UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
1600 E. LAMAR BLVD.
ARLINGTON, TX 76011-4511

February 16, 2016

EA-15-140

Mr. Eric W. Olson, Site Vice President
Entergy Operations, Inc.
River Bend Station
5485 U.S. Highway 61N
St. Francisville, LA 70775

SUBJECT: RIVER BEND STATION – NRC SPECIAL INSPECTION REPORT 05000458/2015010 AND PRELIMINARY WHITE FINDING

Dear Mr. Olson:

On March 24, 2015, the U.S. Nuclear Regulatory Commission (NRC) completed its initial assessment of the circumstances surrounding a loss of control building ventilation, which occurred on March 9, 2015, at the River Bend Station. Based upon the risk and deterministic criteria specified in NRC Management Directive 8.3, “NRC Incident Investigation Program,” the NRC initiated a special inspection in accordance with Inspection Procedure 93812, “Special Inspection.” The basis for initiating the special inspection and the focus areas for review are detailed in the Special Inspection Charter (Attachment 2 of the enclosed inspection report). Based on this initial assessment, the NRC sent an inspection team to your site on March 30, 2015.

On January 20, 2016, the NRC completed its special inspection. The enclosed report documents the inspection findings that were discussed on January 20, 2016, with Mr. Dean Burnett, Acting Director, Regulatory and Performance Improvement, and other members of your staff. The team documented the results of this inspection in the enclosed inspection report.

The enclosed inspection report documents a finding that has preliminarily been determined to be White, a finding with low to moderate safety significance that may require additional NRC inspections, regulatory actions, and oversight. As described in Section 2.6.a of the enclosed report, the team identified an apparent violation for a failure to adequately assess the increase in risk of operating the control building chilled water system chillers in various single-failure vulnerable configurations. As a result of this deficiency, the station reduced the reliability and availability of systems contained in the main control room and failed to account for the significant, uncompensated impairment of the safety functions of the associated systems.

Because actions have been taken to initiate condition reports, to investigate and resolve the technical issues with the control building chilled water system chillers, and to provide guidance to operations personnel, the failure to adequately assess the increase in risk of operating the control building chilled water system chillers in various single-failure vulnerable configurations does not represent a continuing safety concern. The NRC assessed this finding using the best available information, and Manual Chapter 0609, “Significance Determination Process.” The basis for the NRC’s preliminary significance determination is described in the enclosed report.

The finding is also an apparent violation of NRC requirements and is being considered for escalated enforcement action in accordance with the Enforcement Policy, which can be found on the NRC's website at http://www.nrc.gov/about-nrc/regulatory/enforcement/enforce-pol.html. The NRC will inform you in writing when the final significance has been determined.

We intend to complete and issue our final safety significance determination within 90 days from the date of this letter. The NRC's significance determination process (SDP) is designed to encourage an open dialogue between your staff and the NRC; however, the dialogue should not affect the timeliness of our final determination.

Before we make a final decision on this matter, we are providing you with an opportunity to (1) attend a Regulatory Conference where you can present your perspective on the facts and assumptions used to arrive at the finding and assess its significance, or (2) submit your position on the finding to the NRC in writing. If you request a Regulatory Conference, it should be held within 40 days of your receipt of this letter. We encourage you to submit supporting documentation at least one week prior to the conference in an effort to make the conference more efficient and effective. The focus of the Regulatory Conference is to discuss the significance of the finding and not necessarily the root cause(s) or corrective action(s) associated with the finding. If you choose to attend a Regulatory Conference, it will be open for public observation. The NRC will issue a public meeting notice and press release to announce the conference. If you decide to submit only a written response, it should be sent to the NRC within 40 days of your receipt of this letter. If you decline to request a Regulatory Conference or to submit a written response, you relinquish your right to appeal the NRC's final significance determination, in that by not choosing an option, you fail to meet the appeal requirements stated in the Prerequisites and Limitations sections of Attachment 2, "Process for Appealing NRC Characterization of Inspection Findings (SDP Appeal Process)," of NRC Inspection Manual Chapter 0609.

Please contact Greg Warnick at (817) 200-1144, and in writing, within 10 days from the issue date of this letter to notify us of your intentions. If we have not heard from you within 10 days, we will continue with our final significance determination and enforcement decision. The final resolution of this matter will be conveyed in separate correspondence.

Because the NRC has not made a final determination in this matter, no Notice of Violation is being issued for this inspection finding at this time. In addition, please be advised that the number and characterization of the apparent violation described in the enclosed inspection report may change based on further NRC review.

In addition, NRC inspectors documented two NRC-identified findings and one self-revealing finding of very low safety significance (Green) in this report. Two of these findings involved violations of NRC requirements. The NRC is treating these violations as non-cited violations consistent with Section 2.3.2.a of the Enforcement Policy.

If you contest the violations or significance of these non-cited violations, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001; with copies to the Regional Administrator, Region IV; the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; and the NRC resident inspector at the River Bend Station.

If you disagree with a cross-cutting aspect assignment or a finding not associated with a regulatory requirement in this report, you should provide a response within 30 days of the date of this inspection report, with the basis for your disagreement, to the Regional Administrator, Region IV; and the NRC resident inspector at the River Bend Station.

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 2.390, "Public Inspections, Exemptions, Requests for Withholding," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC's Public Document Room or from the Publicly Available Records (PARS) component of the NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

Troy W. Pruett
Director
Division of Reactor Projects

Docket Nos.: 50-458
License Nos.: NPF-47

Enclosure:
Inspection Report 05000458/2015010
w/ Attachments:
1. Supplemental Information
2. Special Inspection Charter
3. Detailed Risk Evaluation

cc w/ encl: Electronic Distribution for River Bend Station

If you disagree with a cross-cutting aspect assignment or a finding not associated with a regulatory requirement in this report, you should provide a response within 30 days of the date of this inspection report, with the basis for your disagreement, to the Regional Administrator, Region IV; and the NRC resident inspector at the River Bend Station.

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DISTRIBUTION: See next page

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Letter to Eric Olson from Troy Pruett dated February 16, 2016

SUBJECT: RIVER BEND STATION – NRC SPECIAL INSPECTION REPORT 05000458/2015010 AND PRELIMINARY WHITE FINDING

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U.S. NUCLEAR REGULATORY COMMISSION

REGION IV

Docket:	05000458
License:	NPF-47
Report:	05000458/2015010
Licensee:	Entergy Operations, Inc.
Facility:	River Bend Station, Unit 1
Location:	5485 U.S. Highway 61N St. Francisville, LA 70775
Dates:	March 30, 2015, through January 20, 2016
Inspectors:	D. Bradley, Resident Inspector J. Watkins, Reactor Inspector R. Deese, Senior Reactor Analyst C. Smith, Reactor Inspector E. Uribe, Reactor Inspector
Approved By:	T. Pruett, Director Division of Reactor Projects

Enclosure

SUMMARY OF FINDINGS

IR 05000458/2015010; March 30, 2015 through January 20, 2016; River Bend Station; special inspection for the loss of control building ventilation on March 9, 2015.

The report covered one week of onsite inspection and in-office review from March 30, 2015, through January 20, 2016, by inspectors from the NRC's Region IV office. One preliminary White apparent violation, two Green non-cited violations and one Green finding were identified. The significance of most findings is indicated by their color (Green, White, Yellow, or Red) using Inspection Manual Chapter 0609, "Significance Determination Process." Findings for which the significance determination process does not apply may be Green or be assigned a severity level after NRC management review. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 4, dated December 2006.

Cornerstone: Mitigating Systems

- TBD. The NRC identified an apparent violation of 10 CFR 50.65, "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," paragraph (a)(4) with preliminary white significance.

  Prior to March 30, 2015, before performing maintenance activities, the licensee failed to adequately assess the increase in risk that may result from proposed maintenance activities. Specifically, the risk assessment performed by the licensee for plant maintenance failed to account for certain safety significant structures, systems, and components that were concurrently out of service. On multiple occasions, the licensee failed to adequately assess the risk of operating the control building chilled water system (HVK) chillers in various single-failure vulnerable configurations. As a result of this deficiency, the station reduced the reliability and availability of systems contained in the main control room and failed to account for the significant, uncompensated impairment of the safety functions of the associated systems. In response to the NRC's conclusions, the licensee initiated Condition Report CR-RBS-2016-00095. The licensee also completed engineering analyses to evaluate alternate cooling methods, including cross-connecting service water and the HVK chiller systems, in order to provide cooling to spaces housing electrical components.

  This performance deficiency is more than minor, and therefore a finding, because it is associated with the configuration control attribute of the Mitigating Systems Cornerstone, and adversely affected the associated cornerstone objective to ensure availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the licensee's failure to account for a loss of all HVK cooling scenario, either quantitatively or qualitatively, resulted in uncompensated impairment to all systems associated within the main control room. A loss of cooling to the control room could lead to multiple systems exceeding their equipment qualification temperatures and impact control room habitability. The finding was evaluated using Inspection Manual Chapter (IMC) 0609, Appendix K, "Maintenance Risk Assessment and Risk Management Significance Determination Process." Using Inspection Manual Chapter 0609, Appendix K, the finding was determined to require additional NRC management review using risk insights where possible because the quantitative probabilistic risk assessment (PRA) tools are not well suited to analyze failures from control room heat-up events. Thus, the analyst evaluated the safety significance posed by the heat-up of components cooled by the HVK chillers using Appendix K, Flowchart 1, "Assessment of Risk Deficit," to the extent practical, with additional risk insights by internal NRC management review in accordance with Inspection Manual Chapter 0612, "Power Reactor Inspection Reports." The significance of the finding was preliminarily determined to be White.

The team determined the most significant contributing cause of the licensee failing to adequately assess the increase in risk from proposed maintenance activities was inadequate procedural guidance in Procedure ADM-0096, "Risk Management Program Implementation and On-line Maintenance Risk Assessment," Revision 316. This finding has a resources cross-cutting aspect within the human performance area because leaders failed to ensure that personnel, equipment, procedures, and other resources are available and adequate to support nuclear safety [H.1]. (Section 2.6.a)

- Green. The team reviewed a self-revealing non-cited violation of 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," for the licensee's failure to promptly identify and correct a condition adverse to quality related to Masterpact circuit breakers. Specifically, the licensee did not promptly identify and correct a Masterpact breaker failure mechanism, even though related industry operating experience was available. The licensee determined the failure mechanism caused nine breaker failures since 2007, and may have contributed to an additional six failures where the cause was not conclusively determined. In response to the NRC's conclusions, the licensee initiated Condition Report CR-RBS-2015-03951. Further, the licensee modified all vulnerable Masterpact circuit breakers to remove this failure mechanism.

  This performance deficiency is more than minor, and therefore a finding, because it is associated with the equipment performance attribute of the Mitigating Systems Cornerstone and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the licensee's untimely corrective action contributed to additional failures of Masterpact circuit breakers and decreased the reliability of Masterpact circuit breakers to respond during design basis events. The team performed an initial screening of the finding in accordance with NRC Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power." Using Inspection Manual Chapter 0609, Appendix A, Exhibit 2, "Mitigating Systems Screening Questions," the finding was of very low safety significance (Green) because it: (1) was not a deficiency affecting the design or qualification of a mitigating structure, system, or component, and did not result in a loss of operability or functionality; (2) did not represent a loss of system and/or function; (3) did not represent an actual loss of function of at least a single train for longer than its technical specification allowed outage time, or two separate safety systems out-of-service for longer than their technical specification allowed outage time; and (4) did not represent an actual loss of function of one or more non-technical specification trains of equipment designated as high safety-significant in accordance with the licensee's maintenance rule program. This finding has an operating experience cross-cutting aspect within the problem identification and resolution area because the licensee failed to systematically and effectively collect, evaluate, and implement relevant internal and external operating experience in a timely manner [P.5]. (Section 2.6.b)

- Green. The team identified a non-cited violation of 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," for the licensee's failure to accomplish an operability determination in accordance with procedure EN-OP-104, "Operability Determination Process," Revision 8. Specifically, the licensee referenced non-conservative data, contrary to steps 5.5 and 5.11 of procedure EN-OP-104, when assessing the reduced reliability of Masterpact circuit breakers as a degraded or nonconforming condition. The licensee restored compliance by completing a design modification to eliminate the failure mode and initiated Condition Report CR-RBS-2015-03952.

  This performance deficiency is more than minor, and therefore a finding, because it is associated with the equipment performance attribute of the Mitigating Systems Cornerstone, and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the reliability of components powered by Masterpact circuit breakers was reduced and, by justifying operability using non-conservative data, the licensee did not recognize the actual unreliability. The team performed an initial screening of the finding in accordance with NRC Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power." Using Inspection Manual Chapter 0609, Appendix A, Exhibit 2, "Mitigating Systems Screening Questions," the finding was of very low safety significance (Green) because it: (1) was not a deficiency affecting the design or qualification of a mitigating structure, system, or component, and did not result in a loss of operability or functionality; (2) did not represent a loss of system and/or function; (3) did not represent an actual loss of function of at least a single train for longer than its technical specification allowed outage time, or two separate safety systems out-of-service for longer than their technical specification allowed outage time; and (4) did not represent an actual loss of function of one or more non-technical specification trains of equipment designated as high safety-significant in accordance with the licensee's maintenance rule program. This finding has a conservative bias cross-cutting aspect within the human performance area because the licensee failed to use decision-making practices that emphasize prudent choices over those that are simply allowable. Specifically, the licensee did not consider that the failure mechanism only occurs on a close command. Instead, the licensee included opening commands when summing the total demands and this resulted in a non-conservative failure rate [H.14]. (Section 2.6.c)

- Green. The team identified a finding for the licensee's failure to identify and correct an adverse condition in a timely manner as required by plant procedures. Specifically, the licensee did not recognize degrading trends associated with incorrect racking of Magne Blast circuit breakers and failures of the Magne Blast circuit breaker for the Reactor Feed Water Pump Motor 1B in a timely manner. For both cases, the licensee failed to initiate corrective action in a timely manner as required by procedure EN-LI-102, "Corrective Action Program." In response to the NRC's conclusions, the licensee updated circuit breaker procedures, replaced the Magne Blast circuit breaker for the Reactor Feed Water Pump Motor 1B, and initiated Condition Reports CR-RBS-2015-04259 and CR-RBS-2015-03437.

This performance deficiency is more than minor, and therefore a finding, because it is associated with the equipment performance attribute of the Mitigating Systems Cornerstone, and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the licensee's untimely corrective action contributed to the unreliability of the Magne Blast circuit breaker for Reactor Feed Water Pump Motor 1B and increased the potential for spurious trips of other Magne Blast circuit breakers during design basis events due to improper racking. The team performed an initial screening of the finding in accordance with NRC Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power." Using Inspection Manual Chapter 0609, Appendix A, Exhibit 2, "Mitigating Systems Screening Questions," the finding was of very low safety significance (Green) because it: (1) was not a deficiency affecting the design or qualification of a mitigating structure, system, or component, and did not result in a loss of operability or functionality; (2) did not represent a loss of system and/or function; (3) did not represent an actual loss of function of at least a single train for longer than its technical specification allowed outage time, or two separate safety systems out-of-service for longer than their technical specification allowed outage time; and (4) did not represent an actual loss of function of one or more non-technical specification trains of equipment designated as high safety-significant in accordance with the licensee's maintenance rule program. This finding has an avoid complacency cross-cutting aspect within the human performance area because the licensee failed to recognize and plan for the possibility of mistakes, latent issues, and inherent risk, even while expecting successful outcomes. Specifically, the licensee tolerated the adverse trends, did not plan for further degradation, and the latent conditions ultimately resulted in several Magne Blast circuit breaker failures in December 2014 before the trend was recognized [H.12]. (Section 2.6.d)

REPORT DETAILS

1. Basis for Special Inspection

On March 9, 2015, during emergency core cooling system and loss of coolant accident (ECCS/LOCA) testing of division I, control building chiller 1C shed from the electrical bus as expected, but failed to restart and sequence onto the emergency diesel generator as designed.

There are two control building chilled water (HVK) chillers in division I, chillers 1A and 1C. HVK chiller 1A had been inoperable and unavailable since August 11, 2014. Since no division I HVK chillers were available, operations personnel attempted to start both of the division II HVK chillers 1B or 1D. Both of the division II HVK chillers failed to start since the equipment had an electrical interlock that prevented a chiller from starting unless both of the division II air handling units (AHUs) were operating. Division II AHU 1B would not start due to an unknown breaker deficiency. Operations personnel attempted to restart HVK chiller 1C on division I without success. The operators entered abnormal operating procedure AOP-60, “Loss of Control Building Ventilation,” due to the loss of the control building ventilation (HVC) system.

A similar failure occurred during division II ECCS/LOCA testing on February 23, 2015. Notable differences that made the March 9, 2015, failure more significant were:

- During the February 23 event, AHU 2B would not start. The Station subsequently identified two relays in the startup sequencer for AHU 2B that were degraded. The station operations personnel were able to start division I AHU 1A as expected. As a result, the electrical interlock did not prevent HVK chiller 1C from starting and control building ventilation was restored. However, during the March 9 event, a known deficiency with the operating mechanism for Masterpact breakers caused the failure of the HVK chiller 1C to start. The station attempted to restore ventilation by starting a division II chiller, but AHU 1B would not start. The electrical interlock prevented HVK chiller 1B from starting since the required AHUs were not operating. The breaker for AHU 1B is a Masterpact breaker which failed to close for a different reason that involved improper breaker installation (See Section 2.3.b).

- HVK chiller 1A had been inoperable and unavailable since August 11, 2014. With chiller 1A out of service and HVK chiller 1C failing to start, the risk implications were more significant.

The March 9 event, and associated equipment failures, revealed a much broader concern with the licensee’s resolution of Masterpact breaker deficiencies in the safety-related standby gas treatment (STGS) and control building HVC systems. These systems support operability for control room air conditioning, equipment in the standby switchgear rooms, battery chargers, and inverters. Additionally, issues associated with GE Magne Blast circuit breakers that were partially inspected during the Special Inspection performed by the NRC to evaluate the causes of the December 25, 2014, unplanned reactor trip with complications (see NRC Inspection Report

05000458/2015009, ADAMS ML15188A532) called into question the overall adequacy of the licensee's breaker maintenance program.

The NRC used Management Directive 8.3, "NRC Incident Investigation Program," to evaluate the level of NRC response for this event. The deterministic criteria of interest were: (1) the event included multiple failures in the control building ventilation system, which is a system to support operability for control room air conditioning, equipment in the standby switchgear rooms, battery chargers, and inverters; and (2) the event involved repetitive failures of safety-related Masterpact breakers. The preliminary Estimated Conditional Core Damage Probability was determined to be 2.6E-6.

Based on the deterministic criteria and risk insights related to the multiple failures of the control building ventilation system, the nature of the Masterpact breaker failures, and the potential generic concern with the Magne Blast circuit breakers, the NRC decided to conduct a Special Inspection. This Special Inspection charter included a review of the recent surveillance testing failures associated with the control building ventilation system; a review of the identified Masterpact breaker deficiency and its impact on equipment operability; a continued review of issues associated with GE Magne Blast circuit breakers; and a review of the licensee's corrective actions including extent of condition. In addition, the Special Inspection evaluated the licensee's actions with regard to technical specification limiting conditions for operation applicability, when control building chillers are declared inoperable or non-functional.

The team used NRC Inspection Procedure 93812, "Special Inspection Procedure," to conduct the inspection. The inspections included field walkdowns of equipment, interviews with station personnel, and reviews of procedures, corrective action documents, and design documentation. A list of documents reviewed is provided in Attachment 1 of this report; the Special Inspection Charter is included as Attachment 2.

2. Inspection Results

2.1 Charter Item 2: Develop a complete sequence of events related to the multiple Masterpact breaker failures to close when demanded during division I Emergency Core Cooling System (ECCS) surveillance testing and subsequent loss of ventilation recovery on March 9, 2015.

a. Inspection Scope

The team developed and evaluated a timeline of the events leading up to, during, and after the loss of control building chilled water on March 9, 2015. This included troubleshooting activities, maintenance practices, and operations procedures. The team developed the timeline, in part, through a review of work orders, action requests, station logs, and interviews with station personnel.

b. Findings and Observations

The team created the following timeline during their review of the events related to the loss of control building chilled water that occurred on March 9, 2015.

Date/Time	Activity
August 11, 2014	HVK chiller 1A is removed from service for maintenance and is not restored due to damage from a human performance error. The licensee replaced chiller 1A during the summer of 2015.
March 9, 2015	
10:50 a.m.	Commenced surveillance procedure STP-309-0601, “Division 1 ECCS Test.”
11:00 a.m.	Entered abnormal operating procedure AOP-0060, “Loss of Control Building Ventilation.” Specifically, HVK chiller 1C failed to start automatically per procedure STP-309-0601. With HVK chiller 1A out of service, control room personnel attempted to start a division II chiller. Neither HVK chiller 1B or 1D started due to a failure of the division 2 air handling unit, ACU 1B, to start.
11:23 a.m.	Operations personnel completed time-critical steps 5.1.3 and 5.1.4 of abnormal operating procedure AOP-0060 to provide alternate cooling for the control room and vital switchgear. These actions included opening doors. Additionally, operations personnel started the safety-related control room fresh air system (CRFA) to mitigate heat-up of the control room. The licensee initiated troubleshooting work order 408340 to restore HVK chiller 1C and troubleshooting work order 408341 to restore ACU 1B.
1:43 p.m.	Failed attempt to restart HVK chiller 1C with engineering personnel present and a computer connected to the local display panel. Troubleshooting determined that the circuit breaker failed to close following receipt of a valid command to close.

Date/Time	Activity
2:10 p.m.	Completed division I diesel generator full load rejection per procedure STP-309-0601.
2:31 p.m.	Successfully started HVK chiller 1C after depressing the local reset pushbutton per the troubleshooting work order.
2:40 p.m.	Exited abnormal operating procedure AOP-0060.

ACU 1B failed to start because of an out of alignment switch linkage rod. Further discussion of this failure mechanism is included in Section 2.3.b of this report.

During the March 9, 2015, loss of HVK chiller cooling, maximum temperatures in spaces cooled by HVK chillers did not reach or exceed equipment limitations. Specifically, the control room reached 91.4°F just prior to opening doors and initiating CRFA. The control room then returned to 70°F. The technical specification limit for the control room is 104°F. The largest change in temperature for other HVK cooled components occurred in the safety-related battery charger/inverter rooms. The temperature rose from 85°F to 90°F. The equipment qualification temperature limit is 104°F.

The team determined the licensee failed to identify and correct an adverse condition associated with Masterpact circuit breaker internal binding that occurred on March 9, 2015, for HVK chiller 1C. Further discussion of this performance deficiency and the internal binding failure mechanism of Masterpact circuit breakers are included in Section 2.6.b of this report.

2.2 Charter Item 5: Evaluate the licensee's actions with regard to technical specification limiting conditions for operation applicability when control building chillers are declared inoperable or non-functional.

a. Inspection Scope

The River Bend Station control building chilled water system consists of two redundant, closed loop chilled water trains. The chilled water system supplies water during normal, shutdown, and design basis accident conditions to the cooling coils in the main control room air conditioning units, standby switchgear air conditioning units, and chiller equipment air conditioning units. Chilled water is supplied by two independent trains, either one of which is capable of meeting the total chilled water demand. Each train contains two 100-percent capacity electric motor-driven, centrifugal liquid chillers (HVK chillers), two 100-percent capacity chilled water recirculation pumps, two 100-percent capacity condenser cooling water pumps, and one chilled water compression tank. The service water systems provide the chiller condenser cooling water. The station typically operates with only one chiller running and the others in a standby status.

At the time of the inspection, the team identified that, during periods when the associated division of HVK chillers are out of service, the licensee would only enter the technical specification action statements for the main control room air conditioning system, which is supported by HVK chillers. The licensee did not enter the action statements for other supported equipment being inoperable, such as DC batteries, inverters, or AC/DC switchgear. To understand the licensee's position on these HVK-cooled components the team reviewed operations procedures, station technical specifications and bases, control room logs, the licensee's actions during prior periods where HVK chillers were removed from service, and met with members of the operations department.

b. Findings and Observations

Unresolved Item (URI) - Technical Specification Allowed Outage Time During Loss of Non-Technical Specification Supported Systems

Introduction. The team identified an unresolved item related to the licensee's treatment of the control building chilled water system (HVK) chillers as a non-technical specification support system for other technical specification systems.

Description. The team noted that when an entire division of HVK chillers is out of service, such as chillers 1A and 1C for division I, the licensee would only enter the Technical Specification (TS) 3.7.3, "Control Room Air Conditioning (AC) System," action statement for the condition of one control room AC subsystem being inoperable (condition A). The licensee did not enter TS action statements associated with inoperability of other components cooled by HVK chillers, such as the AC switchgear, DC switchgear, and vital inverters. The licensee, instead, has incorporated a safety evaluation for the Perry Plant (ML020950074), dated April 5, 2002, into the bases for TS 3.0.6 and applied that document as guidance:

> *…no TS limits the duration of the non-TS support subsystem outage, even though the single-failure design requirement of the supported TS systems is not met. However, by assessing and managing risk in accordance with 10 CFR 50.65(a)(4), an appropriate duration for the maintenance activity can be determined.*

The NRC team questioned whether the Perry Plant's safety evaluation could be applied generically, if the licensee improperly incorporated the safety evaluation via the 10 CFR 50.59 process, if the guidance conflicted with section 9.2.10.3 of the Updated Safety Analysis Report (USAR) for River Bend Station, and if the safety evaluation for the Perry Plant conflicted with guidance found in Generic Letter 80-30, "Clarification of the Term 'Operable' As It Applies to Single Failure Criterion For Safety Systems Required by TS." The aggregate impact of these decisions resulted in the River Bend Station placing TS systems cooled by HVK, such as the AC switchgear, DC switchgear, and vital inverters, in a single-failure vulnerable configuration for durations exceeding the allowed outage time specified in the TS.

Pending further evaluation of the above issue by NRC Headquarters staff via a Technical Specification interpretation request (ML15231A111) and subsequent review by NRC inspectors, this issue will be tracked as URI 05000458/2015010-01, “Technical Specification Allowed Outage Time During Loss of Non-Technical Specification Supported Systems.”

Further discussion of performance deficiencies associated with the HVK chiller system is included in Section 2.6.a of this report.

2.3 Charter Items 3, 4, and 7: For Masterpact circuit breakers, evaluate the causes of breaker failures, corrective actions, and licensee practices.

a. Inspection Scope

To determine the cause of the Masterpact breaker failures experienced at River Bend Station, the team reviewed condition reports, operating experience, vendor failure reports, and spoke with members of engineering and maintenance departments. This information was then compared to the timeline of Masterpact breaker failures and component design documentation. The team also performed walkdowns, reviewed completed surveillance test results, and reviewed corrective actions including modifications. The team assessed the cause evaluation process to verify actions were at a level of detail commensurate with the significance of the problem.

b. Findings and Observations

The River Bend Station uses Masterpact 480 VAC circuit breakers as a replacement for obsolescent GE AK/AKR series breakers. Masterpact breakers were first installed for safety-related applications in 2007 and have experienced three different types of failures:

1. Internal, mechanical binding during anti-pump mode – This is the failure mechanism that occurred on HVK chiller 1C on March 9, 2015. Overall, the station determined the failure mechanism caused nine breaker failures since 2007 and may have contributed to an additional six failures where a definitive cause could not be determined.

2. Spurious trip of a closed breaker – This failure has only occurred once, in January 2015, and is documented in Condition Report CR-RBS-2015-2365. The licensee replaced the circuit breaker and sent the circuit breaker off for vendor analysis. The vendor analysis determined there were no identified or repeatable problems with the circuit breaker. The vendor could not rule out potential failure modes such as momentary overcurrent or inadvertent manual operation. The licensee continues to monitor Masterpact breakers for spurious trips.

3. Position switch (52PS) linkage rod misaligned – This failure has only occurred once at the River Bend Station and is the failure mechanism that occurred on

HVK AHU 1B on March 9, 2015. This position switch changes state based on whether the breaker is racked to the connected position or not. Because of the misalignment, the 52PS contact in the breaker did not change state, and the breaker cubicle did not have control power. The failure of AHU 1B to start is unrelated to the internal mechanical binding failure mechanism discussed in Section 2.6.b. As a corrective action, the licensee adjusted the control rod to be 1/8" longer to ensure proper position switch fit-up for all 32 Masterpact breakers that were vulnerable to this failure mechanism. This fit-up verification has been added to preventative maintenance tasks, system drawings, and to procedures for spare cubicles. The licensee also initiated Condition Report CR-RBS-2015-1922.

The team determined the licensee did not promptly identify and correct the internal binding Masterpact breaker failure mechanism, even though related industry operating experience existed. Further discussion involving the failure mechanism, and the licensee's failure to identify and correct the failure mechanism, is included in Section 2.6.b of this report.

The team noted that the licensee correctly initiated condition reports for the spurious trip of a closed Masterpact breaker and the misaligned 52PS linkage rod. For these one-time failures, the team did not identify any performance deficiencies.

Additionally, the team determined that the licensee failed to accomplish an operability determination in accordance with procedure EN-OP-104, "Operability Determination Process," Revision 8. Specifically, the licensee referenced non-conservative data when assessing the reduced reliability of Masterpact circuit breakers as a degraded or nonconforming condition in the operability determination associated with Condition Report CR-RBS-2014-6284. Further discussion involving the licensee's failure to perform an operability determination in accordance with their procedure is included in Section 2.6.c of this report.

2.4 Charter Items 6 and 7: For Magne Blast circuit breakers, evaluate the causes of breaker failures, corrective actions, and licensee practices.

a. Inspection Scope

To determine the cause of the Magne Blast breaker failures experienced at River Bend Station, the team reviewed corrective action documents, operating experience, vendor failure reports, and spoke with members of engineering and maintenance departments. This information was then compared to the timeline of Magne Blast breaker failures and component design documentation. The inspectors assessed the licensee's corrective actions including extent of condition and extent of cause.

b. Findings and Observations

The River Bend Station uses Magne Blast circuit breakers for both 13.8 kV nonsafety-related loads and 4.16 kV safety-related loads. Of note, there have been zero failures over the past 5 years for the safety-related 4.16 kV Magne Blast circuit breakers. These safety-related breakers provide power to the division III high pressure core spray system and are routinely cycled during surveillance testing. The focus of this discussion is on the non-safety 13.8 kV breakers and associated failures.

Nonsafety-related Magne Blast circuit breakers follow an approximately 18-year refurbishment cycle and have experienced two types of failures over the past five years:

1. Failure to close due to improper circuit breaker racking – The racking process involves orienting the circuit breaker correctly in the housing such that all internal components are fully engaged, and the circuit breaker can fully perform its function. If a circuit breaker is improperly racked, it may experience intermittent faults, trip prematurely, or not close at all. The licensee has experienced nine issues related to improper racking of Magne Blast circuit breakers over a five year period.

2. Material condition of the Reactor Feed Water Pump Motor 1B circuit breaker – The licensee experienced eight failure-to-close issues for the Reactor Feed Water Pump Motor 1B (FWS-P1B) circuit breaker over a 19 month period. This one breaker accounts for 80% of the failure-to-close issues at the site out of a population of 28 nonsafety-related 13.8 kV Magne Blast circuit breakers.

Of note, some of the Magne Blast circuit breaker failures have involved both failure mechanisms.

The team identified a finding for the licensee's failure to identify and correct an adverse condition, in a timely manner, as required by plant procedures. Specifically, the licensee did not recognize degrading trends associated with incorrect racking of Magne Blast circuit breakers, and failures of the Magne Blast circuit breaker for the Reactor Feed Water Pump Motor 1B, in a timely manner. For both cases, the licensee failed to initiate corrective actions in a timely manner, as required by procedure EN-LI-102, "Corrective Action Program." Further discussion related to the failure to identify and correct an adverse condition associated with Magne Blast circuit breakers, including the licensee's corrective actions, is included in Section 2.6.d of this report.

c. Closed: Unresolved Item (URI) – Vendor and Industry Recommended Testing Adequacy on Safety-related and Safety-significant Circuit Breakers

Background. As part of the review of circuit breaker failures at the River Bend Station, the team reviewed URI 05000458/2015009-01, "Vendor and Industry Recommended Testing Adequacy on Safety-related and Safety-significant Circuit Breakers," (see NRC inspection report 05000458/2015009, ADAMS ML15188A532).

That report noted that the licensee's maintenance programs for division I, II, III, and nonsafety-related 4.16 kV and 13.8 kV breakers installed in the plant did not meet the standards recommended by the vendor, licensee corporate, or Electric Power Research Institute (EPRI) guidelines. The licensee's programs were based on EPRI documents TR-106857-V2 and TR-106857-V3, which were a preventive maintenance program basis for low and medium voltage switchgear. However, the licensee only implemented portions of the recommended maintenance program, and did not provide the team with engineering analysis or technical basis to justify the changes. The EPRI developed the guidance for Magne Blast breakers, based on industry operating experience, NRC Information Notices, and General Electric Service Information/Advisory Letters (SILs/SALs). The licensee had not been performing the entire vendor or EPRI recommended tests, inspections, and refurbishments on the breakers since they were installed. The aggregate impact of missing these preventive maintenance tasks needed to be evaluated to determine if the reliability of the affected breakers had been degraded.

Closure. The licensee has used procedures EN-DC-324, “Preventive Maintenance Program” and EN-DC-335, “PM Basis Template,” to modify the preventive maintenance schedules and the refurbishment schedules for their safety-related and nonsafety-related 480V, 4.16kV, and 13.8kV nonsafety-related breakers. Specifically, River Bend Station has the following circuit breakers:

- 57 safety-related 480V Masterpact breakers
- 5 safety-related 4.16kV Magne Blast breakers
- 28 nonsafety-related 13.8kV Magne Blast breakers.

The primary failure mechanism for breakers is age related degradation of the lubrication, which may cause the breaker to operate slowly.

The licensee provided the team with copies of: “General Electric Instructions and Recommended Parts for Maintenance,” manual for the AM-4.16-250-9, 1200 and 2000 ampere with ML-13 mechanism breakers (GEK-41902 C), EPRI Guidance on Routine Maintenance for Magne Blast Circuit Breakers (TR-109641, supplement to NP-7410-V2P2), Service Advice Letter “Lubrication Recommendations Type AM Circuit Breakers ML-13 and ML-13A Mechanisms” (SAL) 354.1, and BWR Owners Group “Final Results for the Simulated Life Cycle Management Evaluation of D6A15A1 Grease in Magne Blast Circuit Breakers.” The SAL and the BWR Owners Group report contain information that would allow the user to extend the maintenance periodicity of the breakers, if using the GE Lubricant D6A15A1 grease (Mobil 28), as opposed to the original grease.

The River Bend Station uses the Mobil 28 grease in all breakers, except the diesel generator output. The BWR Owner’s Group report contains information that states that breakers lubricated with Mobil 28 have a service life of 20 years, based on extensive age testing performed by General Electric. The use of improved grease can justify an extended maintenance periodicity, but other considerations must be taken into account in order to develop a comprehensive preventive maintenance program.

The General Electric and EPRI documents that are used by the industry are not procedures themselves. They are to be used by the end user as guidance in preparing each user’s procedures for performing maintenance and overhauls, based upon the end user’s application. The General Electric and EPRI reference documents are clear that the maintenance of the breakers is highly dependent upon the frequency of operation and the environment in which the breakers are operated. Breakers that interrupt large currents, operate in extreme conditions of dust, moisture or corrosive gases, or are cycled frequently require more frequent maintenance than breakers that are infrequently cycled and operated in dry, clean atmospheres. The River Bend Station considered the frequency of operation and the atmosphere in which their breakers are operated when preparing their breaker preventive maintenance program. The General Electric manual S3221.418.000-003I states that a breaker is rated for 5000 operations before any parts need replacing.

The five safety-related, division III, 4.16kV breakers, which have not experienced a failure within the last five years, were all refurbished between September 3, 1997, and May 18, 1999. These breakers are all operated in a clean, mild, control room type environment and are cycled very infrequently compared to normal industry use.

The most frequently operated 4.16kV safety-related breaker is the division III diesel generator output breaker, which is cycled monthly under surveillance procedure STP-309-0203. Over an 18 year period, this breaker would have been cycled less than 220 times. This represents less than one twentieth of the manufacturer's estimated operations life.

The remaining 4.16kV safety-related breakers are cycled less often than the division III diesel generator output breaker to demonstrate their operability. The River Bend Station replaced the diesel generator output breaker in October 2014, 17 years after it was last refurbished, and has scheduled the replacement of the remaining four division III breakers by May 30, 2017. All of the breakers are scheduled to be replaced within 18 years of their last refurbishment.

The 28 nonsafety-related 13.8kV breakers have experienced 14 reported issues over the last five years. There are several breaker position switches and auxiliary contacts that must be properly connected in order to connect control power, charging spring motors, trip and close coils, and convey status of the breaker (closed or open). These are all dependent on the breaker being properly racked in or out. The 13.8kV nonsafety-related breakers are on a schedule to be refurbished/replaced between 2022 and 2026. Further discussion on improper racking of circuit breakers is included in Section 2.6.d of this report.

Square D/Schneider Masterpact 480V breakers were installed at the River Bend Station to replace the obsolete General Electric Type AK and AKR breakers. The River Bend Station has 310 in-use Masterpact breakers. There are 66 safety-related 480V cubicles with 57 in-use breakers. The Schneider vendor manual for the Masterpact breakers has suggested maintenance, inspection, and replacement intervals that are also dependent upon frequency of operation and atmosphere, similar to the guidance given in the General Electric manual and the EPRI documents. The lubricant used on the Masterpact breakers is Mobilith SHC 100, which is rated for a 60+ year service life, and the breakers are rated for 12,500 lifetime operations before replacement (not refurbishment). These breakers require minimal maintenance, which mostly consists of cycling the breaker open and closed, both remotely and locally. This includes testing the electronic trip unit, inspecting the main contacts and arc chambers based upon number of cycles of operation, and then replacing the parts if they have reached their expected lifetime. The Micrologic Trip Units on the breakers have a contact wear indicator, which measures the contact wear from 0-100% and is displayed on the Liquid Crystal Display (LCD). Visual inspection of the contacts is warranted when the contact wear is greater than 50%. The trip units are tested under the protective relaying test procedures, using primary injection and the Original Equipment Manufacturer (OEM) Full Function Test Kit. Depending on the current carrying capacity and frame size of the breaker, the replacement schedule ranges from 3,000 to 10,000 electrical operations (open-close cycles). No breakers in service at River Bend Station experience this number of operations; therefore, they should require minimum maintenance over their expected 40-year life.

While there have been some issues with the racking of circuit breakers and with the material condition of the Reactor Feed Water Pump Motor 1B breaker, the team determined that a systematic lack of maintenance, which would lead to an overall increase in breaker failures, does not exist. Of note, in December 2014, the licensee instituted Standing Order 299, and, in March 2015, revised procedure OPS-0052, "Breaker Racking and 13.8kV to 480 VAC Transformer Disconnect Operations," to require an electrician to be present to check several key indicators and gaps on the breaker mechanism before a breaker is racked down/up.

Based upon the technical information provided and reviewed, the team noted the low number of breaker operations, the mild operating environment, and the general lack of evidence of a high failure rate over the last five years. As a result of these observations, the team determined the licensee has reasonable justification for an extension of the maintenance periodicity of the 480V safety-related and nonsafety-related, 4.16kV safety-related, and 13.8kV nonsafety-related breakers. The team did not identify a performance deficiency with the licensee's extension of circuit breaker maintenance periodicity.

URI 05000458/2015009-01, "Vendor and Industry Recommended Testing Adequacy on Safety-related and Safety-significant Circuit Breakers" is closed with no associated finding or violation of NRC requirements identified.

2.5 Charter Item 8: Evaluate pertinent industry operating experience and potential precursors to the event, including the effectiveness of any action taken in response to the operating experience.

a. <u>Inspection Scope</u>

The team evaluated the licensee's application of industry operating experience related to this event. The team reviewed applicable operating experience and generic NRC communications with a specific emphasis on breaker maintenance practices. This was done to assess whether the licensee had appropriately evaluated the notifications for relevance to the facility, and incorporated applicable lessons learned into station programs and procedures.

b. Findings and Observations

The team identified two issues regarding the origination and use of operating experience. First, the licensee did not promptly identify and correct a Masterpact breaker failure mechanism even though related industry operating experience existed. Further discussion involving the operating experience aspect of the licensee's failure to identify and correct a Masterpact failure mechanism is included in Section 2.6.b of this report.

The team also noted that the vendor for Masterpact breakers, NLI, did not distribute a vendor notice to River Bend Station as they described in a 2012 Hope Creek Non-Conformance Report (NCR-400). Since the internal, mechanical binding failure mechanism for Masterpact breakers had occurred at Hope Creek prior to the River Bend Station event, there may have been an additional opportunity to identify this failure mechanism. This observation was discussed with the NRC's Vendor Inspection Branch.

2.6 Specific findings identified during this inspection.

a. Failure to Adequately Assess Risk During Chiller Unavailability

Introduction. The NRC identified an apparent violation of 10 CFR 50.65 "Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," paragraph (a)(4) with preliminary white significance.

Prior to March 30, 2015, the licensee failed to adequately assess the increase in risk that may result from proposed maintenance activities. Specifically, the risk assessment performed by the licensee for plant maintenance failed to account for certain safety significant structures, systems, and components that were concurrently out of service. On multiple occasions, the licensee failed to adequately assess the risk of operating the control building chilled water system (HVK) chillers in various single-failure vulnerable configurations. As a result of this deficiency, the station reduced the reliability and availability of systems contained in the main control room and failed to account for the significant, uncompensated impairment of the safety functions of the associated systems.

Description. The team reviewed the operational history of the HVK system and the licensee's actions related to implementation of technical specifications for various HVK system configurations. This chilled water system supplies water during normal, shutdown, and design basis accident (DBA) conditions to the cooling coils in the main control room air conditioning units, standby switchgear rooms' air conditioning units, and chiller equipment rooms' air conditioning units. Chilled water is supplied by two independent trains, either one of which is capable of meeting the total chilled water demand. Each train contains two 100-percent capacity electric motor-driven, centrifugal liquid chillers (HVK chillers), two 100-percent capacity chilled water recirculation pumps, two 100-percent capacity condenser cooling water pumps, and one chilled water compression tank. The service water systems provide the chiller condenser cooling water. Any one running HVK chiller is sufficient to meet 100 percent of the total chilled water demand. The division I HVK chillers are labeled 1A and 1C. The division II HVK chillers are labeled 1B and 1D. The station typically operates with only one chiller running and the other three in a standby status.

The team noted that when an entire division of HVK chillers is out of service, such as chillers 1A and 1C for division I, the licensee would only enter the Technical Specification (TS) 3.7.3, "Control Room Air Conditioning (AC) System," action statement for the condition of one control room AC subsystem being inoperable (condition A). The licensee did not enter TS action statements associated with inoperability of other components cooled by HVK chillers, such as the AC switchgear, DC switchgear, and vital inverters. Note that HVK chillers are not tracked directly in TS but instead are a support system for other TS systems. When the team questioned this practice, the licensee stated that the bases for TS 3.7.3 explicitly discuss chillers as among the minimum subset of components needed to demonstrate operability. Further, the licensee stated the bases for TS 3.8.4, 3.8.7, and 3.8.9 do not contain a discussion of chillers as a required subcomponent for operability. Instead, the licensee utilized guidance found in the bases for TS 3.0.6 as follows:

> *In some cases, the non-TS support system has two redundant 100 percent capacity subsystems, each capable of supporting both TS divisions (e.g., HVR-UC11A and B). Loss of one support subsystem does not result in a loss of support for either division of TS equipment. Both TS divisions remain operable, despite a loss of support function redundancy, because the TS definition of operability does not require a TS subsystem's necessary support function to meet the single-failure design criterion. Thus, no TS limits the duration of the non-TS support subsystem outage, even though the single-failure design requirement of the supported TS systems is not met. However, by assessing and managing risk in accordance with 10 CFR 50.65(a)(4), an appropriate duration for the maintenance activity can be determined. Use of administrative controls to implement such a risk-informed limitation is an acceptable basis for also allowing a temporary departure from the design basis configuration during such maintenance. This allowance is permitted regardless of whether the maintenance is corrective or preventive.*

The licensee added this discussion in the bases of TS 3.0.6 on September 30, 2010, and is based on a safety evaluation that had been issued by the NRC for the Perry Plant (ML020950074), dated April 5, 2002. The licensee evaluated the change via the 10 CFR 50.59 process and determined NRC approval did not need to be obtained because, "this change merely provides clarification on existing guidance."

Pending further evaluation of the use of the Perry Plant's safety evaluation by the licensee and subsequent review by NRC inspectors, this issue will be tracked as an unresolved item, URI 05000458/2015010-01, "Technical Specification Allowed Outage Time During Loss of Non-Technical Specification Supported Systems." Further discussion of the URI is included in Section 2.2.b of this report.

The team then reviewed the licensee's practices for assessing and managing risk, when removing HVK chillers from service, per 10 CFR 50.65(a)(4) and as described in the bases for TS 3.0.6. The River Bend Station utilizes a quantitative, level-1 probabilistic safety analysis (PSA) computer model named, "Equipment Out of Service Monitor (EOOS)." Licensee procedure ADM-0096, "Risk Management Program Implementation and On-line Maintenance Risk Assessment," Revision 316, implements the requirements of 10 CFR 50.65(a)(4) and provides guidance on how and when to perform risk assessments using quantitative and qualitative tools.

Section 5.3 of procedure ADM-0096, "Risk Assessment Overview," states the following regarding use of the EOOS computer model:

> *The Risk Assessment Program is a "Risk-Informed Program", not a "Risk Tool Based Program." This means that the quantitative results provided by the EOOS software must be blended with the qualitative guidance, in order to provide a complete risk picture of the situation. Decisions should never be made based on the EOOS quantitative results alone…Qualitative factors (such as industry operating experience, personnel judgment, etc.) must also be used for fully assessing the effects of equipment out of service on plant risk.*

The team noted that HVK chillers were modeled in EOOS and that the licensee would, using the computer program, disable the affected HVK chillers for a given maintenance period to yield a quantitative risk value.

The team then assessed the application of procedure ADM-0096 to specific work periods where multiple HVK chillers were removed from service simultaneously. For example, starting on December 15, 2014, the licensee removed HVK chillers 1A, 1B, and 1D from service for 41.5 hours. During this work window, only the 1C chiller was available to provide cooling for both divisions of control room air conditioning, both divisions of AC switchgear, both divisions of DC switchgear, and both divisions of vital inverters. The licensee had assessed risk as 7.9 (Yellow) which included the quantitative tool (EOOS) and some qualitative factors for fire scenarios.

The team discovered that EOOS, however, did not model a control room heat-up scenario, such as during a loss of all HVK chillers event. The subsequent effects of failures of numerous control room components across multiple safety systems were, therefore, also not modeled due to the complexity of the event. The team reviewed procedure ADM-0096 for guidance on limitations of the PRA model and noted section 5.2.3 stated the following:

> *When the quantitative assessment tool is not available or the assessment scope is outside the scope of the EOOS risk monitor, qualitative assessments shall be performed.*

The team also reviewed NUMARC 93-01, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 4A. Section 11.3.7.1 of NUMARC 93-01 discusses establishing action thresholds based on qualitative considerations.

…This [qualitative] approach typically involves consideration of the following factors from the assessment:

- *Duration of out-of-service condition, with longer duration resulting in increased exposure time to initiating events…*
- *The number of remaining success paths (redundant systems, trains, operator actions, recovery actions) available to mitigate the initiating events…*

The above factors can be used as the basis for establishment of a matrix or list of configurations and attendant risk management actions.

The team determined that the licensee did not consider the listed factors for qualitative assessments for a loss of control room cooling event. Specifically, the licensee did not establish a more limiting duration for placing control building chilled water system chillers in single-failure vulnerable configurations and, instead, relied upon the associated TS allowed outage time of 30 days. Further, the licensee did not consider the remaining success path, cross-connecting the HVK chillers with service water, and apply, as an example, just-in-time training or daily control room briefings on the procedure during single-failure vulnerable configurations with the potential to lose control room air conditioning.

The team noted that procedure ADM-0096 does not provide further guidance on how to qualitatively assess risk of a loss of all HVK cooling. Interestingly, attachment 7 of procedure ADM-0096 describes how to qualitatively assess and manage risk for removing non-TS auxiliary building cooling (HVR) due to EOOS limitations:

Auxiliary Building unit coolers HVR-UC11A(B) are non-Technical Specification equipment that provide cooling for safety-related equipment in the AB141 and AB170 locations. Each of these unit coolers are capable of providing the required cooling for both safety-related divisions. These unit coolers do not impact quantitative risk as determined using the EOOS risk monitor. To qualitatively address risk if HVR-UC11A(B) are unavailable, the following actions should be taken if one of HVR-UC11A(B) will be out of service…[bulleted list of 13 actions].

Ultimately, the team determined that the licensee failed to adequately assess the risk of operating the control building chilled water system chillers in various single-failure vulnerable configurations. As a result of this deficiency, the station reduced the reliability and availability of systems contained in the main control room and failed to account for the significant, uncompensated impairment of the safety functions of the associated systems.

The licensee, in the example starting December 15, 2014, did not perform a qualitative risk assessment for a complete loss of control room cooling due to the inadequate procedural guidance in procedure ADM-0096. With an inadequate risk assessment of HVK system maintenance, the licensee did not appropriately determine the duration of the maintenance activity as described in the bases for TS 3.0.6.

To understand the exposure time for inadequate risk assessments, the team reviewed maintenance and TS data from control room logs. The team determined that the licensee operated in single-failure vulnerable configurations for the HVK system for 591 hours over a 12 month period or approximately 6.7% of a year.

In response to the NRC's conclusions, the licensee initiated Condition Report CR-RBS-2016-00095. The licensee also contracted for an engineering analysis to credit alternate cooling methods, including cross-connecting service water and the HVK chiller systems, in order to cool vital electrical components and mitigate a loss of HVK event.

Analysis. The team determined that the licensee's failure to adequately assess the risk of operating the control building chilled water system chillers in various single-failure vulnerable configurations was a performance deficiency. This performance deficiency is more than minor, and therefore a finding, because it is associated with the configuration control attribute of the Mitigating Systems Cornerstone, and adversely affected the associated cornerstone objective to ensure availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. As a result of this deficiency, the station reduced the reliability and availability of systems cooled by control building chilled water system chillers by not determining an appropriate duration of maintenance activities.

The team noted that, from section 7 of IMC 0612 Appendix E, "Examples of Minor Issues," that discusses the Maintenance Rule, the performance deficiency is more than minor since the risk assessment failed to account for (at least qualitatively) the loss or significant, uncompensated impairment of a key operating or shutdown safety function. Specifically, the licensee's failure to account for a loss of all HVK cooling scenario, either quantitatively due to EOOS model limitations or qualitatively due to procedure inadequacies, represents a significant impairment to all systems associated with the main control room. A loss of cooling to the control room could lead to multiple systems exceeding their equipment qualification temperatures and lead to subsequent failures. A loss of cooling to the control room could also impact control room habitability. The team also reviewed NUMARC 93-01, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants," Revision 4A. Section 11.3.7.1 of NUMARC 93-01 discusses establishing action thresholds based on qualitative considerations.

> *…This [qualitative] approach typically involves consideration of the following factors from the assessment:*
>
> - *Duration of out-of-service condition, with longer duration resulting in increased exposure time to initiating events…*
> - *The number of remaining success paths (redundant systems, trains, operator actions, recovery actions) available to mitigate the initiating events…*
>
> *The above factors can be used as the basis for establishment of a matrix or list of configurations and attendant risk management actions.*

The team determined that the licensee did not consider the listed factors for qualitative assessments for a loss of control room cooling event. This conclusion further supports the IMC 0612 Appendix E examples of more than minor performance deficiencies associated with the Maintenance Rule.

The finding was evaluated using Inspection Manual Chapter (IMC) 0609, Appendix K, “Maintenance Risk Assessment and Risk Management Significance Determination Process.” Using Inspection Manual Chapter 0609, Appendix K, the finding required additional internal NRC management review using risk insights where possible because the quantitative probabilistic risk assessment (PRA) tools are not well suited to analyze failures from control room heat-up events. Thus, the analyst evaluated the safety significance posed by the heat-up of components cooled by control building chilled water (HVK) chillers using Appendix K, Flowchart 1, “Assessment of Risk Deficit,” to the extent practical, with additional risk insights by internal NRC management review in accordance with Inspection Manual Chapter 0612, “Power Reactor Inspection Reports.” In accordance with Step 4.1.2 of Appendix K, the analyst performed a detailed risk evaluation for the greater than green Flowchart 1 result. See attachment 3 of this report, “Detailed Risk Evaluation,” for further information. The detailed risk evaluation resulted in a preliminarily determination of White (low to moderate safety significance).

Because actions have been taken to initiate Condition Reports, to investigate and resolve the technical issues with the control building chilled water system chillers, and to provide guidance to operations personnel, the failure to adequately assess the increase in risk of operating the control building chilled water system chillers in various single-failure vulnerable configurations does not represent a continuing safety concern.

The team determined the most significant contributing cause of the licensee failing to adequately assess the increase in risk from proposed maintenance activities involved inadequate procedural guidance in procedure ADM-0096. This finding has a resources cross-cutting aspect within the human performance area because leaders failed to ensure that personnel, equipment, procedures, and other resources are available and adequate to support nuclear safety [H.1].

Enforcement. 10 CFR 50.65, “Requirements for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,“ paragraph (a)(4), requires, in part, that before performing maintenance activities (including but not limited to surveillance, post-maintenance testing, and corrective and preventive maintenance) the licensee shall assess and manage the increase in risk that may result from the proposed maintenance activities. Contrary to the above, prior to March 30, 2015, before performing maintenance activities, the licensee failed to adequately assess the increase in risk that may result from proposed maintenance activities. Specifically, the risk assessment performed by the licensee for plant maintenance failed to account for certain safety significant structures, systems, and components that were concurrently out of service. On multiple occasions, the licensee failed to adequately assess the risk of operating the control building chilled water system chillers in various single-failure vulnerable configurations. As a result of this deficiency, the station reduced the reliability and availability of systems contained in the main control room and failed to account for the significant, uncompensated impairment of the safety functions of the associated systems. In response to the NRC’s conclusions, the licensee initiated Condition Report

CR-RBS-2016-00095. The licensee also contracted for an engineering analysis to credit alternate cooling methods, including cross-connecting service water and the HVK chiller systems, in order to cool vital electrical components and mitigate a loss of a HVK event. This is an apparent violation of 10 CFR 50.65(a)(4): AV 05000458/2015010-02, "Failure to Adequately Assess Risk During Chiller Unavailability."

b. Failure to Identify and Correct Circuit Breaker Failure Mechanism

Introduction. The team reviewed a Green, self-revealing non-cited violation of 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Actions," for the licensee's failure to promptly identify and correct a condition adverse to quality related to Masterpact circuit breakers. Specifically, the licensee did not promptly identify and correct a Masterpact breaker failure mechanism even though related industry operating experience (OE) existed. The station determined the failure mechanism caused nine breaker failures since 2007 and may have contributed to an additional six failures where the cause could not be conclusively determined.

Description. The team reviewed the history of Masterpact circuit breaker failures at the River Bend Station, with a focus on relevant operating experience. Between 2007 and 2009, River Bend Station replaced all of their General Electric (GE) AKR circuit breakers with Nuclear Logistics Incorporated (NLI) Masterpact breakers.

As experienced by River Bend Station, the NLI Masterpact circuit breaker is vulnerable to an intermittent failure mechanism under certain scenarios. Generally, the control logic is set up such that the breaker is continuously receiving a 'close' command when the breaker is in the closed position. This is known as a "standing close" signal. When the breaker later receives an 'open' command, the breaker briefly experiences simultaneous 'open' and 'close' commands. This dual open and close signal activates the mechanical "anti-pump" feature. The anti-pump feature is designed to prevent a circuit breaker from rapidly changing state between an open and closed position due to a dual command. Instead, the anti-pump feature causes the breaker to default to an open position for electrical safety by moving the close lever out of the way of the close coil plunger.

The associated failure mechanism, documented by Hope Creek starting in 2012, involves internal mechanical binding as the anti-pump feature engaged. NLI's Nonconformance Report NCR-573 best describes the failure mechanism as follows:

> *The plant logic scheme which allows a standing close signal was determined to be the root cause. The pressure from the anti-pump latch pushing on the close coil plunger (down when energized) caused the rear of the lever to rock up in the back, and would intermittently catch on the top frame of the mechanism. Any mechanism vibration could allow the anti-pump lever to reset properly*.

Overall, River Bend Station has experienced nine Masterpact breaker failures where the cause involved the standing close signal. The number may be higher because the causes were not conclusively determined for other Masterpact breaker failures.

The table below summarizes the timeline for the relevant condition reports, the operating experience for Masterpact breaker failures from internal binding, and when the licensee had the material available for review.

Date	Originator	Description	River Bend Reviewed
3/21/2007	River Bend CR-RBS-2007-0721	Failure of breaker to close for control building chiller (HVK) 1C after initial breaker installation. Cause was indeterminate at the time. Evaluation in 2015 lists the standing close signal as a possible cause.	Yes
1/7/2008	River Bend CR-RBS-2008-0103	Failure of breaker to close for HVK chiller 1A during divisional swap of running chillers. Cause was indeterminate at the time. Evaluation in 2015 lists the standing close signal as a possible cause.	Yes
9/12/2008	River Bend CR-RBS-2008-5397	Failure of breaker to close for HVK chiller 1D during divisional swap of running chillers. Cause was indeterminate at the time. Evaluation in 2015 lists the standing close signal as a possible cause.	Yes
6/18/2010	River Bend Review of OE 31842 Review of OE 243841	Failure of breaker to close for containment cooler 1B during divisional swap. Sent breaker to NLI and identified internal binding during anti-pump mode. Sluggish response from a degraded relay also contributed.	Yes
4/10/2012	Hope Creek Review of OE 306166	Failure of a breaker to close for a diesel room fan. Cause was a failure to address a design discrepancy between GE AKR breakers and NLI Masterpact breaker control circuitry.	Yes, reviewed 9/29/2013 by system engineer.
9/15/2012	NLI NCR-440 Failure Analysis FA-04215193-1 Hope Creek Update Review of OE 306166	Vendor analysis of the failure of Hope Creek Masterpact breakers described in OE 306166. Cause was due to control logic allowing dual open and close signals via relays. These dual signals caused the anti-pump feature to engage and led to internal binding. NLI stated they would issue a technical bulletin to Masterpact users, but River Bend did not receive a bulletin.	No, communicated from NLI to Hope Creek only.

2/17/2013	River Bend CR-RBS-2013-1058	Failure of breaker to close for HVK chiller 1A during integrated emergency core cooling system (ECCS) testing. Cause was indeterminate at the time. Evaluation in 2015 lists the standing close signal as a possible cause.	Yes
3/3/2013	River Bend CR-RBS-2013-1871	Failure of breaker to close for HVK chiller 1D during integrated ECCS testing. Cause was indeterminate at the time. Evaluation in 2015 lists the standing close signal as a possible cause.	Yes
9/9/2013	Hope Creek Review of OE 308489	Failure of breaker to close for a stator water cooling pump. Cause was determined to be similar to previous Masterpact breaker failures experienced at Hope Creek.	No. Although the OE was downloaded by the licensee, it was never reviewed.
7/25/2014	River Bend CR-RBS-2014-3651	Failure of breaker to close for control building air handling unit (ACU) 1A during post-modification (analog to digital controls) testing. Cause was initially thought to be closing coil malfunction but later determined to be due to the standing close signal.	Yes
7/25/2014	River Bend CR-RBS-2014-3651	Failure of breaker to close for ACU 2A during post-modification (analog to digital controls) testing. Cause was initially thought to be closing coil malfunction but later determined to be due to the standing close signal.	Yes
7/28/2014	River Bend No CR	Failure of breaker to close for ACU 1A during post-modification (analog to digital controls) testing. Cause was initially thought to be closing coil malfunction but later determined to be due to the standing close signal.	Yes
7/28/2014	River Bend No CR	Failure of breaker to close for ACU 1B during post-modification (analog to digital controls) testing. Cause was initially thought to be closing coil malfunction but later determined to be due to the standing close signal.	Yes
7/30/2014	River Bend CR-RBS-2014-3714	Failure of breaker to close for ACU 2A during post-modification (analog to digital controls) testing. Cause was initially thought to be closing	Yes

		coil malfunction but later determined to be due to the standing close signal.	
7/30/2014	River Bend CR-RBS-2014-3779	Failure of breaker to close for ACU 2A during post-modification (analog to digital controls) testing. Cause was initially thought to be closing coil malfunction but later determined to be due to the standing close signal.	Yes
8/2/2014	River Bend CR-RBS-2014-3779 Review of OE 313038	Failure of breaker to close for ACU 1A during post-modification (analog to digital controls) testing. Cause was initially thought to be closing coil malfunction but later determined to be due to the standing close signal. Affected breakers sent to NLI for failure mode analysis.	Yes
9/6/2014	NLI NCR-573 Failure Analysis FA-042-351021500-1	Vendor analysis of the failure of Hope Creek Masterpact breakers described in OE 308489. Cause was due to the breaker logic control scheme allowing a standing close signal that caused internal binding. NLI noted that this is the same issue as documented in NCR-440.	No, communicated from NLI to Hope Creek only.
12/9/2014	NLI NCR-573 River Bend CR-RBS-2014-6284	NLI Provided NCR-573 to River Bend Station as preliminary thoughts on the ongoing failure mode analysis. Upon receiving this information, River Bend Station initiated a condition report to assess operability of components utilizing Masterpact breakers.	Yes
3/9/2015	River Bend CR-RBS-2015-1829	Failure of breaker to close for HVK chiller 1C during integrated ECCS testing. Cause was the standing close signal.	Yes
3/10/2015	River Bend CR-RBS-2015-1858	Failure of breaker to close for HVK chiller 1C during integrated ECCS testing. Cause was the standing close signal.	Yes
3/23/2015	River Bend	All Masterpact circuit breakers modified to remove the standing close signal and therefore preclude the internal binding failure mode from occurring again.	N/A

Licensee procedure EN-OE-100, "Operating Experience Program," Revision 23, defines the required reviews and actions when an Entergy plant receives OE. Step 5.2[2](b) discusses the criteria used to determine the potential impact of OE on a station. This would include similar equipment, although not necessarily used in the same application; or when a similar design exists (if design is determined to be a main contributor to the issue); or if a similar event has already been experienced. Step 5.2[3](h) requires vendor documents to be screened as A1, the highest level of review, if the document is applicable to an Entergy site. Step 5.2[3](j) requires all OE for circuit breakers to be screened as A2 or B1 priority for engineering review.

The team determined the licensee missed two opportunities to identify and correct the Masterpact circuit breaker internal binding failure mechanism prior to December 2014. In both cases, engineering personnel did not follow the guidance of the licensee's procedure EN-OE-100.

The first example involved the failures at Hope Creek in 2012, which were communicated to the industry in OE 306166. Although the circuit breaker system engineer at the River Bend Station reviewed the operating experience, the response document stated "these breakers have been in service for five years. RBS have [sic] not experienced this condition." This OE, as reviewed by the licensee, discussed the cause as a failure to recognize a design discrepancy that can yield a dual open/close signal to the breaker. The apparent cause evaluation performed by Hope Creek, as reviewed by the River Bend Station, discussed the failure mechanism in detail:

> *The potential failure mechanism of the breaker trip/close latch getting caught by the close coil or trip coil plunger while the breaker is in an indeterminate state is identified as the cause of the failure….NLI and Square D testing confirmed that the trip/close latch can become "jammed" when the close coil is de-energized at approximately the same time as the shunt trip coil is energized*

Further, the team noted that the River Bend Station itself had experienced a similar failure on June 18, 2010, as documented in OE 38142 and OE 243841. In this case, a containment unit cooler failed to start, and the cause involved internal binding during engagement of the anti-pump feature combined with a sluggish relay response. The containment unit coolers did not have the standing close signal normally applied. Instead, the slow response of the relay enabled the conditions of dual open/close signal and contributed to the internal binding failure. Although not identical to the failure in OE 306166, the team determined that the licensee did not fully assess the aggregate of internal and external OE.

The second example involved the failures at Hope Creek in 2013, which were communicated to the industry in OE 308489. In this case, River Bend Station had downloaded the OE from the industry database but never reviewed the material. When the team asked about the requirement to review all circuit breaker OE per procedure EN-OE-100, the licensee stated that the OE did not require review since it had not been flagged as significant in the industry database. The licensee's explanation differed from steps 5.2[2](b) and 5.2[3](j) of the licensee's operating experience procedure. Since OE

308489 discussed similar failures to OE 306166, this failure to review OE represented a second missed opportunity for the licensee to identify their vulnerable design.

Although River Bend Station became aware of the failure mechanism in December 2014, they elected to schedule the corrective action (modification to standing close signal) for June 2015, after the refueling outage in February and March 2015. As a result of this deferral, they experienced further failures in February and March, which caused the licensee to move-up the circuit modification date to within the refueling outage.

The team noted that the licensee correctly initiated a CR to review the NLI NCRs and relevant OE when provided by NLI in December 2014. The team also acknowledges that NLI did not distribute a vendor notice to River Bend Station as they described in NCR-400. This observation was discussed with the NRC's Vendor Inspection Branch.

In response to the NRC's conclusions, the licensee initiated Condition Report CR-RBS-2015-03951. Further, the licensee modified all vulnerable Masterpact circuit breakers to remove this failure mechanism.

Analysis. The failure to promptly identify and correct an adverse condition to quality associated with Masterpact breakers was a performance deficiency. This performance deficiency is more than minor, and therefore a finding, because it is associated with the equipment performance attribute of the Mitigating Systems Cornerstone and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the licensee's untimely corrective action contributed to additional failures of Masterpact circuit breakers and decreased the reliability of Masterpact circuit breakers to respond during design basis events. The team performed an initial screening of the finding in accordance with NRC Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power." Using Inspection Manual Chapter 0609, Appendix A, Exhibit 2, "Mitigating Systems Screening Questions," the finding was of very low safety significance (Green) because it: (1) was not a deficiency affecting the design or qualification of a mitigating structure, system, or component, and did not result in a loss of operability or functionality; (2) did not represent a loss of system and/or function; (3) did not represent an actual loss of function of at least a single train for longer than its technical specification allowed outage time, or two separate safety systems out-of-service for longer than their technical specification allowed outage time; and (4) did not represent an actual loss of function of one or more non-technical specification trains of equipment designated as high safety-significant in accordance with the licensee's maintenance rule program.

This finding has an operating experience cross-cutting aspect within the problem identification and resolution area because the licensee failed to systematically and effectively collect, evaluate, and implement relevant internal and external operating experience in a timely manner [P.5].

Enforcement. Title 10 CFR Part 50, Appendix B, Criterion XVI, "Corrective Action," requires, in part, that measures shall be established to assure that conditions adverse to quality are promptly identified and corrected. Contrary to the above, prior to December 9, 2014, the licensee failed to assure that a condition adverse to quality was promptly identified and corrected. Specifically, although industry operating experience existed on design problems and failure mechanisms associated with Masterpact circuit breakers' anti-pump feature, the licensee did not identify and correct their deficient design in a timely manner. The licensee restored compliance by completing a design modification to eliminate the failure mechanism and initiated Condition Report CR-RBS-2015-03951. Because the finding is of very low safety significance (Green) and has been entered into the licensee's corrective action program, this violation is being treated as a non-cited violation, consistent with Section 2.3.2.a of the NRC Enforcement Policy: NCV 05000458/2015010-03, "Failure to Identify and Correct Circuit Breaker Failure Mechanism."

c. <u>Failure to Accomplish an Operability Determination In Accordance With Procedures</u>

<u>Introduction</u>. The team identified a Green, non-cited violation of 10 CFR Part 50 Appendix B, Criterion V, "Instructions, Procedures, and Drawings," for the licensee's failure to accomplish an operability determination in accordance with procedure EN-OP-104, "Operability Determination Process," Revision 8. Specifically, the licensee referenced non-conservative data, contrary to steps 5.5 and 5.11 of procedure EN-OP-104, when assessing the reduced reliability of Masterpact circuit breakers as a degraded or nonconforming condition.

<u>Description</u>. The team reviewed an operability determination associated with Condition Report CR-RBS-2014-6284, initiated on December 9, 2014. This condition report documented the vulnerability of Masterpact circuit breakers to experience mechanical binding when the anti-pump feature engaged. See Section 2.6.b of this report for a further discussion of the failure mechanism.

The licensee concluded that the Masterpact breakers, which were experiencing intermittent failures to operate, were operable as follows:

> *The River Bend [Station] specific failure rate is 8.24E-3 (23 failures/2790 demands) or 0.82%. The industry failure rate (generic mean demand failure probability) documented in NUREG/CR-6928 and Entergy report PRAES-01-003 for a circuit breaker "failing to close" or "failing to open" on demand is 2.5E-03/demand or 0.25%. The industry failure rate is based on the failure mode of "fail to operate" for all circuit breakers and includes all failure mechanisms contributing to the total number of failures per total number of demands for operation.*
>
> *The RBS failure analysis of the eight breakers susceptible to the failure mode during normal plant operations showed the failure rate was 0.82%. This represents a small reduction in breaker reliability compared to the overall industry failure rate of 0.25%. However, the increased failure rate is comparable to and bounded by other components listed in NUREG/CR-6928 (for instance, the failure rate for a chiller start is 1.0E-2 or 1%). Engineering concludes that the overall failure rate remains low and that the probability of multiple concurrent*

failures impacting redundant safety trains is low, so the ability of the impacted systems to perform their safety functions is still maintained. Any additional failures of these Masterpact breakers will be evaluated for impact on reliability.

The reduction in reliability introduced by this failure mechanism is acceptable for plant operation. The reduction in reliability does not challenge the ability of the HVC, HVK, and SGTS systems to perform their safety functions in all applicable modes of operation. As a result, the HVC, HVK, and SGTS systems meet the requirements for an operable-degraded nonconforming condition. However, a simple Operator performed Compensatory Action was assigned as an enhancement, to reduce the likelihood of a breaker malfunction of this type during Modes 1, 2 and 3. Based on this Operability Evaluation, the affected Masterpact breakers for the HVC, HVK, and SGTS systems are recommended to be designated Operable-Comp Measures.

Standing Order 298 documented the "enhancement," as defined by the licensee. The enhancement involved operators manually resetting Masterpact breakers when they were tripped. This action, per vendor guidance, released any internal binding that may have occurred prior to the next close command.

The licensee, when questioned, stated that the standing order did not provide the basis for operability and they did not consider the action as a compensatory measure to enhance or maintain operability. Instead, the licensee stated, because of the small reduction in reliability for Masterpact breakers, the SSCs were operable but degraded/nonconforming. The licensee explicitly stated that the standing order improved reliability for an already operable SSC.

The team challenged this operability determination and noted that the licensee's operability procedure incorporated guidance found in NRC Inspection Manual Chapter (IMC) 0326, "Operability Determinations and Functionality Assessments for Conditions Adverse to Quality or Safety," revised January 31, 2014. Mirroring the guidance of IMC 0326 section B.04, "Reduced Reliability as a Degraded or Nonconforming Condition," licensee procedure EN-OP-104 step 5.11[12] states:

When an SSC experiences multiple failures, especially repetitive failures (i.e. failures for the same or similar cause) such as those addressed in licensees' maintenance rule programs, and when the failures exceed the number of expected failures based on operating experience, the reliability of the affected SSC is reduced.

An SSC that has been identified as having reduced reliability should be considered Degraded or Nonconforming and should be evaluated to determine whether the SSC is OPERABLE….When an SSC's capability or reliability is degraded to the point where there is no longer a Reasonable Expectation that it can perform its Specified Safety Function, the SSC should be judged INOPERABLE.

The licensee and the inspection team noted that there is no specific, numerical guidance on an allowable failure rate or increase in failure rate to justify operability for a system experiencing reduced reliability.

Step 5.5[4] of procedure EN-OP-104 requires action to collect information and define the condition associated with the operability evaluation, including determining the failure mechanism. Step 5.5[6] describes the required evaluation of the capability of a system including the magnitude of the degraded or nonconforming condition. Step 5.5[7] describes the process to make a recommendation on operability status, including determining if a SSC should be considered inoperable. Step 5.11[12] describes the process for evaluating reduced reliability as a degraded/nonconforming condition.

Ultimately, the team determined that the licensee used non-conservative data to generate their Masterpact breaker failure rate of 0.82%. This directly led to a failure of the licensee to properly assess and document the basis for operability per their procedures.

The team obtained the Masterpact breaker failure data and noted the 0.82% failure rate determined by the licensee used the following assumptions. First, only the eight safety-related Masterpact breakers subject to a standing close signal were included. Next, all demands for those breakers to open or close were counted. Lastly, the licensee compared the number of failures to open or close to the total demands (23 failures/2790 demands) to arrive at a failure rate of 0.82%. The inspectors noted that the breaker failures included any type of failure, such as problems with relays, fuses, breaker cubicle interlocks, and internal binding.

When the team independently reviewed the relevant vendor documents and industry operating experience, they noted that the Masterpact internal binding failure mechanism manifests itself only when the breaker is commanded to close. That is, the internal binding failure mechanism does not prevent a breaker from opening. Instead, the act of opening a breaker subject to the failure mechanism enables the internal binding to occur, such that the subsequent close command may result in a failure. The team reviewed the 2790 demands at River Bend Station as documented in Condition Report CR-RBS-2014-6284 from December 9, 2014, and noted the following:

Failure to Close:	*23 failures/1395 demands*	*= 1.65% failure rate*
Failure to Open:	*0 failures/1395 demands*	*= 0% failure rate*

If data is included through March 10, 2015, then additional failures are incorporated for a total of 29 failures against total of 2972 demands, resulting in the following failure rates:

Failure to Close:	*27 failures/1486 demands*	*= 1.82% failure rate*
Failure to Open:	*2 failures/1486 demands*	*= 0.14% failure rate*

The team determined that, by including commands to open as demands, the licensee diluted the failure rate as discussed in all relevant documents for the Masterpact circuit breaker internal binding failure mechanism during anti-pump mode. Of note, the highest failure rate discussed in the licensee's operability determination as examples of other equipment failure rates was 1%. The team determined that this operability determination, as written, would not justify a reduced reliability argument for operability at the 1.65% failure rate for closing Masterpact breakers.

The scenario of concern involves design basis accidents with a concurrent loss of offsite power. Safety-related Masterpact breakers would be required to rapidly load-shed from the electrical bus and then later re-sequence back onto the bus as a load after the diesel generators were started. This process would set up the conditions for the internal binding failure mode to occur for the vulnerable Masterpact breakers.

The team reviewed the actions prescribed by the licensee's standing order and determined the guidance would have been adequate to serve as a compensatory action to maintain operability. Specifically, the post-accident loads of concern that are powered by Masterpact breakers are the standby gas treatment system (SGTS) and the HVC/HVK system. The team noted that the STGS is not credited for accident mitigation until 20 minutes after the accident per calculation G13.18.9.5*061, "Alternate Source Term LOCA Off-Site and Control Room Dose Analysis." Further, the HVC/HVK system is not required to initiate for 30 minutes per abnormal operating procedure AOP-0060, "Loss of Control Building Ventilation," Revision 9, and associated calculation G.13.18.12.3*161, "Standby Switchgear Room Temperatures Following Loss of Offsite Power and Loss of HVAC." Of note, the licensee initially stationed operators at the affected Masterpact breakers to maintain operability on December 9, 2014, and this requirement was later relaxed, following development of the reliability-based operability determination.

The licensee restored compliance by completing a design modification to eliminate the failure mechanism and initiated Condition Report CR-RBS-2015-03952.

<u>Analysis</u>. The failure to accomplish an operability determination in accordance with operability procedure EN-OP-104, "Operability Determination Process," Revision 8, was a performance deficiency. Specifically, contrary to section 5.5, "Operability Evaluation," and section 5.11[12], "Reduced Reliability as a Degraded or Nonconforming Condition," the licensee referenced non-conservative data when assessing the reduced reliability of Masterpact circuit breakers. This performance deficiency is more than minor, and therefore a finding, because it is associated with the equipment performance attribute of the Mitigating Systems Cornerstone, and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the reliability of components powered by Masterpact circuit breakers was reduced and, by justifying operability using non-conservative data, the licensee did not recognize the actual unreliability. The team performed an initial screening of the finding in accordance with NRC Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power." Using Inspection Manual Chapter 0609, Appendix A, Exhibit 2, "Mitigating Systems Screening Questions," the finding was of very low safety significance (Green) because it: (1) was not a deficiency affecting the design or qualification of a mitigating structure, system, or component, and did not result in a loss of operability or functionality; (2) did not represent a loss of system and/or function; (3) did not represent an actual loss of function of at least a single train for longer than its technical

specification allowed outage time, or two separate safety systems out-of-service for longer than their technical specification allowed outage time; and (4) did not represent an actual loss of function of one or more non-technical specification trains of equipment designated as high safety-significant in accordance with the licensee's maintenance rule program.

This finding has a conservative bias cross-cutting aspect within the human performance area because the licensee failed to use decision-making practices that emphasize prudent choices over those that are simply allowable. Specifically, the licensee did not consider that the failure mechanism only occurs on a close command. Instead, the licensee included opening commands when summing the total demands, and this resulted in a non-conservative failure rate [H.14].

Enforcement. Title 10 CFR Part 50, Appendix B, Criterion V, "Instructions, Procedures, and Drawings," requires, in part, that activities affecting quality shall be prescribed by documented instructions, procedures, or drawings, of a type appropriate to the circumstances and shall be accomplished in accordance with these instructions, procedures, or drawings. Quality related station procedure EN-OP-104, "Operability Determination Process," Revision 8, steps 5.5 and 5.11[12] require the licensee to properly assess and document the basis for operability. Contrary to the above, from December 9, 2014, to March 10, 2015, the licensee failed to properly assess and document the basis for operability. Specifically, the licensee referenced non-conservative data when assessing the reduced reliability of Masterpact circuit breakers as a degraded or nonconforming condition. The licensee restored compliance by completing a design modification to eliminate the failure mode and initiated Condition Report CR-RBS-2015-03952. Because the finding is of very low safety significance (Green) and has been entered into the licensee's corrective action program, this violation is being treated as a non-cited violation, consistent with Section 2.3.2.a of the NRC Enforcement Policy: NCV 05000458/2015010-04, "Failure to Accomplish an Operability Determination In Accordance With Procedures."

d. Failure to Identify and Correct an Adverse Condition in a Timely Manner

Introduction. The team identified a Green finding for the licensee's failure to identify and correct an adverse condition in a timely manner as required by plant procedures. Specifically, the licensee did not recognize degrading trends associated with incorrect racking of Magne Blast circuit breakers and failures of the Magne Blast circuit breaker for Reactor Feed Water Pump Motor 1B in a timely manner. For both cases, the licensee failed to initiate corrective action in a timely manner as required by procedure EN-LI-102, "Corrective Action Program," Revision 24.

Description. The team reviewed the history of Magne Blast circuit breaker failures at the River Bend Station, with a focus on repetitive failures. Of note, the licensee experienced eight failure-to-close issues for Reactor Feed Water Pump Motor 1B (FWS-P1B) circuit breaker over a 19 month period. The reactor feed water system provides normal makeup water for the reactor during power operations and can also provide makeup water for certain emergency scenarios.

Additionally, the licensee has experienced nine issues related to improper racking of Magne Blast circuit breakers over a five year period. The racking process involves orienting the circuit breaker correctly in the housing such that all internal components are fully engaged and the circuit breaker can fully perform its function. If a circuit breaker is improperly racked, it may experience intermittent faults, trip prematurely, or not close at all.

The table below summarizes, for the past five years, all of the occasions where FWS-P1B failed to close and where, for any Magne Blast breaker, improper racking issues were identified during corrective action.

Date	Description	Condition Report CR-RBS-	FWS-P1B Failed to start	Improper Racking of Circuit Breaker Identified
2/9/2011	FWS-P1A would not fully rack in after maintenance	2011-2090	No	Yes
2/9/2011	FWS-P1C would not fully rack in after maintenance	2011-2089	No	Yes
6/20/2013	FWS-P1B failed to start during plant startup due to racking	2013-4402 2013-4428	Yes	Yes
6/21/2013	FWS-P1B failed to start during plant startup due to closing coil failure	2013-4419	Yes	No
6/21/2013	FWS-P1B failed to start during plant startup. A subsequent attempt was successful	2013-4428	Yes	No
6/21/2013	FWS-P1C would not fully rack in after maintenance	2013-4431	No	Yes
10/31/2013	FWS-P1B failed to start due to failure of electrical contacts	2013-6860	Yes	No
4/1/2014	13.1 kV feeder breaker to 2F/2H/3B switchgear could not be fully racked in	2014-1586	No	Yes

6/17/2014	Make-up water structure transformer supply breaker failed to close due to racking	2015-2940	No	Yes
12/12/2014	FWS-P1B failed to start due to racking	2014-6350	Yes	Yes
12/25/2014	FWS-P1C failed to start after a reactor trip due to racking	2014-6601	No	Yes
12/28/2014	FWS-P1B failed to start due to racking	2014-6649	Yes	Yes
12/31/2014	FWS-P1B failed to start due to failure of electrical contacts	2014-6691 2014-6696 2014-6699	Yes	No
1/31/2015	FWS-P1B failed to start, breaker was removed and sent to vendor for failure modes analysis	2015-0667	Yes	No

Licensee procedure EN-LI-102, "Corrective Action Program," Revision 24, defines adverse trend as a negative change in performance data that knowledge, experience, and judgement indicate is unacceptable because of the adverse impact on safety or reliability. Step 5.2[3](f)(5) requires the initiator of a condition report to include any pertinent trend information. The licensee's Condition Review Group (CRG) is required to review condition reports (CRs) for adverse trends per step 5.4[6](e) of procedure EN-LI-102. Attachment 9.1 of that procedure specifies repetitive equipment failures should be classified category "B," which yields an elevated cause determination process via an apparent cause evaluation. Lastly, step 5.6[2](m)(2) of that procedure requires, in part, that corrective actions for adverse conditions be specific, measurable, and timely to address the issue.

The team noted that the licensee correctly initiated a CR for each failure-to-start for the FWS-P1B breaker. The aggregate of those CRs, however, were not assessed for an adverse trend until December 31, 2014, under Condition Report CR-RBS-2014-6696. At this point in time, there had been a total of seven failures in a 19 month period, including four failures within the previous 20 days.

Likewise, the team noted that the licensee correctly initiated a CR for each time a circuit breaker racking problem was identified during corrective action or troubleshooting. The aggregate of those CRs, however, were never identified specifically as an adverse trend by the licensee and entered into the corrective action program. The licensee did establish Standing Order 299 on December 26, 2014, as a corrective action under Condition Report CR-RBS-2014-6601 to ensure electrical maintenance personnel were present for circuit breaker racking. This standing order served as an enhancement of their circuit breaker racking process until the governing procedure could be updated. At this point in time, there had been a total of eight problems related to racking of circuit breakers in a five year period.

The team determined that the licensee did not follow procedure EN-LI-102 to identify adverse trends and correct the adverse conditions in a timely manner. In response to the NRC's conclusions, the licensee updated circuit breaker procedures, replaced the Magne Blast circuit breaker for the Reactor Feed Water Pump Motor 1B, and initiated Condition Reports CR-RBS-2015-04259 and CR-RBS-2015-03437.

Analysis. The failure to identify and correct an adverse condition in a timely manner, as required by procedure EN-LI-102, was a performance deficiency. This performance deficiency is more than minor, and therefore a finding, because it is associated with the equipment performance attribute of the Mitigating Systems Cornerstone, and adversely affected the cornerstone objective to ensure the availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. Specifically, the licensee's untimely corrective action contributed to the unreliability of the Magne Blast circuit breaker for Reactor Feed Water Pump Motor 1B and increased the potential for spurious trips of other Magne Blast circuit breakers during design basis events due to improper racking. The team performed an initial screening of the finding in accordance with NRC Inspection Manual Chapter 0609, Appendix A, "The Significance Determination Process (SDP) for Findings At-Power." Using Inspection Manual Chapter 0609, Appendix A, Exhibit 2, "Mitigating Systems Screening Questions," the finding was of very low safety significance (Green) because it: (1) was not a deficiency affecting the design or qualification of a mitigating structure, system, or component, and did not result in a loss of operability or functionality; (2) did not represent a loss of system and/or function; (3) did not represent an actual loss of function of at least a single train for longer than its technical specification allowed outage time, or two separate safety systems out-of-service for longer than their technical specification allowed outage time; and (4) did not represent an actual loss of function of one or more non-technical specification trains of equipment designated as high safety-significant in accordance with the licensee's maintenance rule program.

This finding has an avoid complacency cross-cutting aspect within the human performance area because the licensee failed to recognize and plan for the possibility of mistakes, latent issues, and inherent risk, even while expecting successful outcomes. Specifically, the licensee tolerated the adverse trends, did not plan for further degradation, and the latent conditions ultimately resulted in several Magne Blast circuit breaker failures in December 2014 before the trend was recognized [H.12].

Enforcement. This finding does not involve enforcement action because no violation of a regulatory requirement was identified. This issue was entered into the licensee's corrective action program as Condition Reports CR-RBS-2015-04259 and CR-RBS-2015-03437. Because this finding does not involve a violation and is of very low safety significance, it is identified as FIN 05000458/2015010-05, "Failure to Identify and Correct an Adverse Condition in a Timely Manner."

4OA6 Meetings, Including Exit

Exit Meeting Summary

On April 2, 2015, the team debriefed Mr. E. Olsen, Site Vice President, and other members of the licensee's staff following the onsite portion of the inspection. The licensee representatives acknowledged the findings presented.

On January 19, 2016, the team debriefed Mr. E. Olsen, Site Vice President, and other members of the licensee's staff. The licensee representatives acknowledged the findings presented.

On January 20, 2016, the team conducted an exit with Mr. D. Burnett, Acting Director, Regulatory and Performance Improvement, and other members of the licensee's staff. The licensee representatives acknowledged the findings presented. The team asked the licensee whether any materials examined during the inspection should be considered proprietary and none were identified.

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee Personnel

E. Olson, Site Vice President
D. Burnett, Acting Director, Regulatory & Performance Improvement
J. Clark, Manager, Regulatory Assurance
F. Corley, Manager, Design & Program Engineering
T. Creekbaum, Engineer
R. Gadbois, General Manager, Plant Operations
T. Gates, Manager, Operations Support
K. Huffstatler, Senior Licensing Engineer, Licensing
K. Jelks, Engineering Supervisor
P. Lucky, Manger, Performance Improvement
J. Maher, Manager, Systems & Components Engineering
W. Mashburn, Director, Engineering
J. Reynolds, Senior Manager, Operations
P. Sicard, PRA Engineer
S. Vazquez, Director, Engineering
T. Venable, Manager, Operations

NRC Personnel

G. Warnick, Branch Chief
J. Sowa, Senior Resident Inspector

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

05000458/2015010-01	URI	Technical Specification Allowed Outage Time During Loss of Non-Technical Specification Supported Systems (Section 2.2.b)
05000458/2015010-02	AV	Failure to Adequately Assess Risk During Chiller Unavailability (Section 2.6.a)

Opened and Closed

05000458/2015010-03	NCV	Failure to Identify and Correct Circuit Breaker Failure Mechanism (Section 2.6.b)
05000458/2015010-04	NCV	Failure to Accomplish an Operability Determination In Accordance With Procedures (Section 2.6.c)
05000458/2015010-05	FIN	Failure to Identify and Correct an Adverse Condition in a Timely Manner (Section 2.6.d)

Closed

05000458/2015009-01	URI	Vendor and Industry Recommended Testing Adequacy on Safety-related and Safety-significant Circuit Breakers (Section 2.4.c)

LIST OF DOCUMENTS REVIEWED

Procedures

Number	Title	Revision/Date
OSP-0052	Breaker Racking And 13.8 Kv To 480 Vac Transformer Disconnect Operations	18-20
EN-DC-335	Nuclear Management Manual	6
EN-WM-104	On Line Risk Assessment	10
ADM-0096	Risk Management Program Implementation and On-Line Maintenance Risk Assessment	315
STP-309-0601	Division I ECCS Test	47
SOP-0058	Control Building HVAC System (Sys. #402)	21
SOP-0047	480 VAC System	54
RLP-STM-0402	HVAC- Control And Diesel Generator Building	2
SOP-0066	Control Building HVAC Chilled Water System (Sys #410)	321
OSP-0022	Operations General Administrative Guidelines	79
AOP-0060	Loss Of Control Building Ventilation	9

Condition Reports

2014-01977	2014-04108	2015-02525	2015-01843	2015-01830
2015-01829	2010-02432	2014-01091	2014-00985	2014-05162
2015-01681	2015-01596	2015-01502	2015-01399	2015-00929

2015-00795	2015-00779	2015-00482	2015-00050	2014-03779
2014-06284	2014-04585	2015-00272	2014-01091	2015-00985
2014-00416	2014-00418	2014-04104	2104-04105	2014-04106
2015-00231	2014-06284	2014-03651	2014-03714	2014-03731
2014-03779	2015-01125	2015-01829	2015-01858	2015-01922
2013-1058	2013-1871	2015-1830	2015-00667	2016-00095

Work Orders

406805

Engineering Change

Number	Title	Revision
EC-31808	Failure Modes and Effects Analysis (FMEA) for Trane Adaptive Chiller Controls	0
EC-31807	Operating Instruction Manual	301
EC-28237	Operating Instruction Manual	301
EC-30303	RBS PRA Revision 5: Input to Maintenance Rule Risk Significance and MOV and AOV Risk Ranking	0

Calculations

Number	Title	Revision
G13.18.2.1*067	Control Building Area Winter Temperatures During Normal and LOCA/LOOP Operating Conditions	2
G13.18.2.1*059	Control Building Heat Load Evaluation During LOCA w/Offsite Power Available and Normal Operating Conditions	4`

Drawings

Number	Title	Revision
ESK-06HVK14	Elementary Diagram 480V Control Circuit Control Building Chilled Water System Auxiliary Control	16
ESK-06HVK03	Elementary Diagram 480V Switchgear Control Building Chilled Water CPRSR *CHL1C	7
ESK-06HVK03	Elementary Diagram 480V SWGR Control Bldg Chilled Water CPRSR *CHL1C	28
ESK-06HVK01	Elementary Diagram 480V Switchgear Control Building Chilled Water CPRSR *CHL1A	21
ESK-06HVK01	Elementary Diagram - 480V SWGR Control Building Chilled Water CPRSR *CHL1A	24
ESK-06HVK01	Elementary Diagram - 480V SWGR Control Building Chilled Water CPRSR *CHL1A	23
ESK-06HVC02	Elementary Diagram 480V Switchgear Control Room Air Handling Unit ACU2A	26
ESK-06HVC01	Elementary Diagram 480V Switchgear Control Room Air Handling Unit ACU1A	19
0216.210-085-029	Wiring Diagram for Control Panel	1
0216.210-085-028	Wiring Diagram for Control Panel	1
0216.210-085-008	Control Diagram Control Building Chillers HVK-CHL1A, HVK-CHL1B and HVK-CHL1C	1
0216.210-085-023	Wiring Diagram for Control Panel	1
0216.210-085-024	Wiring Diagram for Control Panel	1
0216.210-085-027	Wiring Diagram for Control Panel	1
0216.210-085-026	Wiring Diagram for Control Panel	1
0216.210-085-025	Wiring Diagram for Control Panel	1
PID-22-14N	Engineering P & I Diagram System 410 HVK Chiller Compressor Skid HVK *CHL1D	6
PID-22-14J	Engineering P & I Diagram System 410 HVAC-Chilled Water	20

PID-22-14K	Engineering P & I Diagram System 410 HVK Chiller Compressor Skid HVK *CHL1A	6
PID-22-14L	Engineering P & I Diagram System 410 HVK Chiller Compressor Skid HVK *CHL1B	5
PID-22-14M	Engineering P & I Diagram System 410 HVK Chiller Compressor Skid HVK *CHL1C	6
PID-22-09A	Engineering P & I Diagram System 402 HVAC-Control Building	18
PID-22-14H	Engineering P & I Diagram System 410 HVAC-Chilled Water	20
PID-22-9B	Engineering P & I Diagram System 402 HVAC Control Building	14
PID-22-09C	Engineering P & I Diagram System 402 HVAC-Control Building	10

Miscellaneous

Number	Title	Revision/Date
299	Standing Order - GE Magna-blast Breaker Racking	0
	RBS Maintenance Rule Reliability and Availability Sheet	April 30, 2014
RN-LI-104	Snapshot Assessment/Benchmark Report Template	10
OE 311013	Loss of DC Power to Uninterruptible Power Supply Inverter	April 16, 2014
OE 306166	Fan Breaker Fails to Close on Close Signal	April 10, 2012
T747	Maintain Magne Blast 13.8KV	May 5, 2015
ECH-S-0007	Purchase Specification For Replacement Low Voltage Air Circuit Breakers (Safety Related, Harsh Environment)	0
ECH-S-0006	Purchase Specification For Replacement Low Voltage Air Circuit Breakers (Safety Related, Mild Environment)	0
354.1	Lubrication Recommendations Type AM Circuit Breakers ML-13 & ML-13A Mechanisms	August 22, 2002
OSP-0022	Operations General Administrative Guidelines (Proposed Change)	075CN-A
PDS9906	Final Results For The Simulated Life Cycle Management Evaluation Of D6A15A1 Grease In Magne Blast Circuit Breakers	May 11, 1999
298	Standing Order – Safety Related Masterpact AND Balance of Plant circuit breakers intermittently failing to close	3

ERC-275	ERC for NLI-NW20H1-LGSB9 Replacement Circuit Breaker	0
ERC-232	ERC for NLI-NT08N1-LGSB8 Replacement Circuit Breaker	0
TR-106857-V3	Preventive Maintenance Basis Volume 3: Low Voltage Switchgear	July 1997
TR-106857-V2	Preventive Maintenance Basis Volume 2: Medium Voltage Switchgear	July 1997
TR-112938	Routine Preventive Maintenance Guidance and AK and AKR Type Circuit Breakers	November 1999
VTD-B515-0115	Buffalo Forge Installation and Operation Instructions for Air Handling Cabinets [Pub. #NU9-M65]	November 28, 1995
3216.210-085-001C	Centrifugal Refrigeration Machine	C
RPPT-STM-0402-INLO	Control Building And Diesel Generator HVAC	0
ROJT-NLO-QC001	SNEO Generic Watchstation Tasks On The Job Training And Evaluation	21
RPPT-NLO-0289	Circuit Interruption Devices	1
WM-105-00	Inspect Masterpact Breaker	August 1, 2014
EN-WM-105	Maintain Magne Blast 13.8KV	May 19, 2015
NCR-440	NW Replacement Circuit Breakers	0
NCR-573	NW Masterpact Replacement Circuit Breakers	0
FA-042-351021500-1	Failure Analysis Masterpact Circuit Breaker PSEG	1
IM-052-07860-1	Instruction Manual for NLI/Square D Masterpact AC Breaker (Replacement for GE AKR-30 and AKR-50)	1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
1600 E LAMAR BLVD
ARLINGTON, TX 76011-4511

March 24, 2015

MEMORANDUM TO: Dan Bradley, Resident Inspector
Projects Branch A
Division of Reactor Projects

FROM: Troy Pruett, Director **/RA/**
Division of Reactor Projects

SUBJECT: SPECIAL INSPECTION CHARTER TO EVALUATE CAUSES FOR THE LOSS OF CONTROL BUILDING HVAC AT THE RIVER BEND STATION

In response to the Masterpact breaker issues that resulted in a loss of control building HVAC at the River Bend Station, a special inspection will be performed. Additionally, the special inspection will continue the review of recent issues associated with GE Magne Blast circuit breakers that were partially inspected during the Special Inspection performed by the NRC to evaluate the causes of the December 25, 2014, unplanned reactor trip. You are hereby designated as the special inspection team leader. The following member is assigned to your team:

- John Watkins, Reactor Inspector, Division of Reactor Safety

A. Basis

On March 9, 2015, during emergency core cooling system and loss of coolant accident (ECCS/LOCA) testing of Division I, control building chiller 1C failed to start following the load shed and sequencing start onto the associated emergency diesel generator. Chiller 1C shed from the electrical bus as expected, but failed to restart and sequence onto the emergency diesel generator as designed. There are two control building chilled water (HVK) chillers in Division I, chillers 1A and 1C. HVK chiller 1A has been inoperable/unavailable since August 11, 2014. Since no Division I HVK chillers were available, operations personnel attempted to start either of the Division II HVK chillers 1B or 1D. Both of the Division II HVK chillers failed to start since the equipment has an electrical interlock that prevents a chiller from starting unless both of the Division II air handling units (AHUs) are operating. Division II AHU 1B would not start due to a breaker deficiency that was unknown at the time. Operations personnel attempted to restart HVK chiller 1C on Division I without success. The station entered abnormal operating procedure AOP-60, “Loss of Control Building Ventilation,” due to the loss of the control building ventilation (HVC) system.

A similar failure occurred during Division II ECCS/LOCA testing on February 23, 2015. Notable differences that make the March 9, 2015, failure more significant are:

1. During the February 23 event, AHU 2B would not start. The Station subsequently identified two relays in the startup sequencer for AHU 2B that were degraded. The station operations personnel were able to start Division I AHU 1A as expected. As a result, the electrical interlock did not prevent HVK chiller 1C from starting and control building ventilation was restored.

   However, during the March 9 event, the failure of the HVK chiller 1C to start was due to a known deficiency with the Masterpact breakers. The known problem is associated with a failure probability of Masterpact breakers opening and closing successfully. The station attempted to restore ventilation by starting a Division II chiller, but AHU 1B would not start. The electrical interlock prevented HVK chiller 1B from starting since the required AHUs were not operating. The breaker for AHU 1B is a Masterpact breaker. The failure to close does not appear to be a result of the known Masterpact breaker issue and is still under investigation.

2. HVK chiller 1A has been inoperable and unavailable since August 11, 2014. With chiller 1A out of service and HVK chiller 1C failing to start, the risk implications are more significant.

The licensee is investigating and troubleshooting the cause and will have to effect repairs and re-perform portions of the surveillance to verify operability. The cause of the failures is not fully understood. The licensee indicated that they plan to assess for extent of condition once the causes are better understood.

The March 9 event, and associated equipment failures, reveals a much broader concern that has been ongoing with the identified Masterpact breaker deficiency. The deficiency calls into question the current and past operability of the 10 safety-related Masterpact breakers in the Standby Gas Treatment and Control Building HVC systems. These systems support operability for control room air conditioning, equipment in the standby switchgear rooms, battery chargers, and inverters. Additionally, the recent issues associated with GE Magne Blast circuit breakers that were partially inspected during the Special Inspection performed by the NRC to evaluate the causes of the December 25, 2014, unplanned reactor trip with complications calls into question the overall adequacy of the licensee’s breaker maintenance program.

Management Directive 8.3, “NRC Incident Investigation Program,” was used to evaluate the level of NRC response for this event. In evaluating the deterministic criteria of MD 8.3, it was determined that: (1) The event included multiple failures in the control building ventilation (HVC) system, which is a system to support operability for control room air conditioning, equipment in the standby switchgear rooms, battery chargers, and inverters; and (2) the event involved repetitive failures of safety-related Masterpact breakers. Additionally, the Magne Blast circuit breaker issues that were identified during the Special Inspection performed by the NRC to evaluate the causes of the December 25, 2014, unplanned reactor trip with complications calls into question the overall adequacy of the licensee’s breaker maintenance program. The preliminary Estimated Conditional Core Damage Probability was determined to be 2.6E-6.

Based on the deterministic criteria and risk insights related to the multiple failures of the control building ventilation system, the nature of the Masterpact breaker failures, and the potential generic concern with the Magne Blast circuit breakers, Region IV determined that the appropriate level of NRC response was to conduct a Special Inspection.

This Special Inspection is chartered to review the recent surveillance testing failures associated with the control building ventilation system, the identified Masterpact breaker deficiency and its impact on equipment operability, a continued review of issues associated with GE Magne Blast circuit breakers, a review of the licensee's corrective actions including extent of condition, and evaluate the licensee's actions with regard to technical specification limited conditions for operation applicability when control building chillers are declared inoperable or non-functional.

B. Scope

The inspection is expected to perform data gathering and fact-finding in order to address the following:

1. Provide a recommendation to Region IV management as to whether the inspection should be upgraded to an augmented inspection team response. This recommendation should be provided by the end of the first day on site.

2. Develop a complete sequence of events related to the multiple Masterpact breaker failures to close when demanded during Division I ECCS surveillance testing and subsequent loss of ventilation recovery on March 9, 2015.

3. Evaluate the licensee's progress in determining the causes for the Masterpact breaker failures to close during the February 23 and March 9, 2015, ECCS/LOCA testing. Multiple breaker and relay failures occurred that impacted HKV chiller and AHU equipment operations. Evaluate the licensee's extent of condition and extent of cause review, and corrective actions associated with each event. Further, determine if the cause evaluation is being conducted at a level of detail commensurate with the significance of the problem.

4. Review the effectiveness of licensee actions to address long-standing equipment deficiencies associated with Masterpact breakers.

5. Evaluate the licensee's actions with regard to technical specification limited conditions for operation applicability when control building chillers are declared inoperable or non-functional. Determine whether the required redundancy for safety-related equipment supported by the HVK chillers is met during instances of HVK chiller inoperability. Consider the impact on operability of supported technical specification equipment an additional single failure would have. Specifically, evaluate the operability implications non-functional HVK chillers have on the supported equipment described in the following limiting conditions for operations:

    - LCO 3.8.4 DC Sources – Operating

- LCO 3.8.7 Inverters − Operating
- LCO 3.8.9 Distribution Systems – Operating

6. Continue to review the causes and corrective actions taken to address the failure of reactor feedwater pump C to start during the December 25, 2014, initial scram response and reactor feedwater pump B during the subsequent reactor startup. For issues related to Magne Blast circuit breakers, verify that the licensee's corrective actions have addressed extent of condition and extent of cause. (Review started in the Special Inspection performed by the NRC to evaluate the causes of the December 25, 2014, unplanned reactor trip)

7. Review the licensee's maintenance, testing and operating practices for Masterpact and Magne Blast circuit breakers. Promptly communicate any potential generic issues to regional management. (Review for Magne Blast breakers started in the Special Inspection performed by the NRC to evaluate the causes of the December 25, 2014, unplanned reactor trip)

8. Evaluate pertinent industry operating experience and potential precursors to the event, including the effectiveness of any action taken in response to the operating experience.

9. Collect data necessary to support completion of the significance determination process.

C. Guidance

Inspection Procedure 93812, "Special Inspection," provides additional guidance to be used by the Special Inspection Team. Your duties will be as described in Inspection Procedure 93812. The inspection should emphasize fact-finding in its review of the circumstances surrounding the event. It is not the responsibility of the team to examine the regulatory process. Safety concerns identified that are not directly related to the event should be reported to the Region IV office for appropriate action.

You will formally begin the special inspection with an entrance meeting to be conducted no later than March 30, 2015. You should provide a daily briefing to Region IV management during the course of your inspections and prior to your exit meeting. A report documenting the results of the inspection should be issued within 45 days of the completion of the inspection.
This Charter may be modified should you develop significant new information that warrants review.

CONTACT: Greg G. Warnick, Chief, DRP:BC
817-200-1144

DISTRIBUTION:
See next page

ADAMS ACCESSION NUMBER

Document Name: S:\DRP\PBC\issues\MD8.3s\RBS\2015\03-09-2015\RBS-Special-Inspection Charter

SUNSI Rev Compl.	☑ Yes ☐ No	ADAMS	☑Yes ☐ No	Reviewer Initials	
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GGWarnick	TWPruett			
/RA/	***/RA/***			
03/25/15	03/24/15			

OFFICIAL RECORD

SUBJECT: SPECIAL INSPECTION CHARTER TO EVALUATE CAUSES FOR THE LOSS OF CONTROL BUILDING HVAC AT THE RIVER BEND STATION

DISTRIBUTION:
M. Dapas
K. Kennedy
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R. Azua
J. Drake
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River Bend Station
Control Building Ventilation Risk Assessment Issue
Detailed Risk Evaluation

Performance Deficiency. The licensee failure to adequately assess the risk associated with operating the control building chilled water system chillers in various single-failure vulnerable configurations was a performance deficiency.

Screening to Detailed Risk Evaluation. This performance deficiency is more than minor, and therefore a finding, because it is associated with the configuration control attribute of the Mitigating Systems Cornerstone, and adversely affected the associated cornerstone objective to ensure availability, reliability, and capability of systems that respond to initiating events to prevent undesirable consequences. As a result of this deficiency, the station reduced the reliability and availability of systems contained in the main control room and failed to account for the significant, uncompensated impairment of the safety functions of the associated systems.

The team noted that based on Inspection Manual Chapter 0612 Appendix E, “Examples of Minor Issues,” Section 7, “Maintenance Rule”, the performance deficiency is more than minor because “the risk assessment failed to account for (at least qualitatively) the loss of significant, uncompensated impairment of a key operating or shutdown safety function.” Specifically, the licensee’s failure to account for a loss of all HVK cooling scenario, either quantitatively due to EOOS model limitations or qualitatively due to procedure inadequacies, represents a significant impairment to all systems associated with the main control room. A loss of cooling to the control room could lead to multiple systems exceeding their equipment qualification temperatures and lead to subsequent failures. A loss of cooling to the control room would also impact control room habitability.

Using Inspection Manual Chapter 0609, Attachment 4, “Initial Characterization of Findings,” the inspector determined that the finding involved the licensee’s assessment and management of risk associated with performing maintenance activities in accordance 10 CFR 50.65(a)(4) which required evaluation of the finding using Inspection Manual Chapter 0609, Appendix K, “Maintenance Risk Assessment and Risk Management Significance Determination Process.”

Using Appendix K, the finding was determined to require additional internal NRC management review using risk insights where possible because the quantitative PRA tools are not well suited to analyze failures from control room heat-up events. Thus, the analyst evaluated the safety significance posed by the heat-up of components cooled by control building chilled water (HVK) chillers using Appendix K, Flowchart 1, “Assessment of Risk Deficit,” to the extent practical. The analyst determined the maximum risk deficit by quantitatively estimating the frequency of events which would significantly impact operations in the control room and assuming no successful operator actions to safely shutdown and mitigate the loss of control room cooling event. This method yielded an incremental core damage probability deficit (ICDPD) of 3.1E-5. The specifics of this evaluation were the basis of the final detailed risk evaluation and are included in the detailed risk evaluation section of this document.

Using Flowchart 1, the analyst assumed that the finding related to more than just risk management actions; involved a risk deficit of greater than 1E-5 (ICDPD) but less than 1E-4;

and no risk management actions were taken for the impaired redundancy of control room cooling. These assumptions yielded a “Yellow Finding” result. In accordance with Step 4.1.2 of Appendix K, the analyst performed a detailed risk evaluation since the Flowchart 1 result was greater than Green.

Detailed Risk Evaluation Conclusion. The result of the detailed risk evaluation is a preliminary White finding (low to moderate safety significance).

The analyst estimated the ICDPD and the incremental large early release probability deficit (ILERPD) as no higher than Yellow (substantial safety significance) for use in Flowchart 1 of Appendix K. Use of risk insights with NRC management review in the detailed risk evaluation yielded a best estimate of White.

The estimate from the detailed risk evaluation quantified the CDF associated with the control room reaching temperatures that would significantly impact operations to be 3.1E-5/year. The analyst determined that if the licensee successfully avoided core damage under these conditions at least 67 times out of 100, the increase in CDF estimate would fall in the White range. Further, the analyst determined the licensee would have to be successful in avoiding core damage under these conditions more than 97 times out of 100 for the issue to be Green.

Application of qualitative considerations led the NRC to conclude that operators would successfully and safely shut down and maintain stable shutdown of the reactor for 67 to 97 percent of these cases despite the adverse effects on equipment and operators. This yielded a result of low to moderate safety significance (White).

Detailed Risk Evaluation

Summary of Assumptions. (See the “Discussion of Assumptions” section at the end of this report for full details of these assumptions.)

1. Affected systems, structures, or components. The licensee did not adequately assess risk for inoperable chillers. Therefore, the control building, the control room, and their contents were exposed to conditions where random plant events and failures would make the plant configuration more safety significant.

2. Exposure Time. The analyst determined the exposure time by taking the year (2014) with the most out of service time since 2011. The following table summarizes the amount of out of service time for HVK chillers outages during 2014:

Chillers Which Were Out of Service	Time Chillers Were Out of Service
Chillers 1A, 1B, and 1D	94.33 hours
Chillers 1A, 1C, and 1D	18.13 hours
Chillers 1B and 1D	135.7 hours
Chillers 1A and 1C	343.8 hours

3. Alternate Ventilation in the Control Building. Alternate ventilation (the practice of opening switchgear room and DC equipment room doors upon a loss of control building cooling) provides adequate cooling for AC and DC electrical equipment in the control building. The analyst assigned a failure probability of 2.1E-4 for alternate ventilation.

4. Use of Service Water Cooling. The analyst assigned a failure probability of 5.06E-1 for the use of service water to supply the cooling water to the coils of the control building and control room air handling units in lieu of chilled water. Low experience/training, poor procedure quality, and the decision not to employ this contingency on March 9, 2015, influenced the failure probability.

5. Starting of a fan in the main control room. The analyst assigned a failure probability of 5.02E-1 for starting an air handling unit fan or a smoke removal fan to minimize the increase in main control room temperature. Low experience/training and poor quality procedures to diagnose the need for starting a fan influenced the failure probability.

6. Operating History. The analyst assumed the plant operated at power or at shutdown conditions above those which necessitated operation of the residual heat removal system for decay heat removal. This allowed the analyst to use the at-power SPAR model for the entire exposure time.

Control Room Summary

Overall Result – Low to moderate safety significance (White)

The maximum increase in CDF was estimated to be 3.1E-5/year, which represented the frequency at which the control room would reach temperatures at which operations would be significantly impacted and included the assumption that operators would be unsuccessful in preventing core damage in 100 percent of the cases. Using qualitative considerations, the NRC concluded that operators would successfully and safely shut down and maintain stable shutdown of the reactor in 67 to 97 percent of these cases despite the adverse effects on equipment and operators.

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

Qualitative Risk Insights Considered in NRC Management Review

Risk Insight	Information for and decision making
Defense-in-Depth	Loss of main control room equipment and ability to implement operator actions affect defense-in-depth.
Extent the performance deficiency affects other equipment	Control room equipment, equipment operated from the control room, and control room operators comprised the dominant safety impact for this finding.
Degree of degradation	It is unknown exactly how degraded control room equipment, controls, and operator performance would be affected.
Success of recovery actions	Human error probabilities have been estimated for the recovery actions for this performance deficiency.
Additional insights	The success of operators in the elevated temperature environment and their ability to safely operate the plant should be considered.

Application of the qualitative considerations further assessed the following which are discussed in detail in this detailed risk evaluation:

1. Estimate of Control Room Temperature
2. Impact of Heat-up on Control Room Equipment
3. Human Performance in the Control Room
4. Control Room Habitability

This produced a result of low to moderate safety significance (White).

Internal Events Summary. The analyst estimated the frequency at which the control room would reach temperatures which would significantly impact operations brought about by the loss of normal control room cooling. Since a control room model did not exist, the analyst needed to perform an evaluation to estimate the safety significance of the finding, which showed an increase in CDF of 2.5E-5/year from internal events.

External Events Summary. The analyst reviewed external events and found that fires in the control building ventilation subsystems were dominant. Application of the fire ignition frequency for control building ventilation system to the method used for significance determination for internal events yielded an estimate of an increase in CDF of 6.0E-6/year for external events.

Estimate of Control Room Temperature

<u>Calculations of Control Room Temperature</u>. Before May 2015, Calculation G.13.18.12.3*161, "Standby Switchgear Room Temperatures following Loss of Offsite Power and Loss of HVAC," Revision 2, and Calculation G13.18.2.3-426, "Standby Switchgear Room Temperature Sensitivity with Service Water Aligned to the HVK System," Revision 0, were the only probabilistic risk assessment calculations available to estimate control room temperature following a loss of cooling. These calculations predicted temperatures of approximately 200°F and 160°F respectively. The licensee did not believe the calculations were representative because they were not explicitly developed to predict control room temperature. FLEX calculation G13.18.12.4-042, "Main Control Room Heat up for Extended Loss of AC

Power (FLEX)," Revision 0, dated September 18, 2013, showed control room temperature reaching 104˚F at 24 hours with no FLEX fan used. 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.

Observation of Control Room Temperature. Following a loss of control room cooling on March 9, 2015, control room temperature increased from approximately 65˚F to 91˚F in 30 minutes. The operators implemented a non-procedural action to manually initiate a control room air handling unit and control room fresh air fan. Control room temperature dropped to 70˚F and then rose approximately 1.67˚F per hour. Starting a control room air handling unit mixed cool outside air with recirculated control room air. Weather records indicated an average outside ambient temperature of 62˚F during the loss of ventilation event. This is lower than the average annual temperature which research showed to be 69˚F. Research also determined the average high temperature in July and August to be 92ºF. Mixing warm to hot outside air would not provide a dramatic decrease in temperature. 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).

The licensee stated that operators may also take actions prescribed in Procedure AOP-0050, “Station Blackout,” Revision 51, to remove tiles in the ceiling of the control room if the station conditions progressed to a blackout.

Best Estimate of Control Room Temperature by the NRC. Using all of the available data, the NRC estimated that the control room temperature would approach 130˚F, based on the licensee’s calculations with noted errors accumulated on top of the licensee’s final value and a more realistic time estimate for aligning service water to the main control room air handling unit coils.

Impact of Heat-up on Control Room Equipment

Since the control room contains much equipment that is solid state, prediction of what would fail at what temperature was difficult. However, if large amounts of equipment were to fail in the control room, whether it was indication, control, or alarms, operators would be further challenged to mitigate the effects of a loss of control building cooling. 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.

The NRC noted River Bend Technical Specification 3.7.3, “Control Room AC System,” required that control room area temperature be verified to be less than 104˚F once every 4 hours if both control room AC subsystems were inoperable. 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.

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.

Of note, during a walkdown inspectors noted that Agastat relays were used in the control room in the reactor protection system. It was also noted that some relays were installed in cabinets. When inspectors asked the licensee about the relays, the licensee responded that two types of Agastat relays were used and one type, Type TR, had a maximum design temperature rating of 122˚F. The analyst considered that by noting just this one example, potentially many other components could be affected by temperatures in the 104-130˚F range during a postulated event.

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.

NUREG 1.155, "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 120˚F 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 120˚F value from NUMARC-8700 for control room equipment functionality was less conservative than other approaches outlined 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 room failed at an ambient temperature of 90˚F and described that the failure rate of instrumentation can be expected to increase as the control room temperature increases. Also, NUREG/CR-6479, "Technical Basis for Environmental Qualification of Microprocessor-Based Safety-Related Equipment in Nuclear Power Plants," described that the synergistic effect of high temperature in 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 20˚F 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 120˚F would only be acceptable for scenarios which would only result in elevated temperatures for up to four hours and only if they also demonstrated that humidity did not rise appreciably in those four hours.

Human Performance in the Control Room

The analyst noted that increased ambient temperature also impacted the human factors analysis. SPAR-H guidance stated that environmental factors, often referred to as stressors, such as excessive heat or poor ventilation, can induce stress in a person and affect mental or physical performance. Therefore, even routine tasks are more likely to be performed erroneously by operators in a control room with elevated temperatures. The analyst applied a multiplier of two to the performance shaping factor for stress in most of the human reliability analyses events that were relied upon in the loss of cooling scenarios.

The licensee evaluated effects of stress on the operators and concluded stress would not have significant bearing on safety because many of the operator actions credited in the PRA would be accomplished before temperatures rose. The analyst noted that the control room temperature rose quickly and that licensee procedure EN-IS-108, “Working in Hot Environments,” Revision 10, states, in part that workers in hot environments may experience decreased physical performance and/or mental alertness in the procedure's “Purpose” section. The section continues, “Sweating, fogging of eye and face protection, dizziness, and decreased mental functions can contribute to accidents while working in hot environments.”

Control Room Habitability

River Bend calculations predict that the control room temperature will quickly exceed 100˚F and rapidly approach 120˚F complicating control room habitability. NUMARC-8700 states that loss of cooling in the control room would not prevent operators from performing necessary actions. NUMARC-8700 concluded that an air temperature of 110°F is a conservative limit for control room habitability, citing a military standard that states that 110°F is tolerable for light work for a four hour period while dressed in conventional clothing. In Section 2.7.2, NUMARC-8700 stated that in a conservative case, the expected main control room temperature would be 97˚F at the end of the first hour, 104˚F at the end of the second hour, 108˚F at the end of the third hour, and 110˚F at the four hour point. Because the projections from Calculation ENTR-078-CALC-003 exceeded these times/temperatures from NUMARC-8700, the analyst did not consider the NUMARC-8700 control room habitability heat-up analysis a valid basis for habitability and evaluated the effects of higher temperatures in the control room.

Procedure EN-IS-108, “Working in Hot Environments,” Revision 10, limits stay times to 20 minutes for workers in work clothes with low work demand at 120˚F (wet bulb globe temperature) and for temperatures above that breaks are required and a job hazard safety analysis with a rescue plan per Procedure EN-IS-124 is required.

The analyst assumed that the operators in the control room have a “Low” work demand as defined per EN-IS-108. Also, the analyst assumed that the operators would meet the classification of wearing “Work Clothes” per EN-IS-108. These classifications correlated to values for various temperatures in Attachment 9.4, “Determining Stay Times and Recovery Time / Stay Time Chart,” in EN-IS-108. The analyst produced a more pertinent simplified version of the chart below:

Wet Bulb Globe Temperature	Maximum Stay Time (minutes)
118-120˚F	20
114-116˚F	25
112˚F	30
110˚F	35
108˚F	45
106˚F	50
104˚F	60

This attachment also defines the recovery time as follows:

$$\text{Recovery Time} = \frac{\text{Time Spent in Heat Stress Area}}{\text{Assigned Stay Time}} \times 60 \text{ minutes}$$

From this equation, if a worker stayed in the hot control room for his or her stay time, he or she would be required to recover for 60 minutes. For continuous operation, this would necessitate four control room operating crews at wet bulb globe temperatures from 116 - 120˚F, three control room operating crews from 104 - 112˚F, and two control room operating crews below 104˚F.

The analyst assumed no extension of stay times using personal cooling garments was applicable as these contingencies (frozen cooling garments) would not be readily available or deployable within the 2 hours until the first peak in control room temperature. Additionally, AOP-0060, “Loss of Control Building Ventilation,” Revision 9, contains no guidance to consider deploying this contingency.

Also, Attachment 9.5, “High Heat Stress Physical Qualification Assessment,” of EN-IS-108 requires evaluation by a medical examiner of workers with certain medical conditions.

The analyst used data from the operator licensing data bank and assumed of the 5 required licensed operators called for by procedure EN-OP-115, “Conduct of Operations,” Revision 15, that one, possibly two, would potentially start to be affected by the heat and require evaluation by a medical examiner.

In cases where cooling is lost to the control room, the environment would encroach upon the worker (vice having workers enter a high heat area). Since no guidance is set forth in Procedure AOP-0060 to be alert for these conditions which could affect workers, they could unknowingly become affected by heat as temperature rose. Attachment 9.4 of ENS-IS-108 called for setting stay times for low work demand in work clothes beginning at 90˚F wet bulb temperature. The analyst concluded that it was likely operators could be affected and not fully realize their degraded physical condition.

Heat Stress Estimates. The analyst estimated and modeled a best estimate heat up calculation for the control room using best available data at the time of the analysis. This heat up mimicked the licensee’s latest control room heat-up curve from ENTR-078-CALC-003 and used the following assumptions:

- Start at 85˚F
- Peak 8˚F higher than the licensee’s estimate at 2 hours

The analyst assumed that the control room humidity was initially 40 percent and would increase throughout the event by 1 percent per minute. Humidity was assumed to increase from operators adding humidity, fluid system leakage, and external humid air. The analyst then used dry air temperature and humidity and then plotted a wet bulb globe temperature (WBGT) versus time plot.

With the plot, the analyst performed an integration under this curve to determine when operators would have used up each portion of stay time for the increasing temperatures. For instance, if WBGT was 94 degrees and the operator was in the control room for 10 minutes of their 100 minute stay time, a 10 percent of stay time was noted. The analyst then summed the intervals and determined that at approximately 1 hour and 30 minutes operators would have received a full stay time.

Also, from the plot, the analyst estimated that:

- Heat stress monitoring would be required at 45 minutes (> 90˚F WBGT)
- At 75 minutes, the WBGT would require a 60 minute stay time.
- At 1 hours 45 minutes, the WBGT would require a 25 minute stay time.

From these points, if the licensee were to follow their procedure for heat stress, a second operating crew would need to be available at around 60 minutes. Operations could reduce the control room manning to Technical Specification minimum, but this would complicate event response as fewer operators would be responding to dynamic conditions (at a minimum, Technical Specification 3.7.3 would require a plant shutdown within 12 hours) in the plant. Of note, only about one-fourth of the time on average are there extra day shift operators on site and for three-fourths of the time operator call-ins or an Emergency Action Level declaration would be needed to get extra operators in. The analyst assumed this could not occur within one hour.

Of note, Calculation G.13.18.12.3*161 estimates the Division I and II Remote Shutdown Rooms to have temperatures of approximately 170˚F and 130˚F, respectively, after 24 hours. These temperatures would make remote controls from these panels untenable and therefore the analyst considered them unavailable.

Estimation of Increase in CDF

Internal Events Increase in CDF for the Control Room. Using the information from estimating the control room temperature, the impact of the heat-up on control room equipment, human performance in the control room, and control room habitability, the analyst estimated the increase in CDF.

The analyst considered that the cutsets for the control building cases would provide the ability to estimate the increase in CDF from the control room. The analyst reviewed the Top 171 cutsets composing of >99 percent of the increase in CDF for the control building portion of the analysis. All cutsets contained the following basic events:

- An initiator (which varied)
- Chillers in test or maintenance (Basic event values = 1.0)
- Failure of the remaining train of cooling (which varied)
- Use of the service water contingency (Basic event value = 5.06E-1)
- Alternate ventilation (Basic event value = 2.1E-4)

- Recovery of a chiller or train of cooling (Basic event value = 2.53E-1)

The analyst noted that all of these events were applicable to a loss of control room cooling, except alternate ventilation which was an action taken for survival of control building equipment. A loss of control room cooling would have to be brought about by an initiator, while some chillers were in test or maintenance, when another train of cooling failed, and the service water contingency and chiller recovery were unsuccessful. Therefore, the analyst took those Top 171 cutsets for the control building and divided them by the failure probability of alternate ventilation. The results were cutsets with an initiator, failure of the remaining train of cooling, use of service water, and chiller recovery to attempt to control the control room temperature. The analyst then applied a recovery term for the starting of a control room fan (discussed in the "Discussion of Assumptions" section) to provide some relief from the high temperatures. In applying these, the analyst came to an increase in CDF of 2.5E-5/year from internal events. This value represents the increase in CDF with core damage occurring when the control room heats up and no contingencies are successful.

Equipment would start to be affected as it operated outside of its design temperature range (as discussed by the previously discussed Agastat relay example) and behave unpredictably. Also, control room indications may be erroneous, as these indications are not typically calibrated to accurately display in an environment >85˚F according to the FSAR. Human performance would start to be impacted by heat effects and control room staffing would become challenging. Use of an alternative control room was considered not available because of the excessively high temperatures which would be experienced in those rooms.

<u>External Events Increase in CDF for the Control Room</u>. The analyst reviewed the River Bend Internal Plant Evaluation of External Events and determined that fire was the only external event that would have appreciable impact on safety. After reviewing fire scenarios in switchgear, electrical rooms, and other plant equipment and areas, the analyst concluded the dominant increase in CDF from fires would come from postulated fires in the control building ventilation subsystems.

Using fire ignition frequency for ventilation subsystems from NUREG-2169, "Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Events Database," dated January 2015, the analyst determined that the fire ignition frequency for ventilation subsystems in a plant was 1.64E-2/year. The analyst assumed the plant had 13 ventilation subsystems which would count towards the potential fire sources. The subsystems numbered two for the control building, two for the auxiliary building, two for the turbine building, two for containment, two for the fuel building, and three for the emergency diesel generators. Spreading the fire probability over these subsystems yielded a fire ignition frequency per subsystem of 1.26E-3/year. The analyst used this value to estimate change in CDF by applying the method used to generate the internal events results for the control room, except the fire ignition frequency was used as the initiating event frequency. Any fire was assumed to damage that subsystem rendering it non-functional. This yielded an increase in CDF of 6.0E-6/year.

<u>Total Increase in CDF Estimate</u>. The analyst considered that these aggregated factors (i.e. control room temperature, the impact of the heat-up on control room equipment, human

performance in the control room, and control room habitability) would most likely lead to unsuccessful mitigation of the postulated event. The maximum increase in CDF was estimated to be 3.1E-5/year, or Yellow significance. The analyst determined that if the licensee successfully avoided core damage under these conditions at least 67 times out of 100, the increase in CDF estimate would fall in the White range. Further, the analyst determined the licensee would have to be successful in avoiding core damage under these conditions more than 97 times out of 100 (failure probability = 3.2E-2) for the issue to be Green. The analyst considered this 3.2E-2 failure probability to be too low for the circumstances.

Uncertainties

1. Control Room. As discussed in the "Discussion of Assumptions" section of this evaluation, the analyst did not model the increase in CDF from elevated control room temperatures. The analyst used qualitative assumptions to determine the maximum and best estimate results.

2. Additional metal heat sinks. The licensee took credit for many additional metal heat sinks which were not independently verified by the inspectors.

3. Non-conservatisms. The analyst identified numerous non-conservatisms which were not applied to the estimate, which if they were applied would have made the estimate of increase in CDF higher. These non-conservatisms are discussed in their respective sections and are summarized on the next page:

    a. Common cause failures. Some common cause failures were not fully modeled for HVAC equipment. Based on the results from common cause failures in the existing SPAR model the analyst believes only a slight (less than 5 percent) increase in the maximum and best estimate results would occur.

    b. Dependency of actions in human reliability analysis of service water. The analyst chose not to apply the dependency of having the same crew in the same time frame that would be lining up service water to an air handling unit while attempting to recover a chiller.

    c. Application of high stress in 2 human reliability analyses. The analyst did not apply elevated stress in the human reliability analyses for aligning service water and starting a control room fan. Though appropriate for the analysis, the application would give no credit for the actions.

    d. Operator recovery actions and fire brigade response. The analyst recognized that operator actions to restore control room cooling during a fire event would be more challenging to accomplish due to operator involvement in fire brigade response. However, the analyst concluded that the increase in CDF due to this consideration was not sufficient to alter the overall conclusion from this analysis.

The analyst observed that despite not considering these non-conservatisms, application of the qualitative considerations still drove the assessment of the finding to White. The estimate would have been a higher value, but would remain White.

Sensitivities

The following sensitivities were run showing the results for various scenarios:

- More optimistic recovery of a chiller: The analyst lowered the failure probability from 2.53E-1 to 1.0E-1. Result: Increase in CDF of 1.2E-5/year

- More optimistic credit for starting a control room fan: The analyst assumed a failure probability of 1.0E-1. Result: Increase in CDF of 6.2E-6/year

- Use of the licensee's value for service water: The analyst assumed a failure probability of 6.32E-2 for service water alignment to main control room air handling units. Result: Increase in CDF of 3.9E-6/year

- Credit for fire risk management actions: The analyst assumed the licensee took adequate risk management actions for fire to warrant no increase in CDF from fire. Result: Increase in CDF of 2.5E-5/year

Large Early Release Frequency (LERF)

To address the contribution to LERF, the analyst used NRC Inspection Manual 0609, Appendix H, "Containment Integrity Significance Determination Process," dated May 6, 2004. Since the dominant sequences were high pressure and station blackout sequences, the analyst used Table 5.2, "Phase 2 Assessment Factors -Type A Findings at Full Power," to select the prescribed LERF factor of 0.2. Applying this factor to the CDF yielded a LERF value of 6.2E-6/year. This LERF estimate was also of substantial safety significance (Yellow). The analyst considered due to the bounding nature of the assessment, LERF results were essentially comparable to the core damage frequency estimate.

Licensee's Results

The licensee provided their analysis of the control building portion of the finding from Attachment 9.9 of Calculation PSA-RBS-08-04, "Risk Evaluation for Divisional Chiller Inoperability," Revision 0. The licensee credited the ability of service water to supply the coils of the air handling units to cool the control building. The licensee's evaluation estimated the increase in CDF as 7.8E-8/year. If service water is assumed to fail, the licensee estimated the increase in CDF, without consideration of external events, as 1.0E-6/year.

The licensee's final estimate of the increase in CDF for the control building credited service water and alternate ventilation and resulted in a negligible change in CDF (less than 1.0E-9/year. The licensee assumed the control room would be unaffected because temperature would never exceed 120˚F. As a result, no change in CDF would occur.

Summary of Model Adjustments

Model Version 8.20 of the River Bend SPAR Model, was used with SAPHIRE Version 8.1.2. Default truncation of 1.0E-11 was used.

Changes to the Heating, Ventilation, and Air Conditioning Fault Trees

The analyst noted that the existing SPAR model contained a simplified fault tree for modeling of Divisions I and II of Heating, Ventilation, and Air Conditioning (HVAC) for the control building. That fault tree appropriately contained dependencies on the functioning of the divisions of HVAC of the chilled water system, the chillers, and the air handler which supplied the vast majority of the rooms in the control building.

After researching the HVAC system more thoroughly, the analyst determined that the fault tree did not reflect all of the dependencies needed to more accurately estimate the change in CDF of the performance deficiency. In particular, the following dependencies were identified:

- HVAC dependency on electrical power
- Chiller dependency on the control room air handling units (1A and 1B) and the chiller equipment room air handling units (3A and 3B)
- Contingency to have service water supply the coils of the air handling units

Change to the Recovery of a Train of HVAC

The analyst reviewed Basic Event EHV-XHE-XL-RECOV, "Operator Fails to Recover Switchgear/Battery Room Ventilation." The analyst performed a SPAR-H such that it would more accurately reflect the situation.

Issues with MasterPact breakers which would have complicated recovery of the chillers were not considered, as this was a separate performance deficiency. The analyst did however, adjust Basic Event EHV-XHE-XL-RECOV, "Operator Fails to Recover Switchgear/Battery Room Ventilation," for recovery of control building air conditioning from its baseline value in the SPAR model of 6.0E-3 after performing a SPAR-H human reliability analysis. This change was applied to both the base and affected cases.

The analyst reviewed the existing basic event for recovery of switchgear room cooling in the River Bend SPAR model. Based on the information gathered during the inspection, the analyst re-performed an analysis of the human factors considerations and quantified a new value for Basic Event EHV-XHE-XL-RECOV, "Operator Fails to Recover Switchgear/Battery Room Ventilation." The analyst used the following inputs into the analysis.

Diagnosis (=1E-2)			
Time Available	Nominal	1	No event information is available to warrant a change in this diagnosis performance shaping factor (PSF) from Nominal.
Stress	High	2	The control room would be heating up quickly and the environment in the control room would be inducing stress which would affect mental performance.
Complexity	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Experience/Training	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Procedures	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Ergonomics	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Fitness For Duty	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Work Processes	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Result = 2E-2 = 1 x 2 x 1 x 1 x 1 x 1 x 1 x 1 x 1E-2			

Action (1E-3)			
Time Available	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Stress	High	2	The control room would be heating up quickly and the environment in the control room would be inducing stress which would affect mental performance.
Complexity	Moderate	2	Restoration of a control building chiller is not a simple one or two step process.
Experience/Training	Low	3	The knowledge of how to reset a MasterPact breaker was not known to the site until December 2014.
Procedures	Incomplete	20	The knowledge of how to reset a MasterPact breaker was not known to the site until December 2014.
Ergonomics	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Fitness For Duty	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Work Processes	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.

PSF = 240 = 1 x 2 x 2 x 3 x 20 x 1 x 1 x 1 Result = 1.94E-1 = 1E-3 x 240 / [(1E-3 x (240 - 1)) + 1]

The use of these performance shaping factors yielded a new basic event value of 2.14E-1 (= 2E-2 + 1.94E-1), which was used in this evaluation. Low dependency was considered on basic event HVAC-SW, “Operators align service water to air handling unit coils.” This dependency was based on the same crew performing each of the actions of the basic events and the actions being in close time proximity to each other. This consideration made the final human error probability value change to 2.53E-1.

Treatment of Chiller Test and Maintenance Events

During the outage times the basic events for the chillers which were out of service were set to Test and Maintenance time. The analyst created new Test and Maintenance Basic Events by applying the SPAR template event for each chiller to model this. Also, the analyst created a post processing rule for the chillers to delete any contributions towards the final CDF quantification which had all four chillers in test and maintenance.

<u>Discussion of Assumptions</u>

1. <u>Affected systems, structures, and components.</u> The licensee did not adequately assess risk for inoperable chillers. Therefore, the control building, the control room, and their contents were exposed to conditions where random plant events and failures would make the plant configuration more safety significant.

2. <u>Exposure Time</u>. The exposure time was determined to be the following for combinations of chillers out of service.

Chillers Which Were Out of Service	Time Chillers Were Out of Service
Chillers 1A, 1B, and 1D	94.33 hours
Chillers 1A, 1C, and 1D	18.13 hours
Chillers 1B and 1D	135.7 hours
Chillers 1A and 1C	343.8 hours

The maximum permissible exposure window allowed by the Risk Assessment Standardization Project (RASP) Manual of one year was used. The exposure time was defined by the time in one year where the inspectors determined the licensee should have assessed the risk associated with reduced cooling capability to the control room. To determine this exposure time the inspectors reviewed historical data in order to determine the worst case safety significance for combinations of times when two and three chillers were out of service. The case used for the determination of the exposure time was the Calendar Year 2014. The out of service times and combinations of two and three chillers out of service are discussed below.

Two Chillers out of service. The analyst tabulated that for Calendar Year 2014 there were 479.5 hours in which two chillers were out of service at the same time. More specifically, Chillers 1B and 1D were out of service for 135.7 hours and Chillers 1A and 1C were out of service for 343.8 hours. The following table lists the individual out of service times used.

Date	Chillers out	Time out (hours)
January 23	B and D	2:47
February 3	A and C	35:10
February 6	A and C	5:46
February 19	B and D	14:51
February 27	B and D	14:22
March 6	A and C	2:50
March 14	B and D	7:55
March 17	B and D	13:53
April 21	B and D	75:07
April 27	B and D	0:23
April 29	B and D	0:01
May 14	B and D	4:17
June 3	A and C	1:02
June 20	B and D	2:07
June 21	A and C	7:55
July 28	A and C	1:11
August 9	A and C	24:09
September 3	A and C	0:57
September 25	A and C	0:06
September 25	A and C	3:08
October 8	A and C	71:50
October 21	A and C	0:01
October 23	A and C	133:04
November 12	A and C	28:14
November 15	A and C	24:22
December 4	A and C	0:03
December 4	A and C	1:38
December 5	A and C	0:41

Three Chillers out of service. The analyst tabulated that for Calendar Year 2014 there were 112.5 hours in which three chillers were out of service at the same time. This broke down further into 94.33 hours when Chillers 1A, 1B, and 1D were out of service, 0.13 hours when Chillers 1B, 1C, and 1D were out of service, and 18.13 hours when Chillers 1A, 1C, and 1D were out of service. The following table lists the individual out of service times used.

Date	Chillers out	Time out (hours)
April 9	A, C, and D	18:08
July 2	B, C, and D	0:08
November 15	A, B, and D	3:20
November 17	A, B, and D	16:15
December 15	A, B, and D	41:29
December 17	A, B, and D	17:32
December 20	A, B, and D	15:44

3. Alternate Ventilation. Alternate ventilation (the practice of opening switchgear room doors and use of portable fans upon a loss of control building cooling) was considered adequate for ensuring the survival of the AC and DC equipment which is normally cooled by the control building chillers.

   The licensee performed Calculation ENTR-078-CALC-001, "Control Building Heat-up Analysis following Loss of HVAC and Simultaneous Loss of Coolant Accident," Revision 0, which demonstrated that opening the doors to the switchgear room doors and the DC equipment room doors four hours into a loss of control building cooling event would help mitigate the temperature rises in those rooms. These rooms house the AC and DC electrical switchgear which supplied power to the major safety equipment. The licensee coupled the room heat-up analyses results with Engineering Report PSA-RBS-08-03, "Control Building Equipment Survivability for PRA," Revision 0. Report PSA-RBS-08-03 reviewed all equipment in the AC and DC equipment rooms and determined each component's maximum operating temperature. The pairing of these two reports demonstrated that the control building equipment would survive a loss of control building cooling event provided the room doors were opened by the four hour point of the event. Procedure AOP-0060, "Loss of Control Building Ventilation," Revision 9, called for completing this action by 30 minutes. The analyst noted that during the March 9, 2015, loss of cooling event operators completed this action in 30 minutes. Using this information and knowledge of the procedure and plant from walkdowns, the analyst used SPAR-H to derive the following performance shaping factor values and final human error probability value for the human error probability.

Diagnosis (=1E-2)			
Time Available	Expansive Time	0.01	Four hours are available to accomplish and only 30 minutes are needed for action. Diagnosis and Action Time combined are much greater than the time required.
Stress	High	2	The control room would be heating up quickly and the environment in the control room would be inducing stress which would affect mental performance.
Complexity	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.

Experience/Training	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Procedures	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Ergonomics	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Fitness For Duty	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Work Processes	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Result = 2E-4 = 0.01 x 2 x 1 x 1 x 1 x 1 x 1 x 1 x 1E-2			

Action (=1E-3)			
Time Available	Expansive Time	0.01	Four hours are available to accomplish and only 30 minutes are needed for action. Diagnosis and Action Time combined are much greater than the time required.
Stress	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Complexity	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Experience/Training	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Procedures	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Ergonomics	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Fitness For Duty	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Work Processes	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Result = 1E-5 = 0.01 x 1 x 1 x 1 x 1 x 1 x 1 x 1 x 1E-3			

No dependencies on other events were noted or applied. The use of these performance shaping factors yielded a new basic event value of 2.1E-4 (= 2E-4 + 1E-5), which was used in this evaluation.

4. Use of Service Water Cooling. The use of service water to supply the cooling water to the coils of the control building air handling units in lieu of chilled water (cooled by the chillers) was considered as a method for ensuring the survival of the AC and DC electrical equipment.

   At the beginning of the special inspection, the licensee made a change to their model to reflect this capability. The guidance was previously incorporated into the procedure and available, but not credited in the licensee's PRA model. The analyst noted that the SPAR model did not initially contain this capability either. The analyst changed the SPAR model to reflect this capability (see the “Summary of Model Adjustments” section).

The licensee credited the use of service water to supply the coils of the air handling units at the one hour point into the loss of ventilation. The analyst questioned the reasonableness of this timing. The analyst questioned the licensee as to why this option was not employed during the March 9 loss of ventilation event. The licensee replied that it was not necessary at the time since building temperatures were not rising quickly. The analyst noted that AOP-0060, “Loss of Control Building Ventilation,” Revision 9, stated in Step 5.1.2:

> *“IF unable to restart available HVK/HVC subsystem per SOP-0066, Plant and Control Building HVAC Chilled Water System Section 4.2, THEN with the concurrence of the OSM/CRS use service water to cool the Control Building chilled water loops per SOP-0066, Plant and Control Building HVAC Chilled Water System Section 5.5.”*

The analyst felt that this “if” statement was worded in a non-direct nature with no reference to time limitations that operators could spend up to this hour or more time before employing the service water contingency. The statement also sought concurrence and did not firmly delineate performance, leaving the analyst to further question the one hour implementation. The analyst noted the decision not to employ this contingency on March 9th and considered that operators would wait until a point where they believed they would need some sort of cooling vice ensuring the assumptions in the analyses were followed.

Seven local valve manipulations and five switch manipulations after shutting down the system. Shutdown involves locking out all chillers, securing all chill water pumps, verifying air handling units stop, and resetting trips on the air handling units. During a walkdown on June 30, 2015, the analyst noted that the assigned operator was generally familiar with the location of the valves, but took some extra time (minutes) to find and be able to point out two of the valves which would be needed to be manipulated. These valves were located in the overhead approximately 10-12 feet from floor level and would require retrieval of a ladder to access the valves.

On August 6, 2015, the licensee performed the step to cool the air handling unit coils with service water for Division I. The acting senior resident inspector observed this evolution. The evolution took approximately one hour to complete. This time was deemed typical for the scope of the task.

Because of the discussions above, the analyst concluded that performance of the lineup within one hour would be challenging to meet the one hour assumption of Calculation G13.18.2.3-426, “Standby Switchgear Room Temperature Sensitivity with Service Water Aligned to the HVK System,” Revision 0, and Calculation ENTR-078-CALC-003, “Main Control Room Heat-up Under Loss of HVAC Conditions for 24 hours,” Revision 0. Exceeding this one hour time would allow the various room temperatures to rise even more. The analyst made a best guess estimate based on the diagnosis and action times of two hours to accomplish the lineup. This extra hour would result in allowing the control room to become approximately 8˚F hotter as determined by temperature plot extrapolation.

Using this information and knowledge of the procedure and plant from walkdowns, the analyst used SPAR-H to derive the following performance shaping factor values and final human error probability value for the human error probability.

Diagnosis (=1E-2)			
Time Available	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Stress	Nominal	1	Left as nominal even though the control room would be heating up quickly and the environment in the control room would be inducing stress which would affect mental performance.
Complexity	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Experience/Training	Low	10	No training was identified. The licensee had never performed this lineup.
Procedures	Available, but poor	5	The procedure did not provide information on the need to quickly employ this contingency. The operators were left to estimating when they would need to employ service water cooling. This would be difficult without knowing the potential stakes of delaying.
Ergonomics	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Fitness For Duty	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Work Processes	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Result = 5E-1 = 1 x 1 x 1 x 10 x 5 x 1 x 1 x 1 x 1E-2			

Action (=1E-3)			
Time Available	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal
Stress	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Complexity	Moderate	2	Numerous valve and switch manipulations were needed to accomplish this evolution.
Experience/Training	Low	3	This contingency had never been used before, nor had it been trained on.
Procedures	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Ergonomics	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.

Fitness For Duty	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Work Processes	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Result = 6E-3 = 1 x 1 x 2 x 3 x 1 x 1 x 1 x 1 x 1E-3			

The use of these performance shaping factors yielded a new basic event value of 5.06E-1 (= 5E-1 + 6E-3), which was used in this evaluation. Low dependency was considered on basic event EHV-XHE-XL-RECOV, "Operator fails to recover switchgear/battery room ventilation"; however, this dependency did not affect the final human error probability value appreciably (modified value = 5.3E-1) and the 5.06E-1 value was used.

5. Starting of a fan in the Control Room. The starting of a fan in the control room would provide relief from the high temperatures. Licensee analyses credited the control room smoke removal fan. On March 9, 2015, the licensee started one of the air handling unit fans without cooling supplied to it. Neither of these actions were delineated in plant procedures as actions to be taken for a loss of control room cooling event. Operators would be left to rely on deducing that starting of a fan would be beneficial and would not produce any adverse effects. For example, use of an air handling unit fan would introduce some outside air which could be hotter and more humid than the environment in the control room. When asked by the inspectors, the licensee did not identify any prior training which had been accomplished for this condition which would help the operators decide to start a control room fan.

Diagnosis (=1E-2)			
Time Available	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Stress	Nominal	1	Left as nominal even though the control room would be heating up quickly and the environment in the control room would be inducing stress which would affect mental performance.
Complexity	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Experience/Training	Low	10	No training or experience was identified.
Procedures	Available, but poor	5	The procedure did not provide information to start a fan in the control room. The operators

			were left to decide to leave an air handling unit running from attempts to start a chiller (with no written guidance).
Ergonomics	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Fitness For Duty	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Work Processes	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Result = 5E-1 = 1 x 1 x 1 x 10 x 5 x 1 x 1 x 1 x 1E-2			

Action (=1E-3)			
Time Available	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal
Stress	High	2	The control room would be heating up quickly and the environment in the control room would be inducing stress which would affect mental performance.
Complexity	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal
Experience/Training	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal
Procedures	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Ergonomics	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Fitness For Duty	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Work Processes	Nominal	1	No event information is available to warrant a change in this diagnosis PSF from Nominal.
Result = 2E-3 = 1 x 2 x 1 x 1 x 1 x 1 x 1 x 1 x 1E-3			

No dependencies on other events were noted or applied. The use of these performance shaping factors yielded a new basic event value of 5.02E-1 (= 5E-1 + 2E-3), which was used in this evaluation.

6. Operating History. The analyst assumed the plant operated at power or at shutdown conditions above those which necessitated operation of the residual heat removal system for decay heat removal. This allowed the analyst to use the at-power SPAR model for the entire exposure time.

Summary/Best Estimate:

The result of the detailed risk evaluation is a preliminary White finding (low to moderate safety significance).

The finding was evaluated using Inspection Manual Chapter 0609, Appendix K, “Maintenance Risk Assessment and Risk Management Significance Determination Process.” The finding was determined to require additional internal NRC management review using risk insights where possible because the quantitative PRA tools were not well suited to analyze failures from control room heat-up events.

The analyst determined the maximum risk deficit by quantitatively estimating the frequency of events which would significantly impact operations in the control room and assuming no successful operator actions to safely shutdown and mitigate the loss of control room cooling event. This method yielded an incremental core damage probability deficit (ICDPD) of 3.1E-5, which was used as an input to Flowchart 1 of Appendix K. Using this value as an input and appropriate assumptions yielded a result of “Yellow Finding” and need to perform a detailed risk evaluation.

The estimate from the detailed risk evaluation quantified the CDF associated with the control room reaching temperatures that would significantly impact operations to be 3.1E-5/year. Application of qualitative considerations led the NRC to conclude that operators would successfully and safely shut down and maintain stable shutdown of the reactor for 67 to 97 percent of these cases despite the adverse effects on equipment and operators. This yielded a result of low to moderate safety significance (White).