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U. S. Nuclear Regulatory Commission
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Braidwood Station, Units 1 and 2
Facility Operating License Nos. NPF-72 and NPF-77
NRC Docket Nos. STN 50-456 and STN 50-457

Subject: Follow-up Reply to a Notice of Violation

References:
(1) Letter from G.E. Grant (NRC Region III) to O.D. Kingsley (Exelon Generation Company, LLC), "Braidwood Station, Units 1 and 2, NRC Inspection Report 50-456/01-11 (DRP); 50-457/01-11 (DRP) and Notice of Violation," dated December 12, 2001
(2) Letter from J.D. von Suskil (Exelon Generation Company, LLC) to U.S. NRC, "Reply to a Notice of Violation," dated January 11, 2002
(3) Letter from A.M. Stone (NRC Region III) to J.L. Skolds (Exelon Generation Company, LLC), "Reply to Licensee's Response to Cited Violation for NRC Inspection Report 50-456/01-11(DRP): 50-457/01-11(DRP), Braidwood Station, Units 1 & 2," dated March 11, 2002

In Reference 1, based on the results of an inspection, the NRC determined that Braidwood Station has been in violation of NRC requirements since July 11, 2000. The inspectors determined that instrument uncertainties associated with the Ultimate Heat Sink (UHS) average temperature were not assumed in design analyses and were not accounted for in the Technical Specification (TS) limit or associated testing acceptance criteria. The NRC cited this as a violation of 10 CFR 50, Appendix B, Criterion XI, "Test Control."

In Reference 2, we provided our reply to the Notice of Violation (NOV). Our reply indicated that based on our review of the regulations and guidance, we did not believe that a violation of Criterion XI occurred. Although instrument uncertainties have not been explicitly incorporated in the TS surveillance limit which confirms that the UHS average temperature limit has not been exceeded, instrument uncertainties have been implicitly accommodated in the overall safety analyses due to the methodologies, assumptions and conservatism used in performing the analyses. The determination that instrument uncertainty was implicitly accounted for by the design margin in components served by the UHS and in the safety analyses was based on qualitative evaluations. In our reply, we committed to performing additional analyses and analytical work to provide a quantitative comparison of the inherent margin and conservatism to the instrument uncertainty associated with the UHS temperature.

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In Reference 3, the NRC requested that the results of the quantitative analyses and assessments be provided to the NRC by May 3, 2002 to assist in the NRC's evaluation of the basis for our violation response. Attached is the "Ultimate Heat Sink (UHS) Measurement Uncertainty Assessment." The assessment concludes that the inherent margin is sufficient to accommodate the instrument uncertainty; and, therefore, that the existing TS and associated surveillance procedure have been established in an appropriately conservative manner.

If you have any questions or comments regarding this reply, please contact Ms. A. Ferko, Braidwood Station Regulatory Assurance Manager, at (815) 417-2699.

Respectfully,

James D. von Suskil
Site Vice President
Braidwood Station

Attachment: Ultimate Heat Sink (UHS) Measurement Uncertainty Assessment

cc: Regional Administrator – NRC Region III
NRC Senior Resident Inspector - Braidwood Station
Director, Office of Enforcement

bcc: Project Manager, NRR – Braidwood Station
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Director, Licensing – Mid-West Regional Operating Group
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ATTACHMENT
Ultimate Heat Sink (UHS) Measurement Uncertainty Assessment

1.0 Introduction

In a letter from G.E. Grant (NRC Region III) to O.D. Kingsley (Exelon Generation Company, LLC), dated December 12, 2001, the NRC issued a Notice of Violation (Reference 1). Based on the results of an inspection, the NRC determined that Braidwood Station has been in violation of NRC requirements since July 11, 2000. The inspectors determined that instrument uncertainties associated with the Ultimate Heat Sink (UHS) average temperature were not assumed in design analyses and were not accounted for in the Technical Specification (TS) limit or associated testing acceptance criteria. The NRC cited this as a violation of 10 CFR 50, Appendix B, Criterion XI, "Test Control."

In reply to the Notice of Violation (Reference 2), we concluded that based on our review of the regulations and guidance, we did not believe that a violation of Criterion XI occurred. There is no specific requirement contained within Criterion XI regarding design margin, accounting for instrument uncertainties, or the need for testing to establish limits and/or acceptance criteria that includes measurement uncertainties. As described in Appendix A of the Byron/Braidwood Stations' Updated Final Safety Analysis Report (UFSAR), Braidwood Station is committed to Revision 1 of Regulatory Guide (RG) 1.105, "Instrument Setpoints." This RG describes an acceptable method for ensuring that the setpoints in systems important to safety are initially within and remain within the specified limits, including incorporation of instrument uncertainties. As stated in RG 1.105, Revision 1, the RG describes a method acceptable to the NRC to meet 10 CFR 50.36, "Technical Specifications," which requires, in part, where a limiting safety system setting (LSSS) is specified for a variable on which a safety limit has been placed, the setting be so chosen that automatic protective action will correct the most severe abnormal situation anticipated before a safety limit is exceeded. Thus, it is concluded that the scope of this RG is limited to protective actuation setpoints, i.e., Reactor Protection System (RPS) and Engineered Safety Feature Actuation System (ESFAS) Instrumentation. For setpoints that are applicable to this scope, our method is consistent with the RG criteria. The UHS temperature instrumentation is not associated with a LSSS, not associated with any protective actuation feature, and is not used in accident responses. Consequently, the elements of RG 1.105, Revision 1 do not apply to the UHS temperature instrumentation.

Subsequent revisions to RG 1.105 (i.e., Revision 3) endorse Part 1 of ISA-S67.04-1994, "Setpoints for Nuclear Safety-Related Instrumentation," as a method acceptable to the NRC staff for complying with the NRC's regulations for ensuring that setpoints for safety-related instrumentation are initially within and remain within the TS limits. ISA-S67.04-1994 endorses the concept of allowing for a graduated or "graded" approach, including implicit accounting for instrument uncertainty for "setpoints that are not credited in the accident analyses to initiate a reactor shutdown or the engineered safety features," which is the case for the UHS temperature instrumentation.
The following excerpts from the preface to ISA-RP67.04 - Part II -1994 illustrate the bases for current industry and regulatory practices in this area.

> "The scope of the standard was focused on LSSS and ESFAS setpoints. As the standard evolved, it continued to focus on those key safety-related setpoints...the methodologies, assumptions, and conservatism associated with performing accident analyses and setpoint determinations, like other nuclear power plant technologies, have also evolved. This evolution has resulted in the present preference for explicit evaluation of instrument channel uncertainties and resulting setpoints rather than implicitly incorporating such uncertainties

into the overall safety analyses. Both the explicit and implicit approaches can achieve the same objective of assuring that design safety limits will not be exceeded...

"During the development of this recommended practice, a level of expectation for setpoint calculations has been identified, which, in the absence of any information on application to less critical setpoints, leads some users to come to expect that all setpoint calculations will contain the same level of rigor and detail. The lack of specific treatment of less critical setpoints has resulted in some potential users expecting the same detailed explicit consideration of all the uncertainty factors described in the recommended practice for all setpoints. It is not the intent of the recommended practice to suggest that the methodology described is applicable to all setpoints. Although it may be used for most setpoint calculations, it is by no means necessary that it be used for all setpoints. In fact, in some cases, it may not be appropriate.

"In applying the standard to the determination of setpoints, a graduated or "graded" approach may be appropriate for setpoints that are not credited in the accident analyses to initiate reactor shutdown or the engineered safety features."

Other industry documents also endorse the approach of implicitly incorporating measurement uncertainties into the overall safety analyses. Several examples are contained in NEDC-32972P, "Safety Analysis Evaluations Relative to Measurement Uncertainties for the BWR/6 Improved Technical Specifications." Additional examples are discussed in Westinghouse Letter ET-NRC-92-3699, "Containment Initial Temperature Assumption for Large Break Loss of Coolant Accident Analysis," dated June 1, 1992, transmitted from Westinghouse to the NRC. The implicit approach was appropriate for these examples because (1) the items were not LSSS or ESFAS setpoints, and (2) the safety analyses contained sufficient inherent conservatism to accommodate the measurement uncertainty associated with the assumed value for the parameter of interest.

Although the UHS temperature instrumentation does not perform any protective actuation feature, and does not involve a setpoint, the UHS average temperature limit ensures that the design basis temperatures of safety related equipment will not be exceeded. In support of previous licensing actions, qualitative evaluations of design margin in components served by the UHS and the safety analyses were performed that demonstrate that adequate margin exists to account for instrument uncertainties. However, to substantiate that adequate margin exists, additional analyses and analytical work have since been performed to identify and quantify the conservatism in the analyses. The results of the additional analyses and analytical work are provided below to provide a quantitative comparison of the results of the additional analyses to the instrument uncertainty associated with the UHS temperature.

2.0 UHS Temperature Measurement Uncertainty

2.1 Description of Surveillance Requirement and Results of Uncertainty Calculation

The UHS temperature is verified every 24 hours in accordance with TS Surveillance Requirement (SR) 3.7.9.2. As described in the Bases for SR 3.7.9.2, this is accomplished by measuring the temperature at the discharge of an essential service water (SX) pump. The SX Discharge Header Temperature loops include local indication, control board indication, and a computer point. As is typical of instruments not associated with a LSSS or any protective actuation feature, uncertainty calculations for the SX temperature instruments were not required to be performed as part of the original plant design and licensing process and did not previously exist. However, for the purposes of this demonstration, calculations were performed which determined the uncertainty associated with the SX temperature instruments as SX temperature approaches the TS surveillance limit of

100°F. The methodology employed was in accordance with Exelon Generation Company, LLC Engineering Standard NES-EIC-20.04, which is consistent with ISA-67.04.01-2000 and other industry standards. The following are the results of the calculations:

For Local Indication:

Uncertainty of a single local indication	= + 2.0°F
Uncertainty of the average of two local indications	= + 1.5°F

For Control Board Indication:

Uncertainty of a single control board indication	= + 2.0°F
Uncertainty of the average of two control board indications	= + 1.5°F

For Computer Point Indication:

Uncertainty of a single computer point indication	= + 1.7°F
Uncertainty of the average of two computer point indications	= + 1.2°F

In subsequent sections of this response, the inherent margin and conservatism in the design and analyses are evaluated. If the inherent margin can be shown to be greater than the above values of instrument uncertainty (i.e., > 2.0°F), then the margin is sufficient to accommodate the instrument uncertainty, and the implicit method of incorporating instrument uncertainty remains appropriate for this application.

2.2 Discussion of Setting Tolerance

Calibration setting tolerance is the inaccuracy introduced into the calibration process due to procedural allowances given to the technician during module calibration. Setting tolerance is an additional uncertainty combined with other sources of error that cannot be adjusted or otherwise affected by the act of instrument calibration (e.g. reference accuracy, hysteresis, linearity, etc.). Procedures exist at the station to ensure that instrument channels and calibrated setpoints will not be left outside specific setting tolerances. Furthermore, it is expected that the technician performs the necessary adjustments to leave the instrument channel and calibrated setpoints as close as possible to the ideal value. As a result, not only is it expected that 100% of the population is left within the required setting tolerance, but also that each instrument channel and calibrated setpoint is left much closer to the ideal setting rather than at the extreme of the setting tolerance limit.

The Notice of Violation stated the instrument setting tolerance contained in the Instrument Maintenance Department calibration procedure was ± 2.6°F. It should not be construed from the setting tolerance alone that the true value is or can be 2.6°F higher than the indicated reading. Rather, it should be concluded that the true value is within 2.0°F of the indicated reading using the statistically combined uncertainty of all error terms at the appropriate confidence level.

3.0 UHS and Main Cooling Pond Temperature Response

3.1 Description of the UHS

Braidwood Station's UHS consists of an excavated essential cooling pond integral with the Braidwood main cooling pond. The excavated area is such that the essential cooling pond remains intact in the event of failure of the Category II retaining dikes impounding the main cooling pond. The essential cooling pond has a surface area of approximately 99 acres and is located in the northwestern section of the main cooling pond. The SX System cooling water intakes and discharges are also arranged to extract water from and return water to the cooling pond in that portion which would become the essential cooling pond, should failure of the Category II cooling pond retaining dikes occur. Thus, the essential pond does not depend upon man-made structural features for retention so that redundancy is not required.

The maximum heat load on the UHS consists of one unit undergoing a post Loss of Coolant Accident (LOCA) cooldown concurrent with a Loss of Offsite Power (LOOP), and the unaffected unit undergoing a safe non-accident shutdown. Both units are also assumed to be at full power operation prior to the shutdown. Only the UHS is assumed to be available at the beginning of the accident and the main cooling pond is assumed to be unavailable. The UHS is analyzed as the only source of water for the SX pumps to cooldown the units.

3.2 Temperature Response of the UHS

The thermal response evaluation of the Braidwood UHS was performed using the Sargent & Lundy (S&L) computer code LAKET. This program was developed by S&L to perform thermal analysis of cooling lakes and ultimate heat sinks. LAKET has been used to perform the thermal analysis of the Braidwood cooling pond and UHS as well as several other nuclear and fossil power plant cooling lakes designed by S&L.

LAKET employs a one-dimensional model that assumes the temperature is constant throughout the plane perpendicular to the direction of flow at any point along the water flow path. The analytical model consists of a Lagrangian method resulting in an idealized effective volume channel. The channel is composed of individual distinct fluid volumes with individual length and temperature. The channel thus forms a set of fluid segments in a First In - First Out queue. The analysis accounts for heat transfer between the water and the ambient via the following mechanisms:

- incident (long wave) radiation,
- reflected (long wave) radiation,
- incident solar (short wave) radiation,
- reflected solar (short wave) radiation,
- back radiation (long wave) from the water surface,
- evaporative heat flux, and
- convective heat flux.

The design basis analysis for the Braidwood UHS is consistent with the regulatory requirements identified in Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants," and Sections 2.4.11 and 9.2.5 of NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," and uses weather data based on a synthetic 36-day "worst" case design weather file.

The UHS evaluation indicates that the temperature response of the UHS is such that with an initial UHS temperature greater than or equal to 98°F, the maximum outlet temperature that the UHS will experience during the design basis accident (DBA) is no greater than the initial starting temperature.

The thermal response of the UHS cooling pond is unlike that which may be experienced with some cooling towers or spray canals. Due to the relatively short residence time of cooling towers or spray canals, in some instances they can experience an increase in outlet temperatures shortly after they are initially exposed to the DBA heat loads.

The expected recirculation time for the Braidwood UHS in the design basis case with 3 SX pumps running is approximately 1.5 days. The analysis for the UHS with an initial starting temperature of 100°F indicates that, by the time water that was discharged to the UHS at the start of the accident has had time to transit the UHS, it would have cooled down to less than 98°F.

Even though the UHS outlet temperature is not expected to ever exceed 100°F, the potential impacts of a slightly higher UHS outlet temperature are addressed in other sections of this response.

3.3 Description of the Braidwood Lake or Main Cooling Pond

The condenser water cooling facility at Braidwood Station is referred to as the cooling pond or as the main cooling pond rather than as a cooling lake. This is consistent with the definition of "pond" in EPA Effluent Guidelines and Standards for Steam Electric Power Generation, 40 CFR 423, Section 432.11, which became effective in 1974.

The Braidwood main cooling pond is a large man-made cooling pond of approximately 2500 acres, which was constructed over a previously strip-mined area. The main cooling pond and the associated dikes are Category II structures. The Category I essential cooling pond is not dependent upon the main cooling pond dikes to perform its UHS function.

The main cooling pond is used to dissipate waste plant cycle heat from the Braidwood Units by utilizing the non-safety related main condenser circulating water (CW) and nonessential service water (WS) systems. The main cooling pond has a water storage volume of approximate 22,300 acre-feet at nominal pool elevation, a cooling water flow rate of approximately 1,500,000 gpm and a nominal transit time of approximately 3 days. Unlike the discharge of the SX System, the discharge of the CW and WS Systems are separated from the lake screen house intakes by internal main cooling pond diking to ensure maximum utilization of the main cooling pond surface area for heat dissipation.

Emergency cooling of the plant is not dependent upon the CW or WS Systems. In the event of a failure of the main cooling pond retaining dikes, the CW and WS Systems would not remain in service.

3.4 Temperature Response of the Main Cooling Pond

An evaluation of the Braidwood main cooling pond was also performed to determine the sensitivity of the entire cooling pond to the increased heat loads associated with the Power Uprate Project. Braidwood Station received power uprate approval in May 2001 authorizing an increase in reactor core power level from 3411 megawatts thermal (MWt) to 3586.6 MWt (Reference 3). This represents an approximate 5% increase in reactor core power. Full power uprate was achieved on Braidwood Unit 1 in October 2001. Braidwood Unit 2 will achieve full uprated conditions following the spring 2002 refueling outage.

The sensitivity evaluation was performed using actual National Weather Service data from Peoria, Illinois and/or Springfield, Illinois for the 48-year period from 1948 to 1996. A conservative solar radiation heat load correlation was used in these simulations. (Note that Weather Service data more recent than 1996 for Peoria or Springfield has not yet been converted to a format that is usable by this program.)

Simulations were performed using both the original station cooling pond heat loads and the increased heat loads associated with Power Uprate. Based on these simulations the predicted Power Uprate maximum cooling pond outlet temperature is approximately 0.25°F higher than what was predicted for the pre-uprate heat load condition.

For both of these simulations maximum cooling pond outlet temperatures were predicted to occur on July 15, 1995. To provide an indication of the conservatism of these simulations, the predicted cooling pond outlet temperatures were then compared with the actual measured SX temperatures for each three-hour time period during the months of July and August 1995. The simulations were found to typically predict cooling pond outlet temperatures that were more than 2°F higher than the measured temperatures and the predicted cooling pond outlet temperatures were always at least 1°F higher than the measured temperatures.

This demonstrates that these simulations are conservative compared to actual measured temperatures and will predict an overall maximum cooling pond outlet temperature that is higher than would be expected to actually occur within the same time period. The overall maximum cooling pond outlet temperature predicted by the simulations were 99.0°F for the pre-uprate case and 99.24°F for the Power Uprate case. Also note that the maximum actual Braidwood cooling pond outlet temperature measured through the end of 2001 was between 98.0°F and 98.5°F which occurred in 2001.

3.5 Conclusion

Based on the simulations performed for the main cooling pond and the UHS and the previously recorded temperatures, the main cooling pond and the UHS are not predicted to reach 100°F. Based on the trends provided in the simulations, the main cooling pond should not reach 100°F unless unusually more adverse weather conditions are experienced in the future.

As stated earlier, even though the UHS outlet temperature is not expected to ever exceed 100°F the potential impacts of a slightly higher UHS outlet temperature are addressed in subsequent sections of this response.

4.0 Impact on Accident Analyses

The minimum or the maximum SX temperature is not explicitly modeled in the 10CFR 50.46 LOCA analysis or the Non-LOCA safety analyses. Also, the minimum or the maximum temperature of the component cooling (CC) water is not explicitly modeled in the LOCA or the Non-LOCA safety analyses.

However, the LOCA analyses (and some Non-LOCA transients) assume the minimum and/or the maximum water temperature of the Emergency Core Cooling System (ECCS) and the maximum cooling capacity of the Reactor Containment Fan Coolers (RCFC). Both of these assumptions can be potentially impacted by the assumption of the SX temperature (SX cools the CC water which in turn cools the Residual Heat Removal (RHR) heat exchanger and the RCFC is directly cooled by SX). These impacts are addressed below.

4.1 Large Break LOCA (LBLOCA)

In the event of a LBLOCA, the ECCS water is initially drawn from the Refueling Water Storage Tank (RWST). When the RWST empties (or nearly empties) the pumps are realigned to the sump, i.e., cold leg recirculation. Assuming no single failure and full runout flow from all the pumps, the earliest time the RWST can empty is in excess of 10 minutes.

A review of the LBLOCA results for the current analysis of record (AOR), i.e., Power Uprate analysis, indicates that for the reference cases the peak clad temperature (PCT) occurs by 100 seconds and the transient is over by 400 seconds. At 400 seconds the clad temperatures are at least 500°F lower than the PCT. In other words, the transient is over while the ECCS water is drawing its suction from the RWST. Since SX temperature has no effect on the RWST water temperature, the SX temperature measurement uncertainty of 2°F will have no impact on the outcome of the PCT.

During the long term, when the ECCS water is drawing its suction from the sump, the SX temperature can have an effect on the clad temperatures. However, at this point in the transient, the clad temperatures are significantly lower, and a 2°F variance in SX temperature will not have a significant impact on the results.

Furthermore, it is conservative to minimize the containment pressure when evaluating overall ECCS performance as described in NUREG-0800, Section 6.2.1.5, "Minimum Containment Pressure Analysis for Emergency Core Cooling System Performance Capability Studies." Lower containment pressure results in a lower reflood rate and hence a higher PCT. To minimize containment pressure, maximum RCFC heat removal capacity is assumed in the LBLOCA analysis. Consequently, the heat removal capacity of the RCFCs was calculated based on an SX temperature of 32°F (UFSAR, Figure 6.2-25).

Therefore, the SX temperature measurement uncertainty of 2°F will have no detrimental impact on the outcome of the LBLOCA PCT.

4.2 Small Break LOCA (SBLOCA)

In the event of a SBLOCA, the ECCS water is initially drawn from the RWST. When the RWST empties (or nearly empties) the pumps are realigned to draw suction from the sump, i.e., cold leg recirculation. The current AOR PCT for Braidwood Unit 1 SBLOCA is 1624°F (Reference 4) and occurs at about 3455 seconds in the transient. The current AOR PCT for Unit 2 is 1627°F (Reference 4) and occurs at about 3071 seconds in the transient.

A review of the SBLOCA results indicates that at the time the PCT occurs, the ECCS water is being drawn from the sump. Therefore, there is a potential that the SX temperature could impact the outcome of the results. However, in the SBLOCA analysis during cold leg recirculation, the ECCS water temperature discharged to the Reactor Coolant System (RCS) is assumed to be at 212°F. That is, there is basically no (if one assumes the containment pressure to be 14.7 psia) or little credit taken for the cooling of the ECCS water by the RHR heat exchangers.

Furthermore, there are a number of conservative assumptions applied in the SBLOCA analysis. The following lists a few examples.

1. 1971 ANS decay heat with an additional 20% is assumed in the analysis.
2. Conservative ECCS flows are assumed in the analysis, i.e., the ECCS pumps are assumed to be significantly degraded.

3. All the neutronic parameters (such as power shapes, axial offset, etc.) are assumed to be in the worst conditions at the same time.
4. The most limiting fuel parameters, i.e., stored energy, are assumed in the analysis.

Therefore, the SX temperature measurement uncertainty of 2°F will have no detrimental impact on the outcome of the SBLOCA PCT.

4.3 Hot Leg Switchover (HLSO) Analysis

To preclude boron from precipitating in the core and to ensure long term core cooling, hot leg switchover (HLSO) analysis is performed. The current HLSO analysis assumes cooling of the sump water via the RHR heat exchanger prior to the discharge to the RCS. More specifically, the current HLSO analysis assumes an ECCS water temperature of 170°F at the RHR heat exchanger outlet (entering the RCS). Based on this assumption the HLSO time was determined to be 8.5 hours (UFSAR, Table 6.3-7). Consequently, the assumption of the SX temperature can potentially impact the ECCS water temperature and hence influence the outcome of the results. However, enough conservatism exists in the analysis assumptions to more than compensate for any adverse impact a 2°F increase in SX temperature may have on the HLSO analysis results. This determination is based on an assessment of the following conservatism contained in the HLSO analysis.

1. A boron precipitation limit of 24 wt% is assumed in the analysis. In reality, boron precipitation is 28 wt% at 14.7 psia. This represents a 4 wt% conservatism.
2. No credit for the baffle/barrel region volume is assumed in the analysis. There are flow paths between the baffle/barrel region and the core. This volume could be credited.
3. No nozzle gap leakage was assumed in the analysis. In reality, there will be leakage from the nozzle gaps.

Furthermore, a sensitivity study was performed assuming an ECCS water temperature of 212°F instead of 170°F and compared to the current HLSO AOR. Varying only the assumed ECCS water temperature (assuming 212°F, instead of 170°F) results in a calculated HLSO time of 8.0 hours. Thus, an increase of 42°F in the ECCS water temperature results in a reduction of 1/2 hour (Reference 5). Note that a revised HLSO was recently submitted to the NRC (Reference 6) to satisfy a License Condition imposed during Power Uprate approval. The revised analysis, not yet approved, also assumes an ECCS water temperature of 212°F.

Therefore, based on the above, the SX temperature measurement uncertainty of 2°F will have an insignificant impact on the current HLSO AOR and no impact on the revised HLSO analysis.

4.4 Non-LOCA Analysis

For two Non-LOCA events, Main Steam Line Break (MSLB) and Steam Generator Tube Rupture (SGTR), the ECCS is modeled and assumed to operate. For both of these events the transient is terminated well before the RWST is drained down. The limiting point for MSLB is reached within ten minutes. For SGTR the event can last as long as an hour. However, since only the charging and the safety injection pumps are drawing suction from the RWST, the RWST will not drain down in one hour.

Therefore, the SX temperature measurement uncertainty of 2°F will have no detrimental impact on the outcome of the MSLB and the SGTR results.

4.5 Conclusion

In conclusion, an SX temperature measurement uncertainty of 2°F has either no impact or an insignificant impact on the LOCA and non-LOCA results.

5.0 Impact on Containment Analyses

An evaluation of the impact of a 2°F increase in SX temperature on the short term containment response was performed using the computer code GOTHIC. The GOTHIC computer code was used to model the containment and provides the time dependent thermal response. Since Exelon does not have access to the Westinghouse computer code (COCO) used in the current licensing basis AOR, comparison cases were performed to estimate the impact of the 2°F increase in SX temperature using GOTHIC. A direct comparison to the COCO results shows that the GOTHIC model captures the same key time dependent behavior as COCO. Refer to Figure 1, " Comparison of Containment Pressure GOTHIC SX 102°F with COCO SX 100°F Results," Figure 2, "Comparison of Containment Vapor Temperature GOTHIC SX 102°F with COCO SX 100°F Results," and Figure 3, "Comparison of Containment Liquid Temperature GOTHIC SX 102°F with COCO SX 100°F Results." Differences between GOTHIC and COCO in the first few seconds indicate GOTHIC is allowing a greater flashing to vapor, which conservatively maximizes vapor pressure and temperature. This temporarily lowers the liquid sump temperatures for the first 30 seconds. It was concluded that GOTHIC has acceptable performance in comparison to COCO.

The DBAs that result in challenge to containment operability from high pressure and temperature are a LOCA and a steam line break (SLB). The highest peak pressure is experienced during a LOCA, while the highest peak temperature is experienced during a SLB. The peak pressure case was chosen as the limiting case to be evaluated for impact of a 2°F increase in SX temperature. This is because for the short-term analysis increased SX temperature reduces the RCFC capacity, which is most important for the peak containment pressure that challenges the containment pressure design limit. SLB peak temperature is driven by the rapid mass and energy released prior to the initiation of the RCFC System. Consequently, the RCFC performance does not change the peak temperature values in a SLB that would challenge the containment temperature design limit.

The GOTHIC calculation evaluates the effect on LOCA containment response due to a 2°F increase in SX temperature. Only the RCFC heat exchanger capacity input to the model is affected by the increase in SX temperature for short-term calculations. All other licensing basis containment analysis parameters were assumed unchanged.

The base case selected was the replacement steam generator (RSG) model assuming an initial SX temperature of 100°F. For the short-term analysis where the peak pressure and temperature occur in the first 2 minutes, use of the RSG model mass and energy releases are comparable to the Power Uprate mass and energy releases. In fact, the Power Uprate containment analysis results in a slightly lower peak pressure and temperature than the RSG containment analysis. This validates the assumption that use of the RSG GOTHIC short-term model sensitivity is applicable and conservative as a tool for evaluating the relative impact of SX temperature.

Sensitivity runs were performed and compared to the GOTHIC RSG base case. The results are provided below in Table 5.1, "Summary of LOCA Calculation Results." The impact of a 2°F increase in SX temperature with no other input changes from the base case was evaluated. Following the case that established the impact sought by this study, a sensitivity case was run with 102°F SX temperature, but with the design RCFC air flow rate of 72,280 CFM instead of the conservatively low analytical value of 65,000 CFM. This use of the design RCFC air flow value of

72,280 CFM shows that the penalty from a 2°F increase in SX temperature can be entirely mitigated by this one input change. COCO results from the RSG case most comparable to the GOTHIC cases are also shown to demonstrate the similarity of the results. However, Power Uprate is the current licensing basis for Braidwood, so that the COCO results from Power Uprate are provided for information only. Finally the design limits are provided in the table to clearly demonstrate the 2°F increase in SX temperature in no way challenges the design limits.

Table 5.1 Summary of LOCA Calculation Results

Description	SX Temp(°F)/ RCFC flow (CFM)	Peak Containment Pressure (psig)	Peak Containment Vapor temperature (°F)	Peak Containment Sump temperature (°F)
GOTHIC RSG Base Case	100 / 65,000	44.25	267.2	247.3
GOTHIC RSG w/2°F SX Uncertainty	102 / 65,000	44.27	267.2	247.3
GOTHIC RSG w/2°F SX Uncertainty	102 / 72,280	44.24	267.1	247.3
COCO RSG	100 / 65,000	44.41	266.9	248.8
COCO Power Uprate	100 / 65,000	42.77	264.5	N/A
Containment Design Limits	N/A	50	280	N/A

The impact due to a 2°F increase in SX temperature for the short-term analysis resulted in an increase in peak pressure of 0.02 psig with no increase in vapor temperature or sump temperature. When added to the current containment analysis results for Power Uprate, these are well below the containment design limits. Therefore, the impact due to a 2°F increase in SX temperature is small and does not challenge the containment design limits for the short-term portion.

GOTHIC model results provided in Table 5.2 below demonstrate the amount of conservatism in the containment analysis for several other combinations of input parameter changes in addition to the RCFC air flow rate of 72,280 CFM case given in Table 5.1.

Table 5.2 Summary of GOTHIC LOCA Nominal Calculation Results

Description	SX Temp(°F)/ RCFC flow (CFM)	Peak Containment Pressure (psig)	Peak Containment Vapor temperature (°F)	Peak Containment Sump temperature (°F)
GOTHIC RSG Base Case	100 / 65,000	44.25	267.2	247.3
Nominal RCFC initiation	100 / 65,000	44.24	267.1	247.3
Nominal RCFC initiation at 3.4 psig and Nominal Sizes	100 / 65,000	42.93	265.2	246.3
Nominal RCFC initiation at 3.4 psig, Nominal Sizes and Nominal thermo-physical Material Properties	100 / 65,000	42.83	265.1	246.2

The first change evaluated in Table 5.2 was the RCFC initiation setpoint. The licensing basis input for RCFC initiation, i.e., containment pressure – high 1, was reduced from 6.8 psig to the nominal value of 3.4 psig. With this conservatism eliminated, the peak containment pressure was reduced by 0.01 psig.

The second change evaluated in Table 5.2 included nominal dimensions and sizes for the containment in addition to the setpoint at which RCFC was initiated. Nominal dimensions for the containment were taken from the UFSAR values. An example of a change was that a containment free volume of 2,800,000 ft^3 was used instead of the 2,758,000 ft^3 value used in the licensing basis. The UFSAR has a list of 20 structures that can be credited for heat sinks in the containment analysis and each area was increased to its nominal heat transfer surface area. An example of a change to one of the 20 structures was the cylindrical containment wall surface area of 80,823 ft^2 was used instead of the 72,741 ft^2 value used in the licensing basis. This case included the nominal RCFC initiation setpoint change to 3.4 psig. With a nominal RCFC initiation at 3.4 psig and nominal containment sizes, the peak containment pressure was reduced by 1.32 psig.

The third change evaluated in Table 5.2 included nominal thermal conductivity and specific heat capacity for the containment metal and concrete heat sinks in addition to the first two changes of nominal RCFC initiation at 3.4 psig and nominal containment sizes. Nominal thermal conductivity and specific heat capacity for the containment carbon steel, stainless steel and concrete were taken from published data. Examples of the changes were a carbon steel thermal conductivity of 39.563 BTU/Hr-Ft-degF was used instead of the 27 BTU/Hr-Ft-degF value used in the licensing basis. Similarly, a carbon steel specific heat of 0.1194 BTU/Lbm-degF was used instead of the 0.12 BTU/Lbm-degF value used in the licensing basis. With a nominal RCFC initiation at 3.4 psig, nominal containment sizes and nominal thermo-physical heat conductor properties, the peak containment pressure was reduced by 1.42 psig.

For containment peak temperature, the results must be below the limits set by the containment liner. The liner design limit peak containment temperature is 280°F. The GOTHIC calculation determines the containment liner temperature as a function of time. Liner temperature is one of the heat structure models within GOTHIC. Note, there was no change in peak temperature due to the 2°F increase in SX temperature. Liner temperature calculated by GOTHIC was 245°F for the cases where vapor temperature reached 267°F. This 245°F represents considerable conservatism to the 280°F design limit.

There is conservatism in the UFSAR LOCA containment response analysis for the mass and energy release as well. Mass and energy releases were calculated by Westinghouse and input directly into the GOTHIC input parameters. The GOTHIC calculations did not re-evaluate the mass and energy releases. The assumed ECCS flow temperature has a 20°F conservatism, which has been estimated in past studies (Reference 7) to be worth approximately 0.25 psi reduction in containment pressure.

A comparison of the relative impact of the 2°F increase in SX temperature to the conservatism evaluated by this study is summarized below in Table 5.3 for convenience. Table 5.3 shows the impact on peak containment pressure due to a 2°F increase in SX temperature along with the benefit received when specific conservative inputs in the model were changed to nominal values. Table 5.3 demonstrates that the conservatism in the licensing basis inputs is well in excess of the small, nearly insignificant impact of a 2°F increase in SX temperature.

Table 5.3 Relative Impact and Conservatism

Impact on Containment Pressure:	(psig)
2°F increase in SX temperature	0.02

Conservatism:	
RCFC design air flow rate	-0.03
RCFC Initiation at Nominal Setpoint	-0.01
RCFC Initiation at Nominal Setpoint + Nominal sizes	-1.32
RCFC Initiation at Nominal Setpoint + Nominal sizes + Material Properties	-1.42
ECCS flow temperature	-0.25

Finally, the results using GOTHIC, in general, show the SX temperature uncertainty impact on the AOR for the peak pressure calculations is very small. This leads to the conclusion that there is no need to add SX temperature measurement uncertainty to assure conservative licensing basis containment analysis with the Westinghouse COCO code.

6.0 Component Evaluations

Even though the SX System is not expected to exceed 100°F, various components supplied by the SX System were evaluated to determine their potential sensitivity to slightly elevated SX temperatures. The potential impacts on the closed loop CC System, the Emergency Diesel Generators (EDG), the Auxiliary Feedwater (AF) System, the SX pumps, and the Main Control Room (MCR) chillers are discussed below. The components needed to support operation of the Emergency Core Cooling System (ECCS) pumps and other safety related equipment, including oil coolers, room cubicle coolers, and jacket water cooling systems are also addressed below.

The following summarizes the assessments of the components served by SX.

1. CC System

   <u>CC System Normal Operation</u>
   The main components served by the CC System during normal plant operation include the Letdown heat exchangers, Reactor Coolant Pumps (RCP) Thermal Barriers, RCP Motor Radial Bearing Oil Coolers, Seal Water heat exchangers, Spent Fuel Pool (SFP) heat exchangers, and Containment Penetration Cooling. The original analysis for the CC System also included heat loads from the non-safety related Recycle Evaporator Packages and Positive Displacement Pumps, even though these components are not in use at Braidwood and have been removed from service.

   The CC Heat Exchanger outlet temperature is normally limited to 105°F during 100% power operation and 120°F after initiation of RHR for a normal RCS cooldown. The 120°F limit does not apply to post accident conditions. Based on the available temperature differences between CC and SX, the limiting performance for the CC Heat Exchanger is during normal operation and not during the RCS cooldown case. The larger log mean temperature differences available during an RCS cooldown more than offsets the larger expected heat loads. Therefore, the evaluations to determine the sensitivity of the CC Heat Exchanger to slightly elevated SX temperatures were performed for the 100% power normal operation cases.

If the SX temperature were assumed to be increased to 102°F and no other evaluation inputs were adjusted, then the normal operation CC Heat Exchanger outlet temperature could potentially increase from 105°F to approximately 107°F. However a more realistic evaluation to predict CC Heat Exchanger outlet temperatures would remove the nonexistent heat loads from the Recycle Evaporators and the Positive Displacement Pumps. Additional conservatism also exists in the U values used in the design analyses for the CC Heat Exchangers. The minimum acceptable U values per the CC Heat Exchanger performance verification procedures are 10% greater than the U values used in the design analysis. Measured CC Heat Exchanger U values are higher than the minimum acceptable values specified in the procedures.

If the SX inlet temperature were assumed to be increased to 102°F while also utilizing the CC Heat Exchanger performance verification procedure's minimum U value, along with removing the heat loads and flows for the Recycle Evaporators and the Positive Displacement Pumps, then the expected CC outlet temperature would be less than the 105°F normal operation guideline. It was also verified that for the RCS cooldown cases, utilizing only the 10% higher U value would more than offset a 2°F increase in the SX inlet temperature. In both of these cases, the resulting CC outlet temperatures would remain less than currently predicted by the corresponding design analyses with an SX inlet temperature of 100°F. Based on these comparisons, the CC Heat Exchangers will be capable of maintaining the applicable CC outlet temperatures with an assumed SX inlet temperature of 102°F and, therefore, the components supplied by CC will not be aversely impacted.

Even though the CC Heat Exchanger outlet temperature will be able to be maintained less than 105°F with sufficient heat load and flow balancing, provided below is a discussion of the potential impacts if the CC Heat Exchanger outlet temperature were assumed to increase to 107°F.

(a) Based on the available temperature differences between the CV and CC flows at the Letdown Heat Exchangers, an assumed 2°F increase in the CC supply temperature would not have any significant impact in the heat exchanger performance. Note that RCS letdown flow can be acceptably set at either 75 or 120 gpm. The analyses for both the Letdown and CC Heat Exchangers conservatively assume a letdown heat load that is greater than would be expected even at the maximum letdown flow of 120 gpm. Establishing letdown flow at 75 gpm can be used to offset an assumed temporary increase in CC temperature while maintaining acceptable letdown temperatures. It should also be noted that during normal operation the Letdown Heat Exchangers account for nearly half of the total heat load on the CC Heat Exchangers, and that reducing the letdown flow would also reduce the overall CC System temperatures below what was previously evaluated.

(b) A postulated increase in CC temperature from 105°F to 107°F would still meet the RCP thermal barrier CC inlet temperature normal operation limit of 120°F.

(c) RCP motor radial bearing temperatures during normal plant operation (i.e., approximately 130°F to 150°F) are significantly below the operational limit of 195°F. An increase in CC temperature of 2°F would continue to maintain these temperatures significantly below normal operational limits.

(d) The Seal Water heat exchanger cools the RCP seals return flow (about 12 gpm). The discharge flow from the Seal Water heat exchanger is routed to the outlet of the Volume Control Tank. At this point, this water mixes with the balance of the charging flow, i.e., letdown and makeup, and enters the suction header to the Charging (CV) pumps.

Considering the magnitudes of the seal water flow and the balance of the charging flow, a temporary 2°F increase in seal water temperature would not have a significant impact on the temperature of the water supply to the CV pumps.

(e) The limiting SFP heat load is experienced during a refueling outage while the reactor fuel assemblies are offloaded. During normal operation, the impact of a temporary CC temperature increase of 2°F on the SFP temperature is bounded by the design basis analyses. The TRM requirement for in-core decay time (ICDT) ensures that the SFP temperature remains bounded by the design basis analyses. The maximum SFP temperature is dependent on several parameters, i.e., the number of fuel assemblies in the SFP, the in-core decay time (ICDT) of the fuel assembles prior to starting the core offload, the offload rate, the CC temperature, etc. If a change to a parameter is needed, an evaluation is performed. The evaluation ensures that acceptable SFP temperatures and heat loads are maintained.

(f) CC water is supplied to the cooling coils in a number of mechanical containment penetrations that serve high energy piping (i.e., Main Steam, Main Feedwater, etc.) The function of the cooling coils is to maintain the temperature of the concrete within these penetrations. A worst case temporary increase in concrete temperature of 2°F would not have an impact on the concrete short term or long term degradation.

(g) The CC System also supplies cooling to the shell side of the seal cooler for each RHR pump. A temporary increase of 2°F in the seal water temperature would not have an impact on the RHR pumps' mechanical seals.

2. EDG

The existing EDG Jacket Water Heat Exchanger analysis is based on an SX temperature of 100°F, a heat load of 12.2 MBTU/hr, and an assumption that approximately 8% of the heat exchanger tubes have been plugged. The heat load utilized in the design analysis is conservative, even based on a diesel generator loading of 6,050 kW. Note that a diesel generator loading of 6,050 kW is 110% of the EDG continuous power rating of 5,500 kW and that the actual EDG maximum loading is less than 5,500 kW. The heat load that is actually required to be transferred by the EDG Jacket Water Heat Exchanger is at least 10% less than is used in the design analysis. An evaluation utilizing an assumed SX temperature of 102°F and the original 8% tube plugging assumption would only result in an approximately 2½ % reduction in heat transfer. Based on the margin available due to the conservative heat load assumption, the EDG Jacket Water Heat Exchanger has adequate capability to transfer the actual heat load with an SX inlet temperature of 102°F.

3. Auxiliary Feedwater Pump.

The SX System cools the diesel driven AF pump closed cycle heat exchanger and is also the safety related suction supply for the AF pumps.

(a) The diesel driven AF pump closed cycle heat exchanger was specified and designed for a maximum SX cooling water temperature of 102°F and, therefore, no additional evaluation is required.

(b) SX is the safety related suction supply to the AF System. Accident analyses assume a maximum AF enthalpy that corresponds to a water temperature in excess of 120°F. Therefore, an SX temperature of 102°F is bounded by the existing accident analyses assumptions for AF temperature.

(c) The Net Positive Suction Head (NPSH) calculation for the AF pump assumes a temperature of 120°F. Therefore, an increase in SX temperature to 102°F has no impact on the calculated $NPSH_{available}$ for the AF pump.

4. SX pumps.

The increase in SX temperature from 100°F to 102°F results in a reduction in $NPSH_{available}$ of < 0.2 ft. This reduction is insignificant as the available margin between $NPSH_{required}$ and $NPSH_{available}$ is in excess of 8 ft.

5. MCR Chillers.

A review of the design analysis for the MCR Chillers indicates that the required chiller capacity is approximately 63% of the MCR Chiller's rated capacity. The design analysis also documents that the original chiller capacity testing demonstrated that the MCR chillers were capable of producing their full rated capacity with an SX inlet temperature of 105°F. Therefore, an increase in the SX inlet temperature from 100°F to 102°F would not have an adverse impact on the ability of the MCR chillers to provide the required cooling.

6. Cubicle Coolers, Lube Oil Coolers, and other ECCS support equipment.

It may be conservatively assumed that an increase in SX temperature of 2°F could result in an increase in the equipment operating temperatures by as much as 2°F.

(a) Cubicle cooler performance could be slightly impacted, so as to result in a temporary increase of 2°F to environmentally qualified equipment operating environments. The Braidwood Environmental Qualification (EQ) Program conservatively assumes the maximum continuous area temperature for the normal operating environment when calculating the qualified life of safety-related equipment. The TRM imposes administrative limits on area temperatures, so as to ensure that the basis for EQ remains valid. The existing design basis calculations for the cubicle coolers are based on an SX temperature of 100°F. Due to the diurnal nature of the SX temperature profile and considering an SX temperature of 102°F, it is not expected that the normal environmental area temperature monitoring limits specified in the TRM will be exceeded. Furthermore, the TRM does not require action to be taken unless the temperature in the area is exceeded for greater than 8 hours or by greater than 30°F. Small increases of up to 2°F in each of the affected rooms will not impact the qualified life of the equipment.

(b) For components cooled directly by SX (e.g., lube oil coolers), operability of the affected components at higher temperatures has previously been demonstrated as a result of EQ documentation, including, survivability studies and thermal endurance evaluations. These demonstrate operability of the equipment as a whole, i.e. bearings, lubricant, seals, and terminations, inclusive of ancillary devices, at higher temperatures. Assuming a 2°F increase in lube oil temperatures, the corresponding effect on the operation of the affected equipment is not significant.

Other considerations, such as the impact of increasing the UHS temperature to 102°F on Generic Letter (GL) 96-06, "Assurance of Equipment Operability And Containment Integrity During Design-Basis Accident Conditions," and Station Blackout (SBO), were also evaluated. Conservatism in existing GL 96-06 analyses are sufficient to offset the increased UHS temperature, i.e., assumptions which maximize the extent of voiding and minimize the time to void collapse. The net effect would be well within the calculational uncertainty inherent in two-phase hydraulic analyses. In the case of SBO, the UHS temperature was not used as a direct input. In the SBO analysis, SX is cross-tied between the non-blacked-out (NBO) and the blacked-out (BO) units. The use of a single pump to supply both units' loads during a SBO was shown by flow analysis to be acceptable. Conservatism exists in the required flow value that was established for this analysis, because both trains of RCFCs on the BO unit and one train of RCFC on the NBO unit are assumed to be isolated. The SBO analysis demonstrated acceptable flow values to the required components greater than or equal to minimum flow requirements. Additionally, the assessments described above have demonstrated that the components served by SX will perform their intended safety functions at the higher SX temperature, therefore, a 2°F increase in SX temperature will not have an impact on the SBO analysis.

7.0 Conclusion

Calculations were performed which determined the uncertainty associated with the SX temperature instruments as SX temperature approaches the TS surveillance limit of 100°F. The calculations determined the true value of the SX temperature is within 2.0°F of the indicated reading using the statistically combined uncertainty of all error terms at the appropriate confidence level.

A study performed by S&L confirmed that the temperature response of the UHS is such that with an initial UHS temperature of greater than or equal to 98°F, the maximum outlet temperature that the UHS will experience is the initial starting temperature. The study also modeled the main cooling pond and compared the results to actual measured temperatures since the performance of the main cooling pond determines UHS initial temperature. Based on the simulations performed for the main cooling pond and the UHS and the previously recorded temperatures, the main cooling pond and the UHS are not predicted to reach 100°F. This reaffirms that the design of the UHS is adequate. Additionally, in accordance with the guidance of R.G. 1.27, the design contains sufficient conservatism to ensure that design basis temperatures of safety related equipment are not exceeded. Based on the trends provided in the simulations, the main cooling pond should not reach 100°F unless unusually more adverse weather conditions are experienced in the future.

Even though the UHS outlet temperature is not expected to ever exceed 100°F, the potential impacts of a slightly higher UHS outlet temperature were evaluated. The impacts of a 2°F increase in SX temperature on accident analyses, containment analyses, and various components served by SX were evaluated. It was determined that a 2°F increase in SX temperature has either no impact or an insignificant impact on the LOCA and non-LOCA results. Various conservative assumptions used in the accident analyses were identified. The impact on short-term containment response was quantified and resulted in an increase in peak pressure of 0.02 psig with no increase in vapor or sump temperature. Conservatism in RCFC air flow rate, RCFC setpoint initiation, containment areas, thermal conductivity and specific heat capacity, and ECCS flow temperature were quantified and determined to be well in excess of the nearly insignificant impact of a 2°F increase in SX temperature. Component evaluations were performed and determined that components served by SX would continue to perform satisfactorily despite a 2°F increase in SX temperature.

Thus it is concluded that the inherent margin is sufficient to accommodate the instrument uncertainty. Because the inherent margin has been shown to be sufficient, it is not necessary to add measurement uncertainty to either the analyses or the surveillance procedures, and the implicit method of incorporating instrument uncertainty remains appropriate for this application. Therefore, it is concluded that the existing TS and associated surveillance procedures have been established in an appropriately conservative manner.

8.0 References

1. Letter from G.E. Grant (NRC Region III) to O.D. Kingsley (Exelon Generation Company, LLC), “Braidwood Station, Units 1 and 2, NRC Inspection Report 50-456/01-11 (DRP); 50-457/01-11 (DRP) and Notice of Violation,” dated December 12, 2001

2. Letter from J.D. von Suskil (Exelon Generation Company, LLC) to U.S. NRC, "Reply to a Notice of Violation," dated January 11, 2002

3. Letter from G.F. Dick (NRC) to O.D. Kinglsey (EGC), “Issuance of Amendments; Increase in Reactor Power, Byron Station, Units 1 and 2, and Braidwood Stations, Unit 1 and 2,” dated May 4, 2001

4. Letter from K.R. Jury (Exelon Generation Company, LLC) to U.S. NRC, "Annual Report of the Emergency Core Cooling System Evaluation Model Changes and Errors Required by 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," dated April 18, 2002

5. W Calculation Notebook CN-LIS-01-155, "Revision 0, Byron/Braidwood Units 1 & 2 Hot Leg Switchover (HLSO) Reanalysis for Uprate SER Compliance", January 2002.

6. Letter from K.R. Jury (Exelon Generation Company, LLC) to U.S. NRC, "Hot Leg Switchover Confirmatory Analysis Supporting Uprated Power Operations at Byron and Braidwood Stations," dated April 12, 2002

7. Letter NFM:PSA:98-088, "Diesel Generator Frequency White Paper," from Hak-Soo Kim to T. Luke and W. Kouba, dated November 30,1998

Figure 1
Comparison of Containment Pressure
GOTHIC SX 102°F with COCO SX 100°F Results

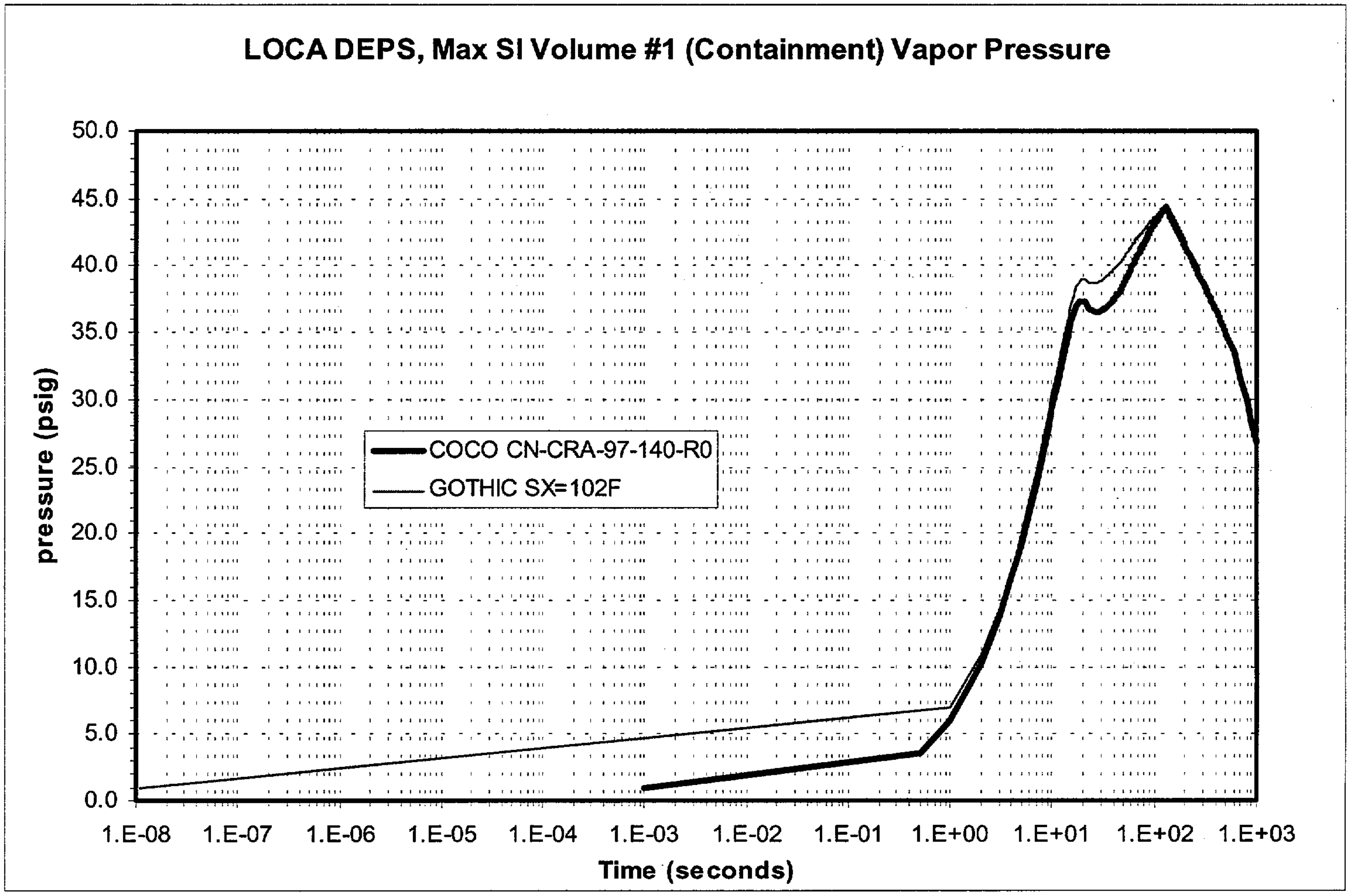

Figure 2
Comparison of Containment Vapor Temperature
GOTHIC SX 102°F with COCO SX 100°F Results

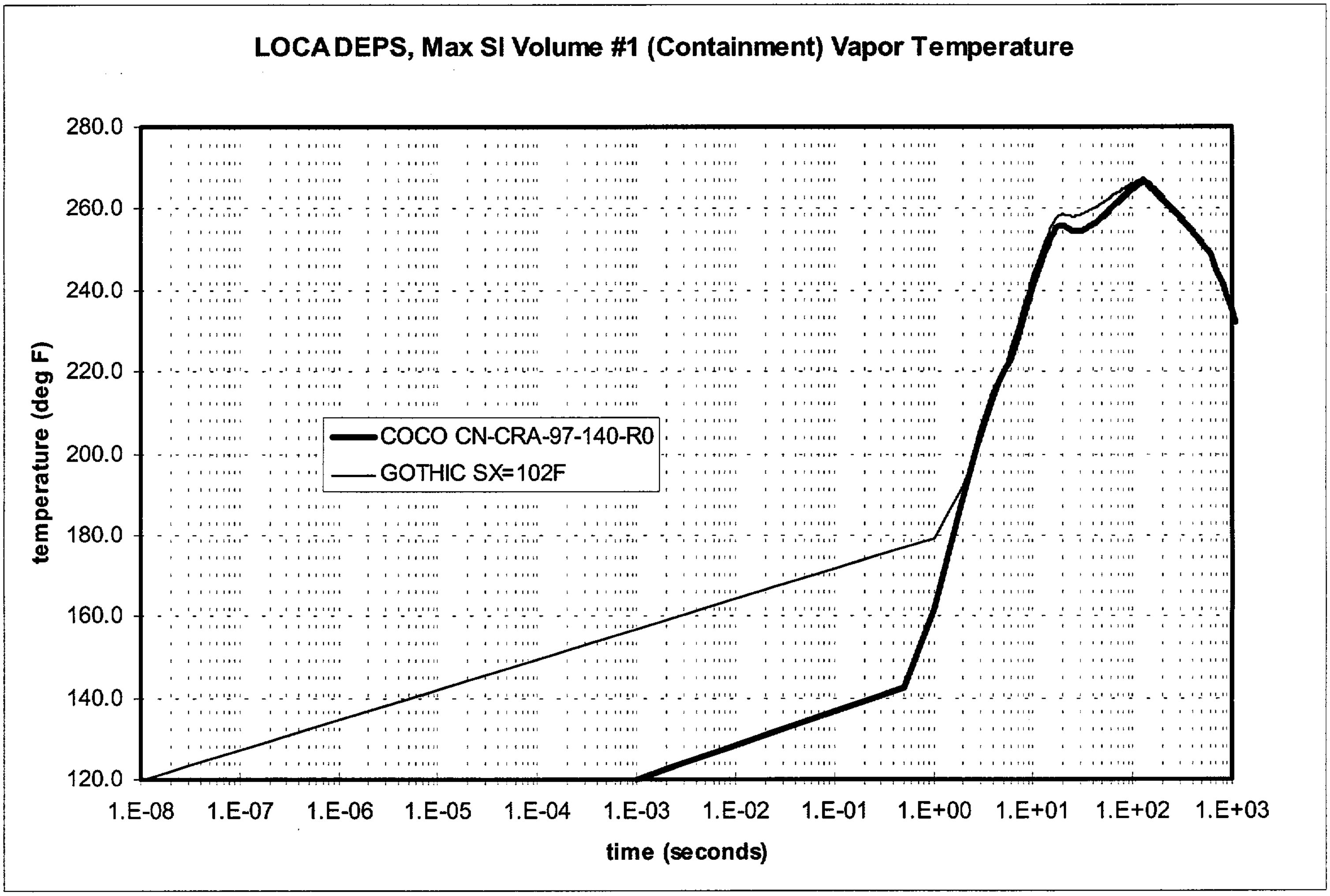

Figure 3
Comparison of Containment Liquid Temperature
GOTHIC SX 102°F with COCO SX 100°F Results