Ultimate Heat Sink License Amendment Request Pre-Submittal Meeting

Exelon Generation Company, LLC

Braidwood Station

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Exelon Generation®

Meeting Agenda

- Objectives
- Background
- Regulatory Criteria/Guidance
- Technical Approach
- Regulatory Commitments
- Conclusions
- Schedule
- Discussion

Meeting Objectives

- Describe the License Amendment Request (LAR) for the Ultimate Heat Sink (UHS)
  - Discuss relevant regulatory criteria/guidance
  - Outline technical basis supporting the LAR
- Discuss planned activities and schedule to support implementation
- Address NRC questions and obtain feedback

Background

- On June 13, 2000, Braidwood Station received NRC approval for LAR to increase UHS temperature from 98 °F to 100 °F
- On July 7, 2012, the UHS measured temperature exceeded 100 °F
  - Braidwood Station verbally requested and received Enforcement Discretion to allow operation with a UHS temperature up to 102 °F to avoid an unnecessary plant shutdown and associated transient
- Recent changes in meteorological conditions (i.e., increased temperature, low wind speeds) have resulted in the current Technical Specification (TS) UHS temperature limit being challenged
- The UHS Design Basis Accident (DBA) has been reanalyzed to support an increase in initial UHS temperature from 100 °F to 102 °F

Background - Planned LAR

- Currently, TS Surveillance Requirement (SR) 3.7.9.2 states:

  "Verify average water temperature of UHS is ≤ 100 °F."

- The proposed TS SR 3.7.9.2 states:

  “Verify average water temperature of UHS is ≤ 102 °F.”

- There are no proposed changes to the TS Required Actions, Completion Times, Frequency of SR performance, or any other portions of TS 3.7.9

Applicable Regulatory Criteria/Guidance

- General Design Criteria (GDC) of Appendix A to 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants, "
  - GDC 2, "Design bases for protection against natural phenomena "
  - GDC 5, "Sharing of structures, systems and components, "
  - GDC 44, "Cooling water "
- Regulatory Guide (RG) 1.27 Revision 2, "Ultimate Heat Sink for Nuclear Power Plants "
  - Consistent with current licensing basis
- NUREG-0693, "Analysis of Ultimate Heat Sink Cooling Ponds," dated November 1980
- SRP 9.2.5, "Ultimate Heat Sink"
- The UHS DBA event is a Loss of Coolant Accident (LOCA) with Loss of Offsite Power (LOOP) on one unit along with the orderly shutdown and cooldown of the opposite unit coincident with limiting single failure (loss of dike)

Technical Approach - Overview

- UHS System Description
  - The UHS is a closed loop system that consists of an excavated essential cooling pond integral with the main cooling pond
  - The UHS dissipates residual heat after reactor shutdown and after an accident through cooling components of the Essential Service Water (SX) System and the Component Cooling Water (CC) system
  - Four SX pumps (two per unit) take suction from intake lines running from the essential cooling pond to the auxiliary building to supply safety-related loads and components essential to safe shutdown
- The normal SX system line up consists of one pump operating on each Unit
  - An Engineered Safety Features (ESF) signal due to an accident on one Unit will result in one additional SX pump automatically starting on the accident Unit; the total number of SX pumps in operation will be three
  - A fourth SX pump may be manually started by the operators later in the event, if needed for the Unit undergoing a normal shutdown

Technical Approach - Overview

- To determine the post-DBA UHS temperature and associated TS limit, synthetic sets of limiting weather data input were developed in accordance with RG 1.27 Revision 2 :
  - Critical time periods unique to the Braidwood Station UHS were determined
  - Updated meteorological data was obtained
  - Meteorological data was screened to determine the most limiting sets of data
- The limiting sets of data were used in the post-DBA UHS analysis to determine the UHS response (i.e., maximum temperature and evaporation)
- Once the limiting post-DBA UHS response was determined, it was used
  - to evaluate performance margins of equipment cooled by the SX and CC systems
  - as input into the safety analysis to ensure responses remained within analyzed limits

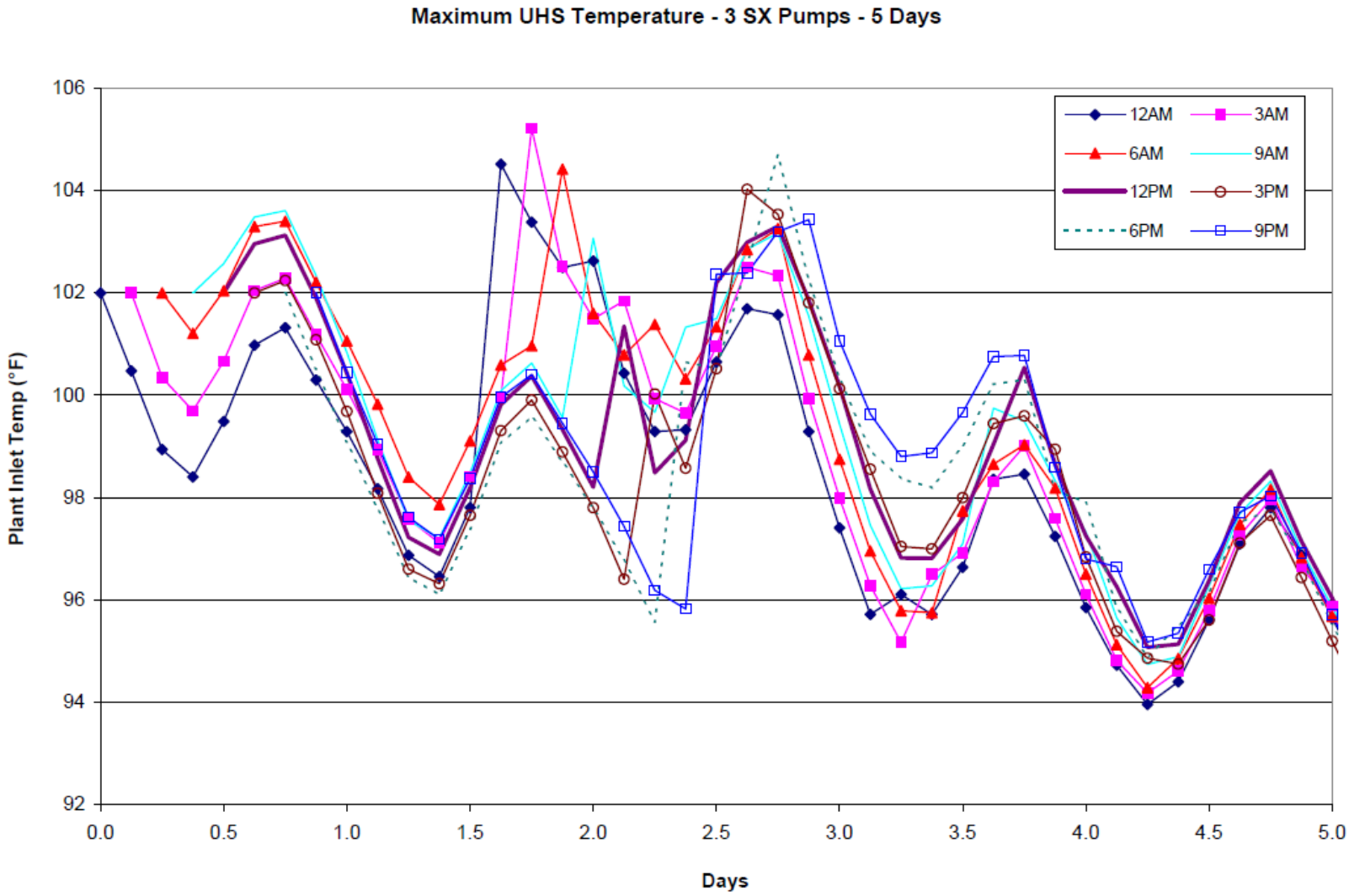
Technical Approach - Development of limiting meteorological input

- Critical Time Periods
  - Number of SX pumps in operation determines transit time around the UHS
  - Based on effective volume and flow rates, the critical time periods were determined in accordance with RG 1.27 Revision 2 to be:
    - 24 hours for four SX pumps in operation
    - 36 hours for three SX pumps in operation
    - 48 hours for two SX pumps in operation
  - In addition to the number of SX pumps in operation, the availability of 30-day cooling was considered
- Updated Meteorological Data
  - Analysis used 64-years of meteorological data up through December 31, 2012, which includes the period of worst meteorological data on site (July 7, 2012)
  - All data collected at one hour intervals
  - Data screened to correct any out of range or missing parameters

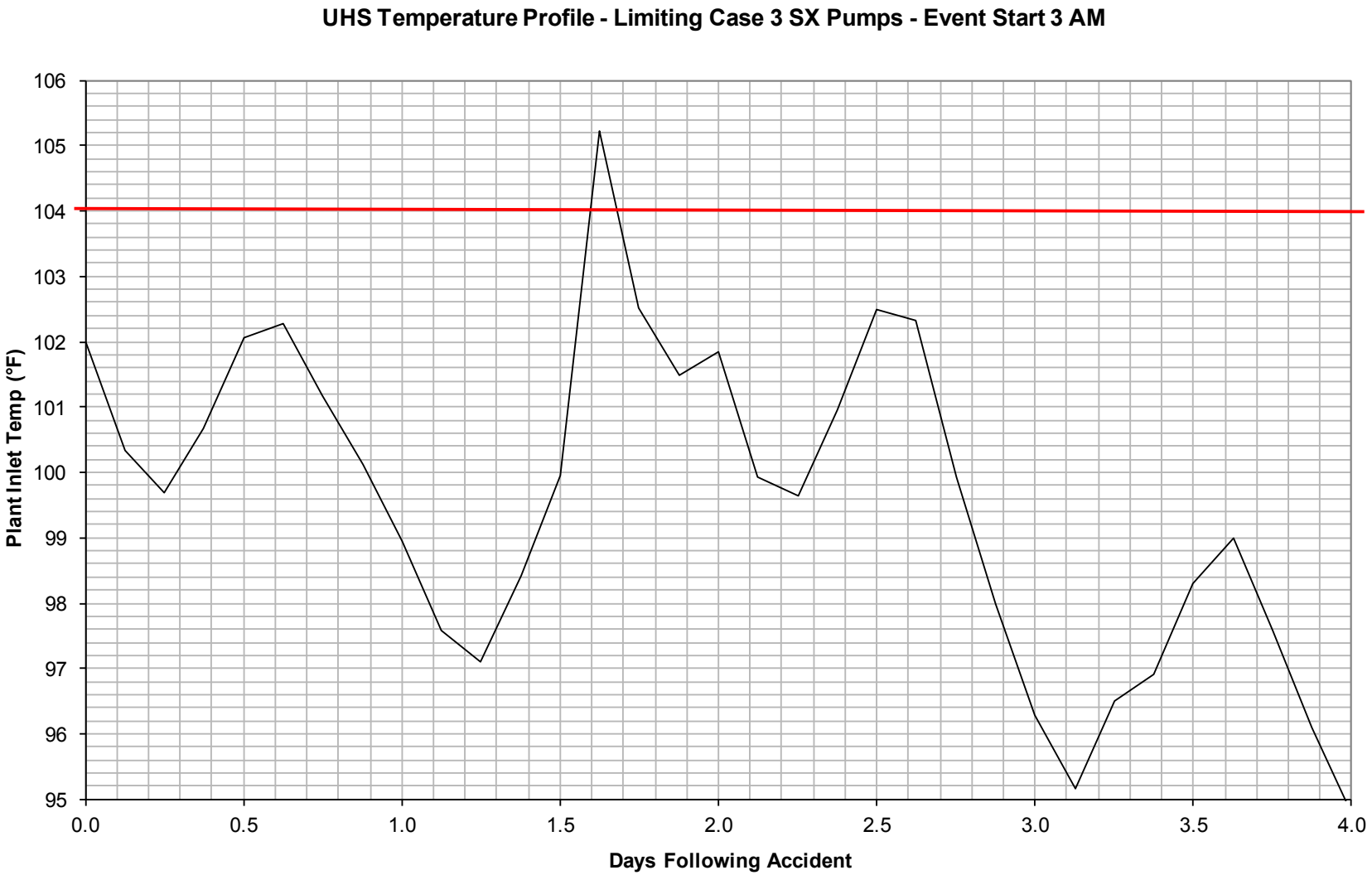
Technical Approach - UHS Analysis

- Data Screening Methodology for Maximum UHS temperature
  - Screening performed in accordance with NUREG-0693 and RG 1.27 Revision 2 at all critical time periods to create synthetic limiting weather file
    - Analyzed each of the critical time periods identified based on number of SX pumps running (i.e., 24 hours, 36 hours, 48 hours, and 30 days)
    - Analyzed eight daily starting times (i.e., 12AM, 3 AM, 6 AM, 9AM, 12PM, 3 PM, 6 PM, 9 PM) used to model the diurnal lake behavior
- UHS Analysis
  - The LAKET-PC computer program is a one-dimensional thermal prediction model and contains methodology consistent with NUREG 0693
  - LAKET-PC was used to determine the maximum UHS temperature and the maximum UHS inventory loss following a DBA using the proposed TS value of 102 °F as an initial input
  - A total of eight cases were run on a 3-hour starting frequency for scenarios with two, three or four SX pumps running
  - Between the two and three-SX pump cases, the three SX pump case with the 3AM starting time results in the maximum UHS temperature of 105.2 °F
  - With four SX pumps in operation, the maximum SX temperature reached 105.9 °F at the 6AM starting time, however four pump operation is not expected post-DBA (see Regulatory Commitment #2)

Technical Approach - Maximum UHS temperature



Technical Approach- Maximum UHS temperature



Technical Approach - Equipment Evaluation

- Calculations and evaluations for equipment serviced by SX and CC were reviewed to evaluate the impact of increased SX temperature of 105.2 °F
- Simplified model of heat exchanger performance was used to determine margin available
- Based on the UHS temperature profile, the following temperatures were selected as representative values for accident analysis and equipment evaluation:
  - 104 °F was used to determine the resulting heat removal performance for the Reactor Containment Fan Coolers (RCFCs). This is an input to the accident analyses that use the RCFCs for heat removal (LOCA Mass and Energy Release and Containment Integrity, Main Steam Line Break (MSLB) Mass and Energy Release and Containment Integrity)
  - Other equipment that is affected by the UHS temperature increase is evaluated for the limiting UHS temperature of 105.2 °F
- The selected temperatures are conservative for the evaluation of the higher UHS temperature because:
  - The UHS temperature remains below 104 °F for the first 36 hours into the event
  - The UHS temperature exceeds 104 °F to a maximum of 105.2 °F for a period less than 6 hours post-accident (hours 36-42)
  - From hour 42 onward, the UHS temperature remains below 104 °F

Technical Approach - Equipment Evaluation

- Cubicle Coolers
  - Evaluated under design conditions at 105.2 °F SX temperature
  - Some coolers required a reduction in allowable tube plugging limit
  - All cubicle coolers have between 10% and 59% margin
  - Includes conservatively applied fouling factor for water side
- Oil Coolers
  - Performance has been determined to be acceptable with SX temperature at 105.2 °F
    - Margin evaluated to be > 10 °F below maximum allowable
    - Recorded operating temperature data with SX temperature approaching 100 °F indicates significantly more margin
    - Oil coolers are cleaned and inspected in accordance with the Generic Letter (GL) 89-13 program to maintain performance

Technical Approach - Equipment Evaluation

- Engine Coolers
  - Diesel Driven Auxiliary Feed Pump Engine Closed Cycle Heat Exchanger
    - > 5 °F margin to high jacket water temperature alarm setpoint exists
    - Considers realistic flow rate based on surveillance testing, bounding pump performance and actual tube plugging
  - Emergency Diesel Generator (EDG) Jacket Water Coolers
    - > 10 °F margin to high jacket water temperature alarm setpoint exists
    - Considers 105.2 °F SX temperature and design tube plugging limits
- Main Control Room Chiller Condenser
  - >25% margin with SX temperature at 105.2 °F and actual tube plugging values
  - Evaluated with fouling factors consistent with other heat exchangers in the Braidwood GL 89-13 program
  - Demonstrated margin for additional tube plugging

Technical Approach - Equipment Evaluation

- Component Cooling (CC) Heat Exchangers
  - Evaluation performed for the UHS Design Basis Case (LOCA on one unit with the non-LOCA unit in a normal shutdown)
  - Evaluation shows significant margin (in excess of 50%) with the increased UHS temperature
  - Thermal Performance Testing results during Spring 2014 Refueling Outage confirms CC Heat Exchanger margins

Technical Approach - Accident Analysis

- Safety Analyses were evaluated based on increased UHS temperature
  - The heat removal performance for the RCFCs (evaluated at 104 °F) is affected by the UHS temperature increase because the RCFCs reject heat to the UHS and the resultant heat removal capacities were used in the following accident re-analyses:
    - LOCA Long Term/Short Term Mass and Energy (Containment Integrity)
    - Main Steam Line Break (MSLB) Inside Containment/Outside Containment Mass and Energy Dose Steam Release (Containment Integrity)
- The LOCA containment integrity results calculated for peak pressure values remained below the existing TS Pa values of 42.8 psig for Unit 1 and 38.4 psig for Unit 2

Break Location	Plant	UHS-Containment Peak Pressure (psig)	TS Pa (psig)
Double Ended Hot Leg (DEHL)	UNIT 1	42.10	42.8 (42.80)
	UNIT 2	37.73	38.4 (38.40)
Double Ended Pump Suction (DEPS)	UNIT 1	42.08	42.8 (42.80)
	UNIT 2	38.37	38.4 (38.40)

Technical Approach - Accident Analysis

- MSLB Containment Integrity
  - For the MSLB inside containment, peak pressure was determined to be below the 50 psig design pressure (34.48 psig for U1; 34.44 psig for U2)
  - The peak containment temperature for Unit 1 and Unit 2 was determined to be lower than the maximum temperature analyzed in the current design basis analyses
  - The composite containment temperature response for Unit 1 and Unit 2 were reviewed and were compared to the enveloping Environmental Qualification (EQ) temperature profile. The revised temperature profile is enveloped by the existing EQ profile
- Evaluation of analysis performed at 104 °F versus maximum UHS temperature (105.2 °F)
  - In accordance with the UHS temperature analysis, the UHS temperature could rise and be as high as 105.2 °F by 36 hours post-LOCA
  - Results of the containment analysis indicates that the containment pressures and temperatures have been significantly reduced 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 when compared to the calculated containment peak temperature
  - Thus, while a 1.2 °F increase in the UHS temperature could be postulated to increase the containment temperature by 1.2 °F and possibly increase the pressure by 0.16 psi based on using saturated steam conditions at 170 °F, the actual affect will be much lower due to the cooling provided by the RCFCs

Regulatory Commitments

- Two Regulatory Commitments will be included in the LAR:
  - Regulatory Commitment #1: Existing design analyses impacted by the proposed TS SR 3.7.9.2 increased UHS temperature will be updated
  - Regulatory Commitment #2: Operating procedures impacted by limitation with four SX pump operation will be updated
- Both Regulatory Commitments will be completed prior to LAR approval

Conclusions

- UHS analysis performed consistent with existing design and licensing basis
- Utilized initial temperature of 102 °F to calculate maximum UHS temperature of 105.2 °F
  - diurnal effect analyzed
  - updated meteorological data
- Accident analyses demonstrated existing TS values remain bounding
- Equipment evaluation identified some components with significant conservatism in which changes to the existing design and operational requirements will be needed in order to allow TS UHS temperature increase

Schedule

- LAR target submittal on June 30, 2014
- Update equipment analyses impacted by TS SR 3.7.9.2 temperature increase will be completed by 2nd Quarter 2015
- Approval requested by June 30, 2015

Braidwood UHS LAR

DISCUSSION