance testing for the CC heat exchangers are as follows:

U-0 CC HX Thermal Performance Test Result – FF 0.000178 hr-ft^2- °F/Btu
U-1 CC HX Thermal Performance Test Result – FF 0.000492 hr-ft^2- °F/Btu
U-2 CC HX Thermal Performance Test Result – FF 0.000434 hr-ft^2- °F/Btu

Both the MCR chillers and CC heat exchangers inspection results have been acceptable. The MCR chillers are located at elevation 383' in the auxiliary building. The CC heat exchangers are located at elevation 364' in the auxiliary building and therefore, are considered more susceptible to potential macrofouling and/or microfouling due to the lower elevations creating potential collection points in the SX piping. Therefore, the CC heat exchangers are considered suitable candidates for comparisons with cleanliness and fouling rates.

Also, the CC heat exchanger thermal performances are evaluated in accordance with EPRI TR-107397, Service Water Heat Exchanger Testing Guidelines, which is considered one of the industry accepted methodology guidelines utilized for GL 89-13 heat exchanger thermal

performance testing. The methodology was applied in conjunction with the use of PROTO-HX safety related shell and tube software program module. PROTO-HX software has been developed in accordance with Zachry Nuclear Engineering Nuclear-Grade Software Quality Assurance Program (SQAP) and is intended to assist the user in the evaluations recommended by NRC GL 89-13 consistent with the guidelines of EPRI TR-107397, Service Water Heat Exchanger Testing Guidelines. Thus, the results of the testing are considered to have a high degree of confidence. The results of the CC heat exchanger testing shows that the fouling was actually much less than the credited fouling of 0.0010 hr-ft^2- °F/Btu which was used for the MCR chiller condenser performance analysis, which is considered conservative. Due to the relative locations of the MCR chillers and CC heat exchangers and because both are exposed to the same SX water system and inspected on the same maintenance frequencies, it is considered reasonable that the fouling of the MCR condensers would result in a similar fouling rate over time as the CC heat exchangers.

Part (b):

The current licensing basis analysis uses a fouling factor of 0.0015 hr-ft^2- °F/Btu. The proposed engineering evaluation uses a fouling factor of 0.0010 hr-ft^2- °F/Btu. This is based on the results of the CC heat exchanger thermal performance testing whereby the worst fouling factor of the 3 CC exchangers was 0.000492 hr-ft^2- °F/Btu. Using a fouling factor of 0.0010 hr-ft^2- °F/Btu for the proposed engineering MCR chiller evaluation provides at least a safety margin greater than 2.

Part (c):

The evaluation of the UHS temperature increase, analyzed the chiller condenser performance using the same model equations in the design basis analysis. The model replicated the analysis contained in the existing evaluation using an 105.2°F SX inlet temperature and a fouling factor of 0.0010 hr-ft^2- °F/Btu. The results of the calculations are listed below. Considering the actual tube plugging for the condenser (i.e., 1 tube), the chiller has a margin of 25%. The analysis further shows that 95 tubes can be plugged and the chiller will maintain the required capacity. Lastly, the analysis shows that the chiller can perform its function for a UHS temperature of 105.2°F with design fouling factor and actual tube plugging, but with minimum margin.

The current licensing basis analysis, for an SX inlet temperature of 100°F, a fouling factor of 0.0015 hr-ft^2- °F/Btu, a design tube plugging of 75 tubes and an Evaporator Capacity of 2,317,200 Btu/hr, shows the chiller unit is able to remove the required heat load with a margin of over 33%.

Table 7: Control Room Chiller Condenser Performance

Component	Condenser Capacity (BTU/hr)	SX Inlet Temperature (°F)	Fouling Factor (-)	Evaporator Capacity (BTU/hr)	Margin[1] (%)	Tubes Plugged
0WO01CA/B	3,000,000	100	0.0015	2,317,200	33.9	75
0WO01CA/B	2,446,000	105.2	0.0015	1,763,000	1.9	1
0WO01CA/B	2,853,000	105.2	0.0010	2,170,000	25	1
0WO01CA/B	2,414,000	105.2	0.0010	1,731,000	0.0	95

1) Margin to 1,730,735 BTU/hr

REFERENCES:

1) Letter from D. M. Gullott (Exelon Generation Company, LLC) to U. S. Nuclear Regulatory Commission, "Request for a License Amendment to Braidwood Station, Units 1 and 2, Technical Specification 3.7.9, 'Ultimate Heat Sink,'" dated August 19, 2014 (ML14231A902)

2) Email from J. Wiebe (NRC) to J. Krejcie (Exelon Generation Company, LLC) Preliminary RAIs for LAR Regarding Braidwood Station Technical Specification, "Ultimate Heat Sink" dated February 5, 2015 (ML15036A431)

3) Email from J. Wiebe (NRC) to J. Krejcie (Exelon Generation Company, LLC) Preliminary RAIs for LAR Regarding Braidwood Station Technical Specification, "Ultimate Heat Sink" dated March 9, 2015 (ML15069A004)

4) Email from J. Wiebe (NRC) to J. Krejcie (Exelon Generation Company, LLC) Revised Preliminary RAIs for LAR Regarding Braidwood Station Technical Specification, "Ultimate Heat Sink" dated March 24, 2015 (ML15084A018)

5) Procedure 1BwOSR 0.1-1,2,3 Revision 80, "Unit One Modes 1, 2 and 3 Shiftly and Daily Operating Surveillance"

6) Procedure 1BwOSR 0.1-4, Revision 32, "Unit One Mode 4 Shiftly and Daily Operating Surveillance"

7) Procedure 2BwOSR 0.1-1,2,3, Revision 80, "Unit Two Modes 1, 2, and 3 Shiftly and Daily Operating Surveillance"

8) Procedure 2BwOSR 0.1-4, Revision 32, "Unit Two Mode 4 Shiftly and Daily Operating Surveillance"

9) Letter from D. Gullott (Exelon Generation Company, LLC) to U.S. Nuclear Regulatory Commission (NRC), "Response to Request for Additional Information Regarding License Amendment Request to Revise Ultimate Heat Sink Temperature Limits" dated December 4, 2014 (ML14352A319)

10) Letter from Mahesh Chawla (U.S. NRC Office of Nuclear Regulation) to Mr. Christopher M. Crane, (Exelon Generation Company, LLC), "Byron Station, Units 1 and 2, and Braidwood Station, Units 1 and 2, Generic Letter 96-06, 'Assurance of Equipment Operability and Containment Integrity During Design-Basis Accident Conditions' (TAC NOS. M96789, M96790, M96782, AND M96783)" dated February 24, 2004 (ML040220400).

ATTACHMENT 2

Braidwood units 1 and 2- Response to NRC Request for Additional Information
Regarding Ultimate Heat Sink Temperature Increase License Amendment Request