RESPONSE TO NRC CONCERN WITH TEMPERATURE EFFECTS ON SAFETY-RELATED ELECTRONICS IN MAIN CONTROL ROOM

PURPOSE

In a recent NRC Inspection Exit Meeting and USNRC Inspection Report 05000458/2015010, Attachment 3, a concern was expressed by the NRC that the evaluation of the Loss of HVAC in the Main Control Room does not appear to be conservative with respect to the potential impact on safety-related electronic components. Two documents were cited as a basis for this concern:

- USNRC Information Notice 85-89, “Potential Loss of Solid-State Instrumentation Following Failure of Control Room Cooling”
- NUREG/CR-6479, “Technical Basis for Environmental Qualification of Microprocessor-Based Safety-Related Equipment in Nuclear Power Plants”

The purpose of this document is to evaluate the information presented in these documents, as well as the inspection report, and determine if the NRC cited documents and concerns identify any unevaluated risks to reliable operation of Main Control Room safety-related electronic equipment with regard to elevated temperature effects.

Additionally, Attachment 1 to this document provides a summary of the evaluations and analyses performed over the past year to address River Bend Station’s loss of Control Building HVAC.

SCOPE

The scope of this evaluation is limited to the potential adverse effect of elevated temperatures on Main Control Room safety-related electronic equipment as discussed in USNRC Information Notice 85-89, NUREG/CR-6479, and USNRC Inspection Report 05000458/2015010, Attachment 3.

METHODOLOGY

Review NRC Inspection Report 05000458/2015010, Attachment 3.

Review the NRC cited documents and applicable analysis to determine the applicability of USNRC Information Notice 85-89 and NUREG/CR-6470 to the River Bend Main Control Room.

Review GE document 22A3888, Rev. 3 “Main Control Room Panels (NSSS) Design Specification” (Reference 7) for Main Control Room design temperatures.

Review the GOTHIC model (Reference 5) for Case 1 and Case 2. Case 1 is Loss of Offsite Power (LOOP) with mitigating actions. Case 2 is normal operation with mitigating actions. The model was developed to determine Main Control Room temperatures and humidity changes on a loss of Main Control Room cooling. Attachment 1 of Reference 5 models a scenario developed from Case 2 in which HVC-ACU1 is aligned to the service water system one hour following the start of the event (Case 2 demonstrates that the acceptable temperature control for the Main Control Room). Because Case 2 results in higher temperatures that bound the Attachment 1 temperatures, only Case 2 will be referenced.

Average temperature and humidity curves from the GOTHIC model are provided in Figures 1 through 3 for Case 1 and Figures 4 through 6 for Case 2. Figure 7 shows the maximum local relative humidity. Figures 8 and 9 show the temperature and humidity curves for subvolume 171, which is the subvolume that contains safety related electronic equipment with the highest peak temperature.

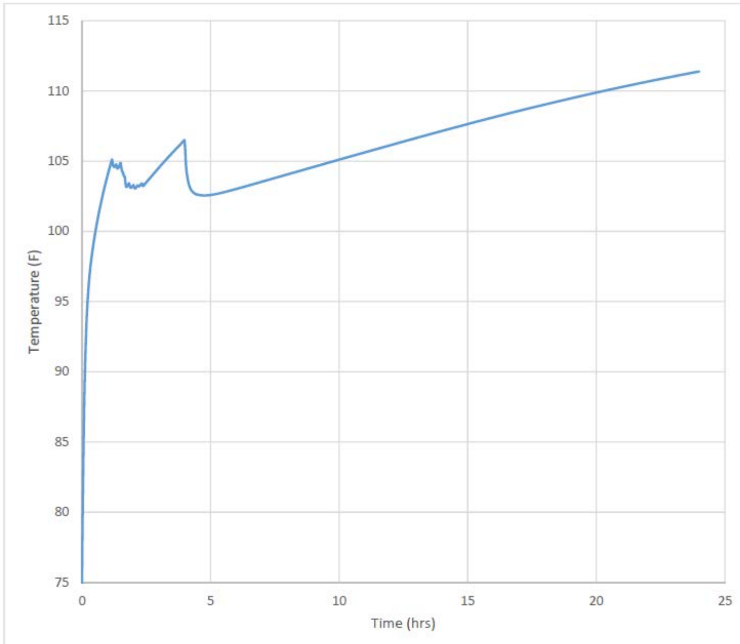

Figure 1: Average MCR Temperature for Case 1

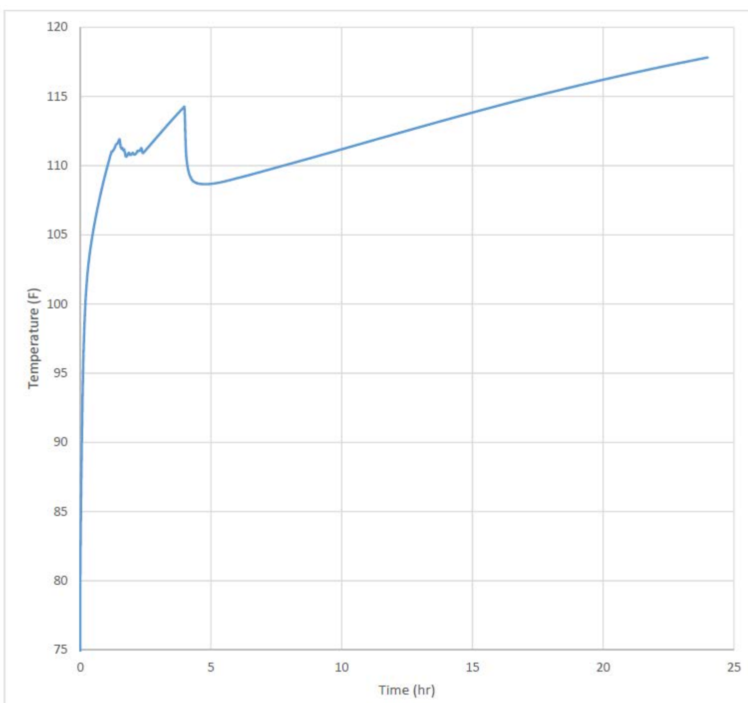

Figure 2: Maximum Local MCR Temperature for Case 1

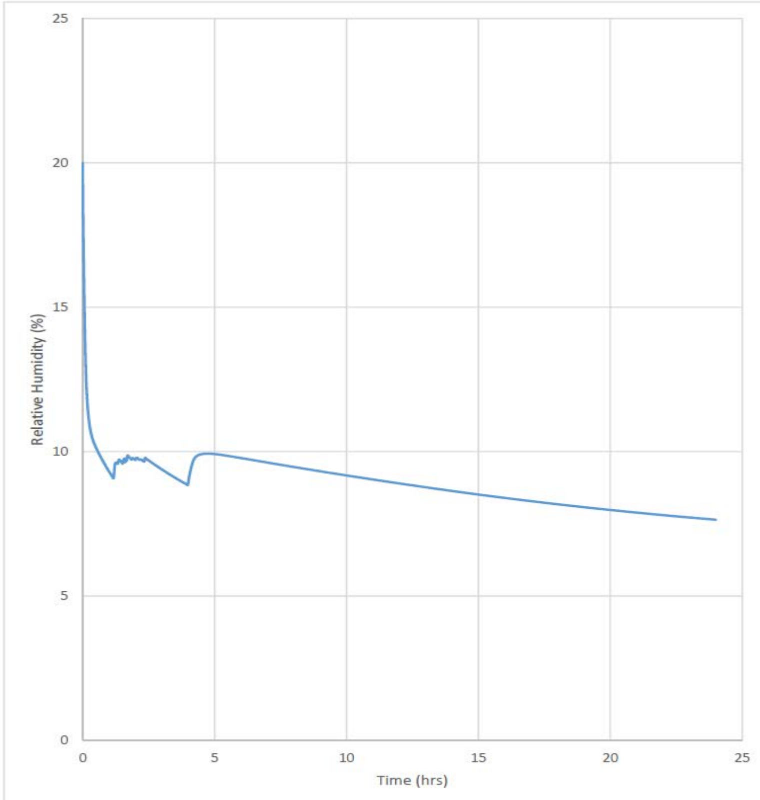

Figure 3: Relative Humidity in the Horseshoe Area for Case 1

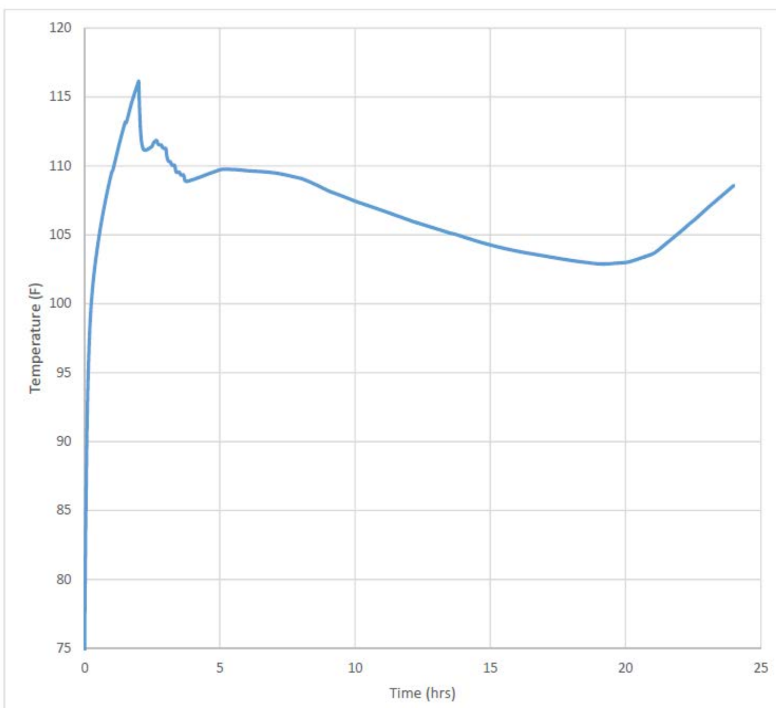

Figure 4: Average MCR Temperature for Case 2

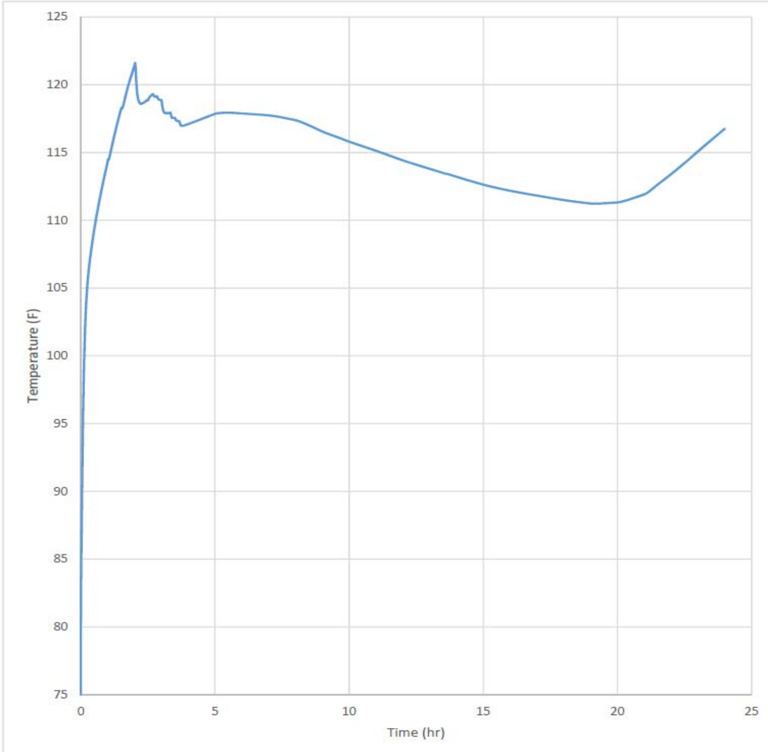

Figure 5: Maximum Local MCR Temperature for Case 2

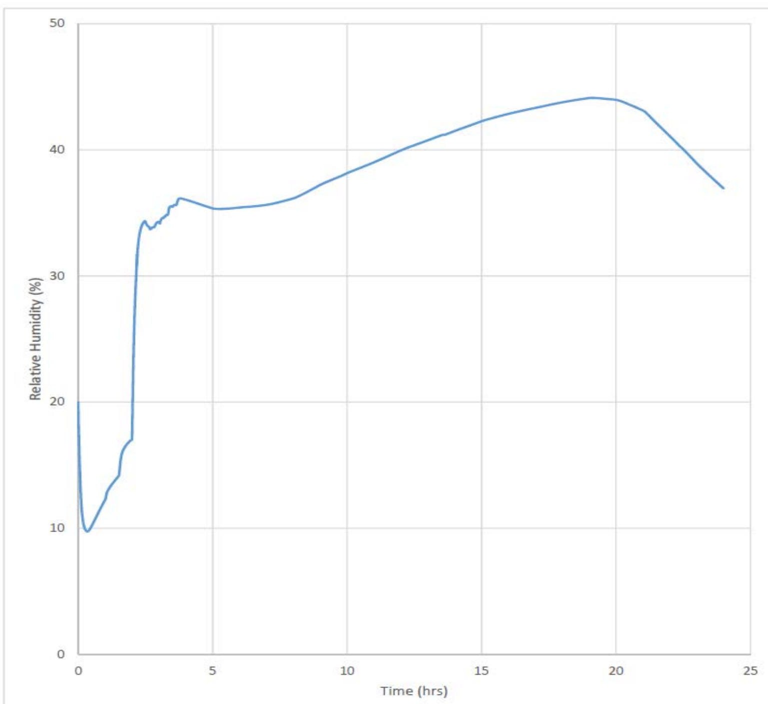

Figure 6: Relative Humidity in the Horseshoe Area for Case 2

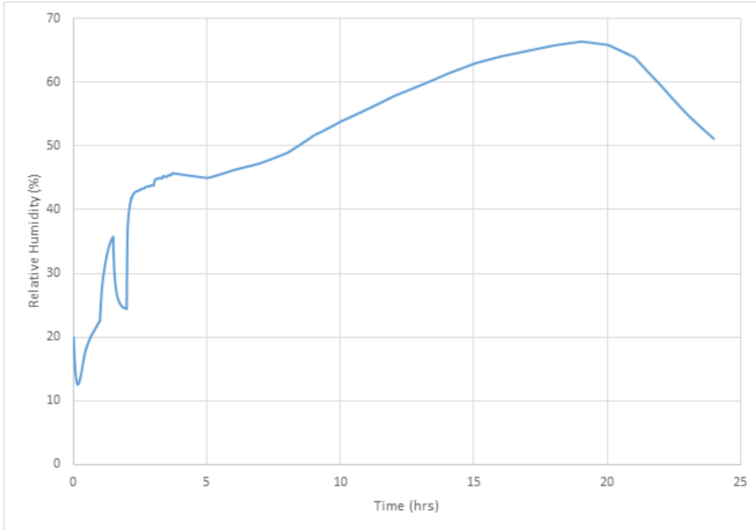

Figure 7: Maximum Local Relative Humidity (Just Inside MCR Door)

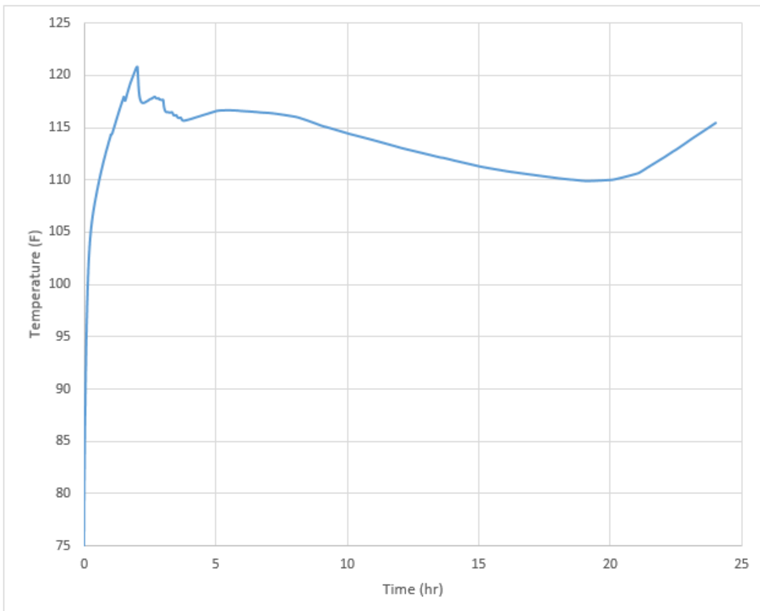

Figure 8: Temperature in Subvolume 171 for Case 2

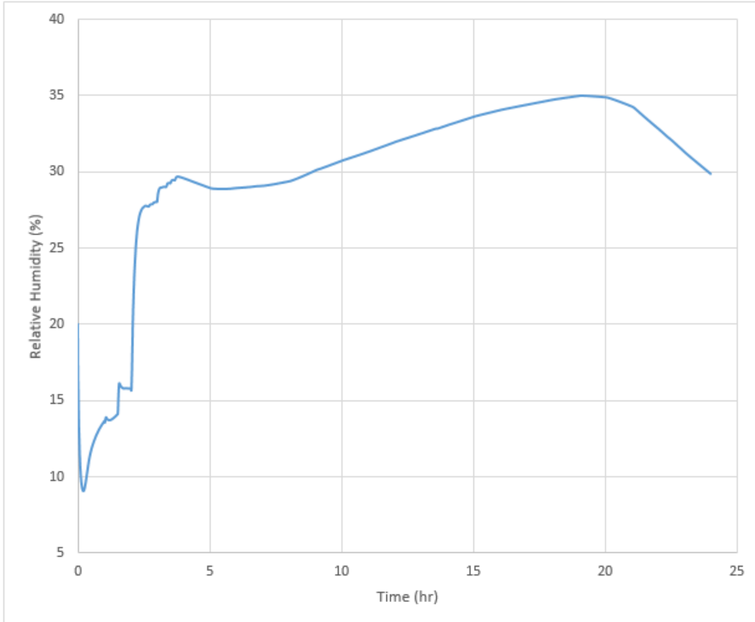

Figure 9: Relative Humidity in Subvolume 171 for Case 2

DISCUSSION

USNRC Information Notice 85-89

Information Notice 85-89 presents an event that occurred at McGuire Nuclear Station in June 1984 in which the station experienced a total loss of Main Control Room cooling and entered a Technical Specification Required Action to reduce power. As control room temperatures increased, several spurious alarms from the safety-related Westinghouse Process Control 7300 System (PCS) began coming in after about 43 minutes. Approximately 2 hours into the event, ventilation and temporary cooling was provided to the PCS 7300 cabinets causing the spurious alarms to stop.

Prior to the June 1984 event, McGuire experienced numerous card failures which they attributed to the elevated temperature conditions in and around the PCS 7300 cabinets. Their basis for this conclusion was the actual ambient air temperature measurement taken (72°F) and internal cabinet temperatures (max reading 125°F) after the event.

River Bend Station Main Control Room is a GE design and does not use Westinghouse PCS 7300 cabinets. GE document 22A3888, Rev. 3 “Main Control Room Panels (NSSS) Design Specification” (Reference 7) states:

> “Apparatus shall be suitable for continuous operation within the panels, or benchboard with a normal and abnormal maximum ambient air inlet temperature as specified in the BWR Equipment Environmental Interface Data Specification (A62-4270). Allowance shall be made for the temperature rise in the cubicle due to heat given off by other equipment in the same cubicle, when considering individual components the maximum temperature in a panel, or benchboard shall not exceed 122°F (50°C) under the above conditions.”

Per the GOTHIC model (Reference 5), the average ambient temperature in the Main Control Room in the 24 hours following a loss of HVAC is 111.4ºF for Case 1 and 116.1ºF for Case 2. The maximum local/subvolume temperature in the Main Control Room in the 24 hours following a loss of HVAC is 118.7ºF for Case 1 and 121.8ºF for Case 2. This maximum temperature in both cases is in subvolume 187 around panel H13-P630, Annunciator Logic Cabinet, which contains non-safety related electronic equipment. The peak temperature occurs 2.02 hours following the start of the event; for less than 30 minutes of the entire 24-hour event, subvolume 187 has a temperature above 120ºF. For the remainder of the event, subvolume 187 experiences temperatures below 120ºF.

The subvolume with the highest temperature (120.8ºF) that contains safety related equipment is subvolume 171 surrounding panel H13-P694, Reactor Protection System Logic Div D (Figure 8). The peak temperature occurs 2.02 hours following the start of the event; for less than 11 minutes of the entire 24-hour event, subvolume 171 has a temperature above 120ºF. For the remainder of the event, subvolume 171 experiences temperatures below 120ºF.

AOP-0060, Rev. 9, "Loss of Control Building Ventilation" (Reference 6) was effective on 6/17/2014 and was the current revision during the Loss of HVAC in the Main Control Room on 3/9/2015. Procedure AOP-0060, Rev. 9, step 5.1.4 instructs operators "At Main Control Room, open all back panel doors" within 30 minutes of the start of the event. Per the Main Control Room Operator's dayshift log from the 3/9/2015 event (Reference 9), operators performed AOP-0060, Rev. 9, step 5.1.4 within 23 minutes of entering AOP-0060.

NUREG/CR-4942 (Reference 3) states, in part on page 12, "…if a closed cabinet can be opened allowing virtually unrestricted air circulation inside of it, then the electrical components inside the cabinet are probably acceptable if they can be shown to survive the maximum ambient or room temperatures…"

NUMARC 87-00 (Reference 4) states, on page 2-10, "Equipment located in Condition 1 rooms are considered to be of low concern with respect to elevated temperature effects and will likely require no special actions to assure operability for a 4-hour station blackout. This condition is defined by a steady state temperature of 120ºF." The document goes on to say, on page 2-10, "By opening cabinet doors, adequate air mixing is achieved to maintain internal cabinet temperatures in equilibrium with the control room temperatures. Therefore, cabinets containing instrumentation and controls required for achieving and maintaining safe shutdown in a station blackout are considered to be in Condition 1. As such, additional cooling may be provided in a station blackout by opening cabinet doors within 30 minutes of the event's onset."

The Farley Response to NFPA-805 RAI (Reference 10) states, on page 12 of Attachment 2, "From reviews of WCAP 8687 accelerating [sic] thermal aging tests…it was found that components in typical electrical/electronic equipment [sic] (including solid sates [sic] components) in nuclear power plants do not fail immediately when exposed to a temperature as high as 105ºC (221ºF) but can survive up to a year at such high temperature (for brand new components). Considering a localized temperature inside a cabinet with limited ventilation may be about 20ºC (36ºF) higher than outside ambient temperature (another insight), the above statement may be restated as that all electrical/electronic components in cabinets can survive up to a year at an elevated outside cabinet ambient temperature of 85ºC (185ºF). A simulation using Arrhenius model showed a similar result."

With average Main Control Room temperatures never exceeding 116.1°F, maximum local cell/subvolume temperatures never exceeding 120.8°F for safety related electronic equipment, and the Main Control Room back panel doors all being opened, the design temperature of the safety-related electronic equipment is reasonably assured to not be exceeded. Additionally, considering the information presented in the Farley Response to NFPA-805 RAI (Reference 10), WCAP 8687 accelerated thermal aging tests shows electrical/electronic equipment can survive up to a year at elevated ambient temperatures up to 185°F.

Therefore, the NRC's reference to Information Notice 85-89 does not identify any previously unevaluated risk factors to electronic equipment during the loss of Main Control Room cooling event at River Bend Station.

NUREG/CR-6479

NUREG/CR-6479 is a generic guidance document not specific to River Bend Station or any specific locations in the plant, but rather the qualification testing of microprocessor based electrical equipment. The document also presents studies to provide a technical basis for environmental qualification of computer-based safety equipment in nuclear power plants. The studies addressed:

(1) Adequacy of present test methods for qualification of digital instrumentation and control (I&C) systems

(2) Preferred (i.e., Regulatory Guide-endorsed) standards

(3) Recommended stressors to be included in the qualification process during type-testing

(4) Resolution of the need for accelerated aging for equipment to be located in a benign environment

(5) Determination of an appropriate approach for addressing the impact of smoke in digital equipment qualification programs.

The significant conclusions of the studies were:

(1) Type testing should continue to be the preferred test method for safety-related I&C systems.

(2) The "state of the art" does not warrant any changes to be made with regard to aging methodologies for digital systems in nuclear power plants.

(3) A stressor not previously considered for analog safety system qualification is smoke exposure.

(4) The synergistic effect of high temperature in combination with high relative humidity is potentially risk-significant to digital I&C.

(5) Based on comparative analysis of IEEE 323-1974 and IEEE 323-1983, it is recommended that IEEE 323-1983 be endorsed.

(6) Dynamic response of a *distributed* system under environmental stress should be considered during type-testing.

(7) There is a need for electromagnetic compatibility standard(s) for the nuclear power plant environment.

(8) The nuclear industry should adopt a new philosophy of qualification, in which the assurance that safety-related equipment will perform properly is “built-in” as well as being “tested-in.”

The NRC inspection concerns the event that occurred at River Bend Station on 3/9/2015 in which there was a loss of cooling to the Main Control Room. Because of this, conclusions (1), (2), and (5) through (8) are not considered due to their focus on qualification testing of new microprocessor based electronic equipment. Therefore, the only conclusions from NUREG/CR-6479 considered are (3) and (4), which concern environmental stressors.

Concerning smoke as a significant environmental stressor, the scenarios modeled in the GOTHIC model (Reference 5) do not assume smoke to be present in the River Bend Main Control Room or a smoke/fire source anywhere in the Control Building that would affect the environmental conditions of the Main Control Room. Case 2 of the GOTHIC model (Reference 5) credits the use of smoke removal fans for air circulation purposes only. Therefore, with respect to River Bend Station’s loss of Control Building HVAC, smoke as a significant environmental stressor is not applicable.

Concerning the synergistic, or combined, effect of high temperature and high humidity, the GOTHIC model (Reference 5) shows that temperature will not exceed 122°F. The highest cell/subvolume temperature for the cases considered is 121.8°F in subvolume 187 at 2.02 hours into the event. Subvolume 187 contains panel H13-P630 which is a non-safety related annunciator logic cabinet. Relative humidity is expected to be ~65% RH (in the subvolume around the Main Control Room door into the southwest stairwell), which is not high and within the maximum relative humidity of 70% specified in the River Bend Environmental Design Criteria for the Main Control Room.

- Per NUREG/CR-6479, page 26, “Under these conditions, semiconductors are not likely to exhibit significant failure mechanisms because of temperature...High humidity (~85%) is unlikely to be a problem unless it is accompanied by high temperature.”
- Per NUREG/CR-6479, page 72, “With regard to temperature and humidity, the study found that the combination of high temperature at high relative humidity was the condition to affect the [experimental digital safety channel] EDSC, rather than temperature acting alone.”
- Per NUREG/CR-6479, pages 62 and 63, “For the levels of stressors analyzed, risk effects from temperature in digital I&C equipment locations, and that from assumed levels of vibration, appear to be insignificant.”

Because humidity is not expected to be high (~65% RH per Figure 7) and temperature alone appears to have “insignificant” risk effects, any risk to microprocessor based safety-related equipment is low. Therefore, the NRC’s reference to NUREG/CR-6479 does not identify any previously unevaluated risk factors to electronic equipment during the loss of Main Control Room cooling event at River Bend Station.

USNRC Inspection Report 05000458/2015010

The inspection report (Reference 11) documents the special inspection performed on River Bend Station following the 3/9/2015 event where River Bend Station lost Control Building cooling. Attachment 3 of the report (River Bend Station Control Building Ventilation Risk Assessment Detailed Evaluation) documents the assumptions and facts used to evaluate risk significance of the event.

Page A3-5 states:

> "Enercon Calculation ENTR-078-CALC-002, 'Main Control Room Heat-Up under Loss of HVAC Conditions,' Revision 0, dated June 29, 2015, showed the control room reaching 104-108˚F in one hour. Design Basis Calculation G.13.18.12.4*027, 'Control Room Temperature during Station Blackout,' Revision 2, dated December 12, 2012, concluded that control room temperature will reach approximately 120˚F in 4 hours under blackout conditions. NRC inspectors determined that each of these calculations had limitations, conservatisms, and non-conservatisms when attempting to determine control room temperature. In response to NRC inspectors' questioning, the licensee performed Calculation ENTR-078-CALC-003, 'Main Control Room Heat-up Under Loss of HVAC Conditions for 24 hours,' Revision 0, to predict control room temperature during several conditions and made this calculation available to the inspectors on August 3, 2015. The inspectors again determined that the licensee's analysis contained several non-conservatisms, including assumptions of a wrong initial cabinet material temperature, not fully including the effects of sunshine warming the external concrete of the control building, dividing the control room into large sub-volumes for GOTHIC analysis, inadequate floor modelling, and inaccurate momentum transport. Sensitivities were run on Calculation ENTR-078-CALC-003 resulting in Revision 1, dated August 27, 2015, and Revision 2, dated September 10, 2015, being issued. The sensitivities run for each of the licensee errors were determined to have less than 1˚F rise each in the control room. These non-conservatisms were never aggregated by the licensee to produce a cumulative effect on control room temperature.
>
> The inspectors found an incorrect value for the specific heat capacity of steel in Calculation ENTR-078-CALC-003 in September 2015. The licensee used a value of 0.16 BTU/lbm-˚F, where a more appropriate value of 0.116 BTU/lbm-˚F should have been used. The correct value resulted in a 14˚F increase in control room temperature. The licensee then performed another analysis using the correct heat capacity of steel and added more steel (heat sink) at the same time. The licensee reported that they added the steel to the analysis to account for steel identified in the control room during a walkdown performed in July 2015. The effect of using the appropriate heat capacity of steel with these added steel heat sinks produced a final control room temperature of 119.9˚F. This value of 119.9˚F included use of the service water contingency to the coils of the air handling units within 2 hours. If the service water contingency is not credited, the main control room temperature rises above 120˚F. This analysis did not include the several non-conservatisms described above. The inspectors determined that the control room would exceed 120˚F during a loss of control building cooling event, given the non-conservatisms in the licensee's analysis, and the high failure probability of the service water contingency."

Response to A3-5 statement:

Calculation ENTR-078-CALC-004 was prepared to specifically address the NRC's concerns regarding techniques used in the development of previous GOTHIC models in calculations ENTR-078-CALC-002 and ENTR-078-CALC-003. MPR and NAI performed separate and independent third party reviews of these calculations and their comments and recommendations have been incorporated into ENTR-078-CALC-004. Listed below are the NRC concerns and the changes incorporated into calculation ENTR-078-CALC-004 to address those concerns. The sections and tables referred to are from ENTR-078-CALC-004.

1. Heat capacity of structural steel: Calculations ENTR-078-CALC-002 and ENTR-078-CALC-003 incorporated an incorrect value for the specific heat of structural steel. A corrected value of 0.116 Btu/lbm-ºF was used in ENTR-078-CALC-004. This value was verified through two independent references (Section 3.15 and Table 2). As demonstrated in Attachment 9 of ENTR-078-CALC-003, the effects of the incorrect steel specific heat value was an under prediction of the average Main Control Room (MCR) temperature of 6.6ºF in the limiting case. When combined with the addition of steel heat sinks identified during a MCR walkdown conducted in July, 2015 and with the effects of solar heating on the external surfaces of the MCR envelope (see Item 6 below), the effect of use of the incorrect steel heat capacity was an approximately 3ºF under prediction of average temperature.
2. Density of concrete: The value used for the density of concrete (131.5 lb/ft^3) in all calculations was questioned as being about 2% lower than the "commonly accepted value" (140 lb/ft^3). In preparing calculation ENTR-078-CALC-004, this value was reviewed and verified, together with the other concrete thermal properties (specific heat and thermal conductivity), to be appropriate for this application. The verification was based on values from two independent references (Section 3.15, Table 2).
3. The control room floor modeling: The modeling of the MCR raised floor has been reviewed and revised, removing any credit for the aluminum honeycomb support structure and including modeling of the hardwood floor tiles (Section 3.5 and Figure 1, 2 and 3, Section 4.10).
4. Subvolume size: Calculations ENTR-078-CALC-002 and ENTR-078-CALC-003 employed MCR subdivided volumes of the upper and lower main control rooms based on a 4 (x direction) x 2 (y direction) x 2 (z-direction) grid, resulting in relatively large subvolumes. The mesh size of the GOTHIC subdivided volumes representing the upper and lower main control room regions has been increased to 16 (x-direction) and 8 (y-direction) nodes. The lower main control room subvolumes have also been increased to 3 (z-direction) nodes (Section 6.1). This change results in a significant reduction in the size of each subvolume.
5. Momentum Transport: Appropriate momentum transport options are now included in flow paths between subvolumes and between a subvolume and lumped volume or boundary condition (Section 6.6).
6. Solar heating: The effects of solar incidence (heating) on the MCR are included in the thermal conductors representing the control room external walls and roof in all GOTHIC models (Section 6.3).

7. Control Cabinet Temperatures: The NRC questioned the initial temperature of the thermal conductors representing the control panel (cabinet) material in the control room. The cabinets were previously modeled as passive heat sinks (thermal conductors) with initial surface temperature equal to the MCR temperature. Calculation ENTR-078-CALC-004 revises the conductors to include an initial control panel internal heat rate equal to the electrical heat load within the enclosure. With this approach, the initial temperature of the panel conductors is greater than 85°F; significantly above measured control panel temperatures. Since the panel doors are opened early in the transient (within the first 30 minutes), the cabinet heat load is input into the room using heater components. Therefore, the internal heat rate in the control panel thermal conductors is shut off after the first time step so that any residual heat in the panels is released to the MCR.

In addition to the above changes, calculation ENTR-078-CALC-004 also incorporates revised MCR heat loads. These heat loads are distributed in the MCR subvolumes based on their actual location in order to model the effects of localized heating.

Some other discrepancies in the NRC's reasoning should be noted:

- Changing to the correct value for the specific heat of steel did not result in a 14°F increase in control room temperature- the increase was approximately 7°F (see Item 1 above). After this was found, known heat sinks that were conservatively not credited in previous analysis were added in to mitigate this increase, which resulted in an MCR temperature of less than 120°F.
- ENTR-078-CALC-003 and ENTR-078-CALC-004 also evaluated another method of cooling the main control room if the service water contingency fails, specifically running the smoke removal fan, opening the MCR doors and staging a small portable fan, and opening ceiling tiles.

Page A3-6 states:

1. "Also on March 9, 2015, the plant was in a condition where the reactor cavity was flooded up in cold shutdown with lower electrical loads (heat sources)."
2. "When requested, the licensee could not provide the NRC a detailed analysis of the equipment survivability of control room equipment at the temperatures which would be expected to be experienced during a postulated heat-up scenario. The licensee instead provided analyses to indicate the control room would never reach 120°F, a temperature at which they assumed equipment would not be affected."
3. "When asked by inspectors about the basis of 104°F, the licensee cited section 6.4 of their Final Safety Analysis Report and stated 104°F was the maximum temperature limit main control room equipment was designed to operate."
4. "The analyst considered use of the guidance of Section 3.0, 'Failure Modeling,' of Volume 1, 'Internal Events,' of the Risk Assessment Standardization Project (RASP) Manual. Section 3.2 states, 'no credit should be taken for component operability beyond its design or rated capabilities unless supported by an appropriate combination of test or operational data, engineering analysis, or expert judgment.' Use of this provision would have control room components fail at 104°F"

Response to A3-6 statements:

1. Electrical loads in the Main Control Room are relatively constant because the loads consist primarily of lighting heat loads, computer heat loads, and control panel heat loads. Panel heat loads are due to indication and control power, and therefore, have very little variation for the differences in at-power conditions and cold shutdown conditions. Thus, the Main Control Room heat load for shutdown conditions is essentially equivalent for at-power conditions. Case 2 of the GOTHIC model (Reference 5) models a loss of Main Control Room cooling with normal at-power loads.

2. Design temperature of the Main Control Room equipment will not be exceeded, therefore a detailed analysis of the equipment survivability is not required. GE-22A3888, Rev. 3 (Reference 7) provides a design temperature of 122ºF for the Main Control Room equipment. AOP-0600, Rev. 9 (Reference 6), in step 5.1.4 instructs Operators to open the control panel doors. Per NUMARC 87-00 (Reference 4), opening panel doors allows adequate air mixing and internal panel temperatures will be in equilibrium with Main Control Room ambient air temperature. The GOTHIC Model (Reference 5) shows Main Control Room temperature will not exceed 122ºF (temperature will peak at 120.8ºF around Safety Related control panel H13-P694 and remains above 120ºF for only 11 minutes).

3. The temperature of 104ºF is the maximum ambient temperature for control room equipment assuming closed control panel doors. Per GE-22A3888, Rev. 3 (Reference 7), the equipment is designed to operate at temperatures up to 122ºF. Assuming the control panel doors are open, the ambient temperature and internal panel temperatures will reach equilibrium. Ambient temperature, and therefore internal panel temperatures, will not exceed 122ºF per the GOTHIC model (Reference 5).

4. GE-22A3888, Rev. 3 (Reference 7) provides a design temperature of 122ºF for the Main Control Room equipment. Therefore, the NRC's use of the provision in Section 3.2, of Volume 1, "Internal Events," of the RASP Manual should apply the design temperature of 122ºF and assume failure of components at or above 122ºF.

Page A3-7 states:

1. "The analyst reviewed the River Bend Updated Final Safety Analysis Report to determine the expected temperature range that control room equipment would experience during events. Table 9.4-1, 'Environmental and System Design Parameters for HVAC,' listed 65-80˚F as the range with the highest temperature for control room equipment. This range is typically used for application of instrument inaccuracies in plant calculations. Operation at elevated control room temperatures, as would have occurred from the finding, would place instruments above the 80˚F temperature value and likely affect instrument readings. The use of erroneous instrument readings during response to the event initiators and during the technical specification required shutdown of the plant would complicate operator response and lead to potential improper operation of systems."

2. "NUREG 1.115, 'Station Blackout,' describes that NUMARC 8700, 'Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors,' provided guidance acceptable to the NRC for meeting the requirements of 10 CFR 50.63, Station Blackout'. NUMARC-8700 discusses that maintaining a temperature below 120ºF in the control room would assure proper functioning of equipment for up to four hours. For this case, most scenarios would last greater than four hours which exceeds the premises of NUMARC-8700. The NRC therefore qualitatively considered effects beyond four hours as described below.

   The use of the 120ºF value from NUMARC-8700 for control room equipment functionality was less conservative than other approaches outline in various NRC documents, and would provide lower increases in core damage frequency. The analyst noted that NRC Information Notice 85-89, Potential Loss of Solid-State Instrumentation Following a Loss of Control Room Cooling,' discussed an event where solid-state instrumentation in the control failed at an ambient temperature of 90ºF and described that the failure rate of instrumentation can be expected to increase as the control room temperature increases. Also, NUREF/CR-6479, 'Technical Basis for Environmental Qualification of Microprocessor-Based Safety-Related Equipment in Nuclear Power Plants,' described that the failure rate of instrumentation and combination with high humidity was potentially safety significant to digital instrumentation and control equipment as it recounted a test of some instrumentation and control equipment which failed 20ºF below the equipment's maximum rated operating value.

   Accounting for all inputs, the NRC considered that the licensee's posture of ensuring the control room was maintained less than 120ºF would only be acceptable for scenarios which would only result in elevated temperatures up to four hours and only if they also demonstrated that humidity did not rise appreciably in those four hours."

Response to A3-7 statements:

1. **Temperature Effect on Nominal Trip Setpoints (NTSP)**

   A review of forty-six (46) G13.18.6.1 instrument setpoint calculations critical to plant operations was performed to determine the effect of elevated temperatures (120°F max) in main control room on nominal trip setpoints. Thirty-one of the instrument loops evaluated use Rosemount 510DU or 710DU trip units to perform the trip function. Other instrument loops use a variation of Bailey model 745, NUS Model A076PA, or GE 184C5988 trip units. In each of the loops evaluated at an increased temperature of 120⁰F, the procedural as left band was greater than the loop reference accuracy (RA) and therefore, per reference EN-IC-S-007, the RA of each individual device is set to zero for the remainder of the calculation. In that scenario, the zero RA is not used when calculating the nominal trip point (NTSP). The conclusions in the associated calculations were not affected and the calculated NTSPs do not change. Therefore, it can be concluded that the elevated temperature evaluated has no adverse effect on the aforementioned instruments.

   Temperature Effect on Control Room Indicators

   Some of the indicators/recorders found to be in the main control room are GE 180 edgewise meters and Bailey, Westronics, and Yokogawa recorders. A review of the referenced documentation concerning these devices indicate the following operating temperatures and temperature effects:

Instrument	Operating Temperature /Temperature Effect	Reference
Bailey 771/772	40 to 120°F Temperature Effect = ± 0.4% span/10°F (above 80°F)	B045-0134
Westronics M5E/M11E	Rated: 59 to 104°F Extreme: 15.8 to 122°F	3242.414-000-012G
Yokogawa DX200, DX364, DX2000	32 to 122°F Temperature Effect = ± (0.1% reading + 1 digit)/18°F (above 77°F)	Y006-0162, 0164, 229
GE 180 Edgewise Meters	-4 to 150°F No Temperature Effect specified	7242.433-000-003A

Although there is some operating temperature data given for a sampling of indicating instruments used in the main control room, there are no known accuracy requirements for indicating instruments. GE Specification GE-22A3888, Rev. 3 (0242.411-000-009), provides a design temperature of 122ºF for all instruments within control room panels. The operating temperatures given for the indicating instruments reviewed fall within the design temperatures given in the GE specification for control room instruments. Therefore, it is concluded that the elevated control room temperatures as modeled in the GOTHIC calculation (Reference 5) will not cause erroneous instrument readings during a response to an event and during the technical specification required shutdown of the plant that would complicate operator response and lead to potential improper operation of plant safety system instruments.

2. Per GE-22A3888, Rev. 3 (Reference 7):
“Apparatus shall be suitable for continuous operation within the panels, or benchboard with a normal and abnormal maximum ambient air inlet temperature as specified in the BWR Equipment Environmental Interface Data Specification (A62-4270). Allowance shall be made for the temperature rise in the cubicle due to heat given off by other equipment in the same cubicle, when considering individual components the maximum temperature in a panel, or benchboard shall not exceed 122ºF (50ºC) under the above conditions.”

   Allowance is made for temperature rise (up to 18ºF, i.e., up to the 122 ºF design temperature) in the panel assuming an ambient air temperature of 104ºF. This assumption is based on a panel being in operation with the doors closed. Opening the panel doors will allow the temperature inside the panel to reach equilibrium with the ambient air temperature (per NUMARC 87-00). Per AOP-0060, Rev. 9, “Loss of Control Building Ventilation” (Reference 6), step 5.1.4 operators will open the panel doors within 30 minutes of a loss of Control Building cooling. Additionally, per Reference 9 (River Bend Station Main Control Room Dayshift Log for 3/9/2015) step 5.1.4 was successfully completed 23 minutes into the event.

The control room equipment is designed for a maximum temperature of 122ºF. The GOTHIC model (Reference 5) shows that ambient air temperatures will not exceed the equipment design maximum temperature of 122ºF. Additionally, Figures 3, 6, 7, and 9 show that humidity will remain low and within the Main Control Room's Environmental Design Criteria. Therefore, the 4-hour limit is not applicable to River Bend Station Main Control Room.

<u>CONCLUSION</u>

A review of USNRC Information Notice 85-89, NUREG/CR-6479, ENTR-078-CALC-004, and USNRC Inspection Report 05000458/2015010, Attachment 3 concludes USNRC Information Notice 85-89 and NUREG/CR-6479 do not identify any previously unevaluated risk factors for reliability to the electronic equipment in the River Bend Station Main Control Room during the loss of cooling event because:

- Mitigating actions will be performed within 30 minutes (per Reference 6) to provide ventilation to the Main Control Room panels resulting in a different outcome than that presented in USNRC Information Notice 85-89.
- Per the GOTHIC model (Reference 5), the Main Control Room humidity is expected not to be high (maximum local of ~65% RH). Without a high humidity environment, there is no synergistic effect between high temperature and high humidity and, per NUREG/CR-6479, risk effects from high temperature alone are insignificant.

The review of USNRC Inspection Report 05000458/2015010, Attachment 3 also revealed the application of an incorrect maximum design temperature of 104ºF. GE-22A3888, Rev. 3, (Reference 7) shows a maximum design temperature of 122ºF for the Main Control Room equipment. Application of the correct maximum design temperature alters some conclusions of the USNRC inspection report, as detailed previously, and shows the Main Control Room equipment will not be challenged by the elevated temperatures cause by a loss of Main Control Room cooling event.

REFERENCES

1. USNRC Information Notice 85-89, “Potential Loss of Sold-State Instrumentation Following Failure of Control Room Cooling”
2. NUREG/CR-6479, “Technical Basis for Environmental Qualification of Microprocessor-Based Safety-Related Equipment in Nuclear Power Plants”
3. NUREG/CR-4942, “Equipment Operability During Station Blackout Events”
4. NUMARC 87-00, “Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors”
5. ENTR-078-CALC-004, Rev. 0, “Main Control Room Heat-Up Analysis During Loss of HVAC Conditions for 24 Hours”
6. AOP-0060, Rev. 9, “Loss of Control Building Ventilation” (effective 6/17/2014)
7. GE-22A3888, Rev. 3, “Design Specification Main Control Room Panels” (eB doc. 0242.411-000-009)
8. 215.150, Rev. 6, “Environmental Design Criteria”
9. River Bend Station Main Control Room Dayshift Log for 3/9/2015
10. ADAMS ML14038A019, “Joseph M. Farley Nuclear Plant Response to Request for Additional Information Regarding License Amendment Request for Transition to 10 CFR 50.48(c) – NFPA 805 Performance Based Standard for Fire Protection for Light Water Reactor Generating Plants”
11. USNRC Inspection Report 05000458/2015010, “River Bend Station – NRC Special Inspection Report 0500458/2015010 and Preliminary White Finding”

ATTACHMENT 1 – NRC Inspection Support Deliverables

1. Calculation G13.18.2.3-426, Standby Switchgear Room Temperature Sensitivity with Service Water Aligned to the HVK System
2. Calculation G13.18.4.0-063, Cooling Capacity of the Standby Service Water System to the Control Building Air Handling Units
3. 4216.110-996-001, Rev. 1, Control Building Heat Up Analysis following a Loss of HVAC
4. 4216.110-996-002, Rev. 0, Main Control Room Heat Up under Loss of HVAC Conditions
5. 4216.110-996-004, Rev. 3, Main Control Room Heat Up under Loss of HVAC Conditions for 24 Hours
6. RBS-ME-16-0002, Main Control Room Heat Up Analysis during Loss of HVAC Conditions for 24 Hours
7. Calculation ENTR-078-CALC-005 [in progress], Effectiveness of Ventilation with No Chilled Water
8. Engineering Report PSA-RBS-08-04, PRA Analyses supporting March 2015 NRC Special Inspection Issues (HVK Chillers, CR-RBS-2014-6284 Masterpact Breakers)

9. Engineering Report PSA-RBS-08-05, PRA Main Control Room Analysis following Loss of Control Building HVAC
10. Engineering Report PSA-RBS-08-03, Control Building Equipment Survivability Report
11. Engineering Report RBS-ME-15-00034, Vibration And Mechanical Design Evaluation for Aligning Service Water to Control Building Chilled Water (HVK) per AOP-0060 For Control Building Loss of Cooling / Loss of HVAC
12. Engineering Report RBS-NE-15-0001, Notice of Enforcement Discretion (NOED) Template and Typical Analysis for Control Building Cooling Systems (HVC, HVK)
13. Engineering Report RBS [in progress], Main Control Room Heat Load Assessment based on data obtained 2/11/16 during the performance of STP 402-4203
14. MPR Engineering Report 2062-1502-05-01, Rev. 1, January 5, 2016, Survey of US Nuclear Plants for Main Control Room Temperature Data
15. MPR Calculation CALC 2062-0005-0001, Rev. 0, February 12, 2016, Steady-state Analysis and Benchmark of River Bend Station Main Control Room GOTHIC Model
16. RBS-ME-15-00036, February 11, 2016, Main Control Room (MCR) Operator Habitability under Beyond-Design Basis Loss of HVAC Condition