Attachment 2
to RBS-47668

Engineering Report No.
RBS-ME-16-00003,
Evaluation of Main Control
Room Realistic Heat Load
Based on Measured Data

Engineering Report No. RBS-ME-16-00003 Rev 0
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Engineering Report Cover Sheet

Engineering Report Title:
Evaluation of Main Control Room Realistic Heat Load Based on Measured Data

Engineering Report Type:

New ☒ Revision ☐ Cancelled ☐ Superseded ☐
Superseded by: ______

Applicable Site(s):

IP1	☐	IP2	☐	IP3	☐	JAF	☐	PNPS	☐	VY	☐	WPO	☐
ANO1	☐	ANO2	☐	ECH	☐	GGNS	☐	RBS	☒	WF3	☐	PLP	☐

EC No. 62957

Report Origin: ☐ Entergy ☒ Vendor
Vendor Document No.: N/A

Quality-Related: ☐ Yes ☒ No

Prepared by:	ENERCON (Ronald Cole, Jerry Parker, Erica Ransom) (See Page 5) Responsible Engineer (Print Name/Sign)	Date:	See Page 5
Design Verified:	Not Required Design Verifier (if required) (Print Name/Sign)	Date:	N/A
Reviewed by:	Paul Sicard (Acceptance Review) (See AS) and MPR (Erin Tindall)(See Page 4) Reviewer (Print Name/Sign)	Date:	See AS and Page 4
Approved by:	Jim Rogers (See AS) Supervisor / Manager (Print Name/Sign)	Date:	See AS

Revision	Record of Revision
000 (EC 62957)	Initial Issue.

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Engineering Report
Technical Review Comments and Resolutions Form

Engineering Report Number	RBS-ME-16-00003	Rev. 000	Title: Evaluation of Main Control Room Realistic Heat Load Based on Measured Data
Quality Related: ☐ Yes ☒ No		**Special Notes or Instructions:**	

Comment Number	Section/ Page No.	Review Comment	Response/Resolution	Preparer's Accept Initials
N/A	N/A	For all comments and resolutions, see P2E Attachments 10.005 and 10.006 in EC 62957.	N/A	N/A

Verified/Reviewed By:		Date		Resolved By:	
Site/Department:		Ph.		Date:	

MPR

March 20, 2016
LTR-2062-1502-06-01

Mr. Paul Sicard
River Bend Station
5485 U.S. Highway 61
St. Francisville, LA 70775

Subject: MPR Associates Independent Review of RBS-ME-16-00003 Revision 0, "Evaluation of Main Control Room Heat-up on Loss of HVAC Based on Empirical Temperature and Flow Data"

Dear Mr. Sicard:

RBS-ME-16-00003, "Evaluation of Main Control Room Heat-up on Loss of HVAC Based on Empirical Temperature and Flow Data" compares the main control room (MCR) design basis heat loads with measured data during MCR normal operation and during a loss of ventilation event.

At the request of Entergy Nuclear, MPR Associates performed a third party review of a draft version of RBS-ME-16-00003 Revision 0 and provided several comments. Our review of the final Revision 0 document confirmed that those comments were incorporated.

We appreciate the opportunity to have assisted Entergy in this review. If we can be of further assistance, please do not hesitate to contact me at 703-519-0243.

Sincerely,

Erin C Tindall

Erin Tindall

ENERCON

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RBS-ME-16-00003, Rev. 0

Preparation, Review, and Approval Signatures

PREPARATION	NAME	SIGNATURE / DATE
Preparer	Ronald E. Cole	Ronald E Cole / 3-19-16
REVIEW	**NAME**	**SIGNATURE / DATE**
Reviewer	Jerry Parker	Ronald E Cole 3-19-16 for Jerry Parker by Telecon
APPROVAL	**NAME**	**SIGNATURE / DATE**
Approver	Erica Ransom	[signature] 3/19/16

1. Table of Contents

2. Revision Summary

Initial Revision

3. Scope and Objective

Background:

On March 9, 2015, during a scheduled refueling outage, RBS experienced a loss of all cooling to the Main Control Room (MCR) during the Division I LOP/LOCA test of STP-309-0601 (Division I ECCS Test). This portion of the STP is designed to trip the running Division 1 safety-related main control building chiller, HVK-CHL1C, on loss of power and demonstrate that it will restart and sequence onto the diesel generator. When the test was performed, the chiller failed to restart and attempts to start the standby chiller on the other division were not immediately successful. The MCR was without recirculation air flow for approximately 52 minutes and without cooling from an operating chiller for approximately 3 hours and 42 minutes.

River Bend Station (RBS) Calculation E-226, "Control Building Electrical Equipment Heat Release", in part, calculates the heat loads in the Main Control Room (MCR) in various scenarios such as Normal Conditions, LOCA, Loss of Offsite Power (LOOP), and various combinations. For all conditions the Normal Condition was found to be the highest heat load, at 112,679 watts per rev 5 of Calculation E-226, dated 4/23/2015, page 15. A spatial distribution of the E-226 heat loads was developed in EC61975, which also included refinements to the heat loads and corrections to account for issues identified in CR-RBS-2015-8967; the corresponding heat load per EC61975 is 105,673 watts. This value was used to develop a GOTHIC Model to calculate the rate of change and maximum temperature for a loss of all cooling under normal steady state conditions. Initial calculations performed using this value, as cited in the NRC Inspection Report, EA-15-140, dated February 16, 2016, uses GOTHIC data runs which were based on design heat loads from E-226 and which have been found on further analysis to be very conservative compared to measured heat loads.

The temperature and the heat-up rate of the MCR during the March 9, 2015 event could not be directly monitored due to the lack of instruments located inside the MCR to measure ambient conditions when there is no HVC air flow. However, a detailed evaluation of the events has determined that the actual temperature rise on the day of the event was much less than what was thought based on the initial data review and much less than what was predicted, assuming design heat loads, by the initial calculations performed in response to this event. Also, two other evaluations have been performed which independently conclude that the actual heat load in the MCR is much lower than design heat loads. This Engineering report summarizes the results of each of these evaluations and provides the basis for the determination that the realistic heat loads in the MCR are much lower than initial calculations performed using the E-226 Rev. 5 design heat load values. As a result this supports the basis for the determination that the time for the MCR to heat up will be much longer and the maximum temperature reached will be lower than the values calculated using the design basis heat loads if there is a loss of all HVAC.

4. Assumptions

None

5. Detailed Discussion

Attachment 1: Summary of evaluation of March 9, 2015 event:

A detailed evaluation was performed of the MCR heat-up rate and maximum temperature obtained during the March 9, 2015 event and is documented in Attachment 1. This was performed by an engineer with many years of Operations and Systems Engineering experience and who was involved with the performance of STP 309-0601, "Division 1 ECCS Test" when the Loss of Power/ LOCA was performed on March 9, 2015. He was inside the MCR at the time of the event. Included is an evaluation of the off-normal HVC flow paths which resulted from the test failure and a review of all available instrumentation, test documentation and design drawings, to develop a timeline and sequence of events. It also includes a review of MCR temperature indicators at various stages of the event and interviews with licensed and non-licensed Operators who were in the MCR the day of the event to obtain input on actions taken to monitor MCR temperature as well as their perceived level of "comfort" on the day of the event.

Based on this evaluation, it was determined that the actual MCR temperature only rose by about 4.9 degrees F during the approximately 52 minutes that there was no cooling and no air flow in the MCR (e.g. no chiller running and no air circulation due to no air handling unit running). Following the start of air handling unit (HVC-ACU1A), temperature stabilized initially and then began to rise slowly by about 2.8 degrees over the next approximately 2 hours and 43 minutes until a chiller was restarted.

The MCR temperature, as indicated by Plant Data System (PDS) computer point HVCTA01, CONT RM EXHAUST, at the time of event initiation (10:47) was 64.5 °F. The MCR temperature only increased about 4.9 degrees in the 52 minutes with no chiller and no circulation (from 65.1 degrees at 10:52 to 70.0 °F at 11:44), and then 2.8 degrees in the 2 hours and 43 minute period with circulation but no chiller (from 69.4 °F at 11:46 when the air handling unit was started to 72.2 °F at 14:29 when the chiller was started.) After HVC-ACU1A was started and air circulation was provided, an overall temperature rise of 7.7 °F in approximately 3 hours and 42 minutes was indicated or an average of about 2.1 °F per hour. Based on this evaluation and with an initial MCR temperature of 64.5 °F, assuming a linear extrapolation, the Tech Spec value of 104 °F for maximum MCR temperature would not have been reached until almost 19 hours into the March 9, 2015 event. During this time, if none of the four chillers could be restarted, which is considered very unlikely, other operator actions would be performed, such as aligning Service Water to provide cooling directly to the HVC system, to stabilize the temperature.

The cause of the inaccurate temperatures recorded by computer point HVCTA01, was determined to be the heated back flow of air from the CRFA system which initiated

automatically as part of the test performance, and remained running throughout the event. This is described further in the next paragraph and Attachment 1 provides a more detailed description and evaluation of the flow paths and the impact on indicated MCR temperatures during the timeline of the event. The CRFA discharge air temperature was measured at 96 °F when it was running for testing on February 3, 2016. The MCR filter train heaters are designed to provide a 19 °F temperature rise under normal design conditions. The outside air temperature at the time of this measurement was approximately 72 °F. On March 9, 2015, the outside air temperature was about 66 °F. Since approximately 50% of the total CRFA flow is drawn from outside and the rest is recirculated from the MCR, this 6 degree difference would not be expected to make more than a few degrees difference in the outlet temperature of the filter train. As noted above, it is important to understand that the CRFA system started on the LOCA signal at the time of the test initiation and remained running throughout the event. In this scenario, the normal MCR suction flow path from outside air is isolated, dampers realign, and HVC-FN1A, Filter Train Booster Fan, starts to force the air flow through the filter train, where it is heated and filtered before discharging into the common suction duct for the MCR air handling units. Since neither HVC-ACU1A or 1B were running and their suction dampers were closed, the available flow paths are to partially recirculate the air back to its suction, some small amount of leakage through closed dampers (which are not designed to be zero leakage per Spec 215.480), or the remainder will be forced to back flow through the MCR return duct discharging into the MCR exhaust plenum area above the false ceiling (where normal MCR suction occurs) or into the Control Building mechanical equipment room. (Reference PID-22-09A and 22-09B) Note that HVC-FN1A flow rate is only about 4,000 CFM compared to normal HVC-ACU1A/B flow rates of 38,500 CFM which is about 10.5% of the normal flow rate. The Main Control Room doors are normally closed except for ingress/ egress, the smoke removal fan was off and isolated and no other flow paths existed other than leakage paths. This further reduced the backflow of heated air through the return duct since only MCR envelope leakage flow could enter the MCR. It should also be noted that the flow rate through the filter train during the March 9, 2015 event was likely significantly reduced because the normal discharge path was isolated and other possible flow paths were isolated or restricted. Therefore, the air temperature from the filter train may have been higher than 96 °F. This temperature supports the conclusion that the value indicated by computer point HVCTA01 of 91.4 °F was indicative of backflow from the filter train and not indicative of actual MCR temperature.

Attachment 2: Determination of MCR Heat Load by Measurement of HVAC Air Flow and Temperature Data:

Based on engineering knowledge of the conservatism in the E-226 Rev. 5 Heat Load calculation and evidenced by the actual measured temperature change during the March 9, 2015 event, it was decided to take air flow and temperature data to measure the worst case actual MCR heat load. This provides information pertinent to establishing realistic heat-up rates if Control Building HVAC is lost. Calculations indicate that the highest heat load occurs for normal conditions with offsite power available. Thus, a decision was made to measure the actual steady state heat load generated in the MCR under normal conditions. The heat load in the MCR is essentially the same during normal at power conditions or during shutdown periods such as existed during the March 9, 2015 event. The MCR

contains mainly the instrumentation and controls used to monitor and operate the plant. There is a significant difference in the systems and components running in the plant itself, and the heat load produced in those buildings, but the instrumentation, controls, and circuitry used to control them are still operating and using effectively the same power.

Attachment 2 to this Engineering Report provides the details of this data taking and evaluation. Existing STP-402-4203, HVC-ACU1A Performance Monitoring, contains steps to measure the flow rate through HVC-ACU1A to the MCR that would occur during design accident conditions. It measures the air flow rate in two locations, and adds them for a total flow rate into the MCR. The first flow measurement is the makeup and pressurization flow rate from the Control Room Fresh Air (CRFA) filter train, in a 24 inch by 24 inch duct, using 5 duct access ports for a 25 point Pitot tube flow traverse. The second flow measurement is the return air leaving the MCR going back to HVC-ACU1A to be cooled, in a 78 inch by 32 inch duct, using 5 duct access ports on each side for a 60 point Pitot tube flow traverse

For purposes of this data taking effort, additional steps were added to the Work Order and performed after the STP was complete. The CRFA system was secured and the suction was realigned to the normal intake path with the MCR Kitchen and Toilet exhaust fans left secured. The duct traverse points for the normal suction path or the CRFA suction line-up are in the same location. (Reference Attachment 9.1 of Attachment 2 to this report for simplified flow path) although the flow rates are lower for the normal suction line-up since the filter train booster fan (HVC-FN1A/B) is secured.

Temperature measurements were made using calibrated M&TE for both the supply and return air to the MCR to calculate the differential temperature across the MCR. The same temperature M&TE device was used for both supply and return temperatures to minimize any errors since only the differential temperature is required for the calculation, not actual temperatures.

Calculation of actual MCR heat load was performed using the equation:

$$Q_{MCR} = \text{density X flow X specific heat capacity X (outlet temperature} - \text{inlet temperature)}$$

The analysis was initially performed for dry air and resulted in a calculated 58,703 watts compared to the value from E-226, Rev. 5 of 112,671 watts or 52.1%. The calculation was also performed using the maximum value for humidity from the Environmental Design Criteria (EDC) for the Main Control Room of 70%. This calculation determined the heat load to be 59,871 watts which is 53.1% or slightly over half of the design basis heat loads.

In addition, an engineering evaluation was performed to further refine the conservative estimates for heat load in the MCR. The results of this evaluation were documented in EC 61975 (Reference 3). The total heat load determined by EC 61975 of 105,673 watts was used in ENERCON calculation ENTR-078-CALC-004. Comparing the heat load determined by testing to the value established per EC 61975:

$$(59{,}871 \text{ W} / 105{,}673 \text{ W}) \times 100 = 56.6\%$$

Steady-state Analysis and Benchmark of River Bend Station Main Control Room GOTHIC model:

Reference 9.4, ENTR-078-CALC-004 uses a GOTHIC model to predict the transient temperature in the MCR during a loss of ventilation using design heat loads. Reference 9.14, MPR Calculation CALC-2062-0005-0001 was developed to benchmark the GOTHIC model used in Reference 9.4 using measured data taken in the MCR during steady state operation. As documented in Reference 9.14, MPR Calculation CALC-2062-0005-0001, measurements were made of the RBS MCR inlet and outlet temperatures as well as ambient temperatures at various locations and elevations inside the MCR. These measurements were made on November 10, 2015 between 14:00 and 17:15. The data was taken during normal plant operation with handheld temperature measurement devices and the system flow rate is assumed based on actual flow measurements made on February 2, 2016 under WO 52509588.

The purpose of this data taking was to provide actual field data for use as an input to a Steady-state GOTHIC model that could then be used to predict average and local temperatures at various locations in the MCR for normal operating conditions. The predicted temperature results from the GOTHIC model were compared with the measured steady state room temperatures. In addition, the MCR heat load was calculated based on measured data and compared with the design basis heat load from Reference 9.3 used by the GOTHIC models.

The conclusion from this report is that the heat load input in the steady-state benchmark case is higher than the actual (measured) heat load during normal operation. In the case of comparison of the data collected under steady state conditions on November 10, 2015, the actual heat load calculated based on measurements is about 64% of the design basis heat load from Reference 9.3 used by the GOTHIC analyses in References 9.4 and 9.14. Additionally, for the case of WO 52509588 data collected on Feb. 3, 2016, the heat load calculated based on measurements is about 57% of the design basis heat load from Reference 9.3 used by the GOTHIC models.

The heat load calculated based on the data taken on November 10, 2015 are expected to be less accurate than the heat loads calculated using the data taken on February 3, 2016 (as part of WO 5259588) because on November 10, 2015 the method of measurement was less controlled and the flow rate was not measured.

6. <u>Operating Experience</u>

CR-RBS-2015-1830, Entered AOP-0060, Loss of Control Building Ventilation, due to HVK-CHL1C failing to re-start after initiation of STP-309-0601, DIVISION I ECCS TEST, and failure to start of HVK-CHL1D and HVK-CHL1B due to a failure of HVC-ACU1B to start. The failure of HVC-ACU1B to start was due to the Masterpact breaker's position switch (52PS) contacts opening due to the breaker tripping open. When this happened, control power was lost to the start circuit and the breaker could not close when given a demand signal. The cause was that the 52PS linkage rod in the Masterpact

breaker cradle was not lengthened enough to ensure solid switch contact was made when the breaker was racked in.

Also, it was found that a Masterpact breaker with a standing close signal could intermittently fail to close, due to the pressure from the anti-pump latch pushing on the close coil plunger causing the rear of the lever to rock up in the back and intermittently catch on the top frame of the mechanism. The main control room was without any forced air flow for approximately 52 minutes and without a running chiller for 3 hours and 42 minutes. Operators took actions per AOP-0060 and subsequently restarted HVK-CHL1C. The details of this event are discussed further in Attachment 10.1 of this report.

7. Summary of Results

As demonstrated by the analysis of data from the March 9, 2015 event contained in Attachment 1 to this report, the actual increase in temperature due to the loss of all Main Control Room cooling was only 7.7 °F in a period of 3 hours and 42 minutes. The MCR temperature increased about 4.9 °F in 52 minutes with no chiller and no circulation (from 65.1 degrees at 10:52 to 70.0 degrees at 11:44), and then 2.8 °F in the 2 hours and 43 minutes with circulation but no chiller (from 69.4 degrees at 11:46 to 72.2 °F at 14:29). This averages to an overall temperature rise of 7.7 °F in approximately 3 hours and 42 minutes, or about 2.1 degrees per hour. Using a value of 2.1 °F per hour and based on an initial temperature of 64.5 degrees, extrapolation indicates it would take almost 19 hours for the Tech Spec maximum MCR temperature of 104 °F to be reached. Using the lower value of about 1 degree per hour (from 69.4 degrees at 11:46 to 72.2 °F at 14:29 or 2.8 degrees in 2 hours and 43 minutes) when the air handling unit was running without the chiller, it would take about 39 hours to reach the Tech Spec maximum value.

As documented in Attachment 2, the analysis of actual field data measurements for MCR inlet and outlet air temperatures and total air flow, determined that the actual MCR heat load is about 53% of the design value calculated in E-226 Rev. 5 (Reference 4.3). This is 56.6% of the updated design value as determined by EC61975. This calculated value was used as an input to a revised GOTHIC Model and the maximum MCR average temperature was calculated to be 113.1 °F at six hours into the postulated event, before assumed operator actions to start MCR cooling using service water or remove ceiling tiles and start the smoke removal fan

As documented in Reference 9.14, the GOTHIC analysis of data taken in the MCR during steady state operations calculates room air temperatures that are generally greater than those measured during normal operating conditions. The heat load in the MCR was calculated based on two sets of measured data: data collected on November 10, 2015 during normal operations and data collected on February 3, 2016 under WO 52509588. The heat load based on these two sets of measured data is significantly lower than the design heat load used by the GOTHIC model in References 9.4 and 9.14.

8. Conclusions and Recommendations

It is concluded from the evaluation of these three data sources, that the actual MCR heat loads are significantly less than the conservative values calculated in E-226 Rev. 5 and refined in EC61975. This is not surprising based on a review of the calculation approach and interviews with experienced engineering personnel as the calculation is intended to be a bounding analysis of heat load for use as an input to MCR HVAC sizing calculations.

The initial review of MCR temperature indications immediately following the March 9, 2015 event, erroneously concluded that computer point HVCTA01 was indicative of actual MCR temperatures during the event. Contributing to this error was the coincidence that the computer point temperature trend was extremely similar to the calculated trend for the MCR temperature response. It was not recognized until further analysis, that the sensor for this computer point (HVC-RTD140) as well as the sensor for HVC-TIS141 (HVC-RTD141) which was used by Operations to attempt to monitor MCR temperature during the event, are located in the HVC Return and Supply ductwork outside of the MCR and are not representative of actual MCR temperature if there is no flow through the system.

An accurate indication of actual MCR temperature is only available during the times that an air handling unit is running, with or without the chiller operating. The higher values of temperature indicated by HVCTA01 during the period when the air handling units were not running, was due to the backflow of heated air being supplied by the Control Room Fresh Air (CRFA) sub-system which supplies air through the filter trains where it is heated and filtered prior to supplying it to the suction of the air handling units. Because the normal flow paths were isolated and no air handling unit was running, the only flow paths for this air were backwards through the normal return duct into the plenum area of the MCR above the false ceiling. Because the flow rates for these fans are only about 10% of normal system flow rates and other leakage paths were also available, the impact of this heated air on actual MCR temperatures were probably very low, but was enough to significantly affect the temperature indicator feeding HVCTA01. The fact that the Main Control Room was isolated further reduced the backflow of this heated air through the Return Duct.

The measurements of actual MCR air flows and temperatures performed under WO 52509588 in conjunction with STP 402-4203 also confirmed that MCR heat loads are much lower than design heat loads from Calculation E-226 Rev. 5. The calculated heat load using a conservative assumption for humidity of 70% determined that the actual heat load is about 53% of the value per E-226 Rev. 5, and 56.6% of that determined in EC61975 which was used in the GOTHIC calculations of MCR temperature.

Finally, steady state temperatures were taken in the MCR in November 2015 and were used as an input to a steady-state GOTHIC model to calculate MCR temperatures. This calculation also concluded that actual MCR heat load is significantly less than the design heat loads.

Discussions with several of the individuals who were in the MCR during the March 9, 2015 event further supports the conclusion that the actual MCR temperature did not change significantly over the course of the event and remained comfortable for Operator performance during this time.

The Operations crew on shift at the time, supplemented by others on site, took appropriate actions including those required by AOP-0060 as well as others based on Operator training and knowledge. Opportunities were identified to enhance the guidance provided by this procedure if there is a loss of MCR cooling. A revision to AOP-0060 has been made to provide this additional guidance.

9. References

9.1 2013 ASHRAE Handbook, *Fundamentals*, Inch-Pound Edition, Atlanta, Georgia

9.2 STP 402-4203 R. 0, HVC-ACU1A (Div. I) Performance Monitoring

9.3 EC 61975, "References for E-226 Calc Revision" developed to address issues identified in the E-226 R. 5 calculation documented in CR-RBS-2015-8967.

9.4 ENTR-078-CALC-004 (RBS-ME-16-0002), "Main Control Room Heat-Up Analysis during Loss of HVAC Conditions for 24 Hours"

9.5 RBS Work Order 52509588

9.6 Mechanical Engineering Reference Manual for the PE Exam, 13th Edition, Michael R. Lindeburg, PE

9.7 INPO ICES Report #316193, "Loss of Control Building Ventilation While Performing Emergency Core Cooling Surveillance Testing"

9.8 PID-22-09A, Rev. 19, Engineering P & I Diagram, System 402, HVAC Control Bldg.

9.9 PID-22-09B, Rev. 14, Engineering P & I Diagram, System 402, HVAC Control Bldg.

9.10 Calculation Number E-226, Rev. 005, Control Building Electrical Equipment Heat Release During LOCA Condition with Offsite Power Available and also Control Building Electrical Equipment Heat Release During LOCA Condition Without Offsite Power (LOOP) and with Diesel Generator EGS-EG1B Not Responding

9.11 Drawing No. EB-039D, Rev. 9, Ventilation & Air Conditioning Plan, El. 135'-0" Control Building

9.12 FSK-22-9A, Rev. 19, Flow Diagram, Control Building Air Conditioning

9.13 FSK-22-9B, Rev. 12, Flow Diagram, Control Building Air Conditioning

9.14 RBS-ME-1600004, Rev. 0, Steady-state Analysis and Benchmark of River Bend Station Main Control Room GOTHIC Model (MPR Calculation CALC-2062-0005-0001)

9.15 Specification No. 215.480, Specification for Air Dampers, Safety-Related

10. Attachments

10.1 Evaluation of March 9, 2015 Loss of MCR HVAC Event and Analysis of MCR Temperature over the Course of the Event

10.2 Determination of Main Control Room Heat Load by Measurement of HVAC Air Flow and Temperature Data

Evaluation of March 9, 2015 Loss of MCR HVAC Event and Analysis of MCR Temperature Over the Course of the Event

Executive Summary:

A discussion is presented herein on what occurred during the AOP-0060 entry (Loss of Control Building HVAC) in the Main Control Room (MCR) on March 9, 2015. This event is documented in CR-RBS-2015-1829 and CR-RBS-2015-1830.

- The initial temperature rise indicated by HVCTA01 on 3/9/2015 was due to backflow from the Control Room Fresh Air (CRFA) system which was started at the time of test initiation on the LOP/ LOCA signal. This is heated backflow due to the 23KW heater in the CRFA filter train and is much lower flow rate (4,000 CFM vs. 38,200 CFM for the air handling units).
- The temperature sensor (HVC-RTD140) for Plant Data System (PDS) computer point, HVCTA01, for MCR temperature indication is located in the MCR HVC return air duct outside of the MCR. When there is no circulating air flow due to HVC-ACU1A (B) not in operation, this indication is not representative of actual MCR temperature.
- Manual start of HVC-ACU1A at about 52 minutes into the event provided effective MCR temperature control by mixing MCR air with air in the duct work through the air handling unit, with no chiller running, and restored proper indication of HVCTA01 to measure accurate MCR temperatures.
- Review of the sequence of events and actual temperature changes during this event concludes that the actual MCR temperature increase was about 7.7 degrees F, which is less than 1/3 of the calculated temperature rise, based on the conservative design information for MCR equipment heat loads assuming no cooling in the MCR.

Purpose and Event Summary:

The purpose of this paper is to explain the sequence of the pertinent events during the loss of HVC/HVK which occurred during the Division I LOP/LOCA test of STP-309-0601 ("Division I ECCS Test") on 3/9/15, and to describe the reasons for the response of the available temperature indicators including the PDS computer point data for HVCTA01, Control Room Exhaust Temperature. A detailed timeline is included at the end of the discussion.

Before the event started, PDS computer point HVCTA01, Control Room Exhaust Temperature, indicated 64.5 degrees. Initiation of the Division I LOP/LOCA test of STP-309-0601 started CRFA and cycled the MCR cooling to isolate the Kitchen Exhaust Fan and Toilet Exhaust Fan as part of simulating a LOCA and Loss of Power (LOP) event. However, HVK-CHL1C failed to restart. HVC-ACU1A sequenced on properly, however it tripped at about 10:52 due to its interlocks with the chiller. At the time the chiller tripped, MCR temperature indicated on HVCTA01 was about 65.1 degrees. Subsequent failures in HVC/HVK caused entry into AOP-0060, Loss of Control Room Cooling. After HVC-ACU1A was manually started and temperature stabilized at about 11:44, indicated temperature on HVCTA01 was 70.0 degrees. This is only a 4.9 degree rise in about 52 minutes. Subsequently HVCTA01 temperature slowly rose from 69.4 degrees at 11:46 to 72.2 degrees at 14:29 when the chiller started. This is indicative of a slow temperature rise in the MCR of 2.8 degrees over a period of 2 hours and 43 minutes. During this time some heat gain from CRFA running and some heat loss through the airflow in the ductwork is anticipated but this change in temperature is indicative of the realistic magnitude of the MCR temperature rise from the heat load with HVC-ACU1A running with no chilled water supply. This small temperature rise is indicative of the actual temperature increase in the MCR over the course of the event as also recalled by Operators who were in the MCR during the event. This is also indicative of the actual lower heat loads in the MCR compared to the conservative design basis calculation values.

Detailed Discussion and Analysis:

All times given are from the RBS Plant Data System (PDS) computer times unless noted otherwise. The LOP/LOCA test of STP-309-0601 was initiated at 10:47 on 3/9/15. By 10:48, the isolation valve for Control Room Fresh Air (CRFA), HVC-MOV1A, (as confirmed by review of sign-offs in the STP 309-0601 procedure copy in use at the time of the event) had closed as part of its initiation from the LOCA signal. Closing HVC-MOV1A isolates the normal HVC suction path and is designed to prevent HVC-ACU1A/B from pulling outside air directly. In addition to the isolation of normal supply air, the CRFA fan (HVC-FN1A for Division 1) starts and dampers realign to force MCR intake suction through the filter trains where it is filtered and heated via the 23KW heater in each filter train. Note that HVC-FN1A/B, also known as the Filter Train Booster Fans or Charcoal Filter Train Fans, are relatively small compared to the HVC-ACU1A/B fans. HVC-FN1A/B are rated for 4,000 CFM compared to 38,200 CFM for the HVC-ACU1A/B fans or about 10.5% of the Air Handling Unit flow rates. CRFA continued to run in this mode and was not secured until approximately 15:01 based on MCR logs. HVC-ACU1A and HVK chiller C also tripped on the load shed signal from the test at the same time and attempted to load sequence back on. HVC-ACU1A started at 10:48, but tripped again at 10:51 because of its interlock with the HVK-CHL1C chiller which failed to start.

Note that initiation of the LOP/LOCA test of STP-309-0601 isolates three other smaller flow paths from the MCR. These are HVC-AOD51A, CR TOILET DN STREAM ISOL,

HVC-AOD52A, CR KITCHEN DN STREAM ISOL, and HVC-AOD108, SMOKE REMOVAL FAN SUCTION. These were verified to have occurred properly in Attachment 8 of STP-309-0601 on the day of the event.

Operations attempted to swap to Div. 2 HVK/HVC, but HVC-ACU1B failed to start. They then attempted to start Div. 1 again. HVC-ACU1A started at 11:04 and ran for approximately 3 minutes, but tripped off again when the chiller failed to start. At 11:39, HVC-ACU1A was started manually by Operations at the MCR control boards, without a chiller running and it ran for the duration of the event. Note that manually starting the air handling unit with the pushbuttons from the MCR panel bypasses the chiller interlocks and allows the air handling unit to run without the chiller. The chiller, HVK-CHL1C, was returned to service at 14:29. During this time, the air handling unit was recirculating the air in the MCR without any cooling until the chiller was started.

During the majority of the first approximately 52 minute period of this event (e.g. other than the 3-4 minutes the HVC-ACU1A ran during attempts to restart a chiller), CRFA (e.g. HVC-FN1A, Filter Train Booster Fan) was running with no forced ventilation flow for the MCR. Review of the system logic and P&IDs, allows an evaluation of what would happen in this scenario. CRFA is designed to work in conjunction with HVC-ACU1A/B. The CRFA system, when in operation, takes approximately 2000 cfm of outside air, mixes it with 2000 cfm of recirculating air returning from the MCR, then heats it, filters it, and discharges it into the common suction duct for HVC-ACU1A/B. (Reference PID-22-9A and PID-22-9B) If HVC-ACU1A/B are both off then their suction dampers (HVC-AOD8A/B) are closed, isolating the flow path to the MCR. If the CRFA isolation damper HVC-MOV1A is also closed, which it was, then the only flow-path for the air is through HVC-AOD106/148 and to attempt to go through the normal exhaust line in a reverse flow path into the MCR or into the mechanical equipment room. This is also the same line where, during normal line-up, the system would be drawing 2000CFM from the MCR return via HVC-AOD171/ 172 for recirculation. Therefore, the system would be attempting to discharge 4000 cfm up the Control Room Exhaust line while also attempting to draw 2000 cfm from the same line, resulting in recirculation of its discharge back to its suction. Flow could also try to go through the Smoke Removal Fan discharge flow path, but recall that this path was also isolated by closure of HVC-AOD108 as part of the test. Some leakage would be expected through each of the closed dampers since these are not leak tight devices, however, there is no way to quantify this. Also, it is not possible to quantify the exact resultant flow rates in each path, but due to isolation of the other flow paths, it would most likely result in some heated air going in the reverse path up the Control Room Exhaust line (e.g. back-flowing to the Main Control Room through the HVAC return ducting). The fact that the Main Control Room was isolated further reduced the backflow of this heated air through the return duct since only MCR equivalent envelope leakage flow could go into the MCR.

As noted previously, the sensing RTD for computer point HVCTA01, HVC-RTD140, is physically located in the Control Room Exhaust line immediately upstream of the HVC-AOD106/148 dampers. The RTD is located in the Return Air duct several feet below

the Main Control Room floor, in the HVAC Equipment Room. In this scenario with CRFA running and HVC-ACU1A/B off, any flow past HVC-RTD140 would be outside air heated by the CRFA charcoal filter train heaters. It could not be flow from the MCR and could not be representative of MCR air temperatures. However, when HVC-ACU1A is running it will pull MCR air through the MCR HVC Exhaust line, reversing the flow to the normal flow path, past HVC-RTD140, and mix it with the discharge from CRFA, and discharge it back into the MCR through the normal Supply Line. When the chiller is running it will cool the air before returning it to the MCR. If the chiller is not running it will recirculate air across whatever cool water is still in the air handling unit heat exchanger, which would likely provide some amount of cooling for a short time period.

Note that the operations crew had been briefed and was prepared to go to the Control Building chiller room to align Service Water to provide cooling to HVC-ACU1A when Operations management stopped this action since MCR temperature control had been successfully established, thus this cross-tie was no longer needed for MCR cooling and contamination of the HVK Chilled Water system chemistry could be avoided.

Once HVC-ACU1A was off with CRFA on, HVCTA01 indicated temperature rose very quickly. (Refer to the first attached PDS trace below). Indicated temperature went from 64.5 degrees before the test to 91.4 degrees, at 11:23, an increase of 26.9 degree in approximately 36 minutes. But note that during this same time window, from 11:04 to 11:07 when HVC-ACU1A was running briefly during the attempted Div 1 start, HVCTA01 indicated temperature dropped from 85 to 73 degrees in less than three minutes. These indications are not indicative of real temperature changes in the MCR, but represents the decrease seen in the return duct temperature as cooler air from the MCR entered the duct and mixed with and cooled the hot air in the duct. 85 degrees was not indicative of the MCR temperature, but once flow was established, the temperature indicated by HVCTA01 would trend down toward a temperature representative of the temperature in the MCR. Twelve degrees of MCR temperature drop in three minutes without a chiller running, is not reasonable, and therefore this data is not representative of MCR temperatures. For comparison refer to the second PDS trace at 14:30 when Chiller C was started. At that time it took 30 minutes for the temperature to drop 2.8 degrees, from 72.2 to 69.4 degrees. This is representative of cooling down the entire Main Control Room with a chiller, and is reasonable. Note that start of a HVC-ACU unit even without a chiller running would provide some cooling for the MCR as MCR air is mixed and air flow through the duct work and the HVC-ACU coils would be cooled somewhat by the quiescent chilled water in the HVC-ACU unit.

It should also be noted from the first attached PDS trace, that the temperature dropped from the peak indicated temperature of 91.4 degrees at 11:23 to 76.5 degrees, at 11:39, a difference of 14.9 degrees in 16 minutes without HVC-ACU1A running. HVC-ACU1A was started at 11:39. There was no forced air to the MCR except perhaps some hotter CRFA back-flow, during this temperature drop. This is not indicative of MCR temperature, but is indicative of what may have been occurring in the HVAC duct in this situation. This temperature drop is likely due to the CRFA internal heater cycling off and is not indicative of actual MCR temperature. The CRFA heater, HVC-FLT3AH, can

cycle automatically on the air temperature at the heater as sensed by temperature switch HVC-TS30A, as long as there is flow through the unit. The nominal setpoint is 200 degrees F per SPDS HVC*TS30A. When the temperature switch trips it turns the heater elements off, and when it resets it turns the heater elements back on. (Reference schematic drawing 0225.220-115-021 and VTD N431-0101). The CRFA discharge air temperature was measured at 96 degrees F when it was running for testing on February 3, 2016. The outside air temperature at the time of this measurement was approximately 72 degrees. On March 9, 2015, the outside air temperature was about 66 degrees. Since approximately 50% of the total CRFA flow is drawn from outside and the rest is recirculated from the MCR, this 6 degree difference would not be expected to make more than a few degrees difference in the outlet temperature of the filter train. This temperature supports the conclusion that the value indicated by computer point HVCTA01 of 91.4 degrees was indicative of backflow from the heater train and not indicative of actual MCR temperature.

Note that temperature data from HVCTA01 is used for this analysis because it is the only MCR temperature indicator which is recorded and available for use after the event. During the event, Operations made attempts to monitor MCR temperature using HVC-TIS141 located in the rear of the MCR. The RTD feeding this indicator is located in the supply duct to the MCR and, similar to HVCTA01, is not indicative of actual MCR temperature when there is no forced air flow through the duct. This temperature indicator does not feed a computer point and values were not recorded by the MCR crew and the crew did not recognize this limitation at the time. Again, these readings would not have been indicative of actual MCR temperature and based on discussions with several operators on shift at the time of the event and others in the MCR (including the Engineer who was the Test Director for the ECCS test and developed this evaluation), all noted that the actual change in MCR temperature seemed fairly low and conditions were not uncomfortable. This was consistent with Operator reports from other parts of the Control Building which was also impacted by the loss of the HVK chiller.

The total Main Control Room volume in the GOTHIC heat up calculations (e.g., ENTR-078-CALC-003) is 170,566 ft3, consisting of 87417 ft3 in the lower volume below the false ceiling and 83,149 ft3 above the false ceiling. At the 37000 CFM design air flow rate of HVC-ACU1A (B), the time to turnover this total volume is 4.6 minutes. This indicates that the HVC-ACU1A (B) units would be capable of quickly establishing an equilibrium temperature in the MCR when they are started after a loss of ventilation heat up transient.

The calculated temperature above the MCR ceiling is calculated to be less than below the ceiling, where most of the heat loads are located. Using an in process version of the heat up calculation, bulk temperature above the ceiling at 30 minutes into a loss of HVC/HVK event was 87.6F compared to a bulk temperature below the ceiling of 104.8oF. When HVC-ACU1A (B) are started, the initially cooler air would be seen at the temperature sensor before air drawn from the MCR lower volume would be seen at the instrument.

Under a loss of MCR ventilation scenario as of 3/9/2015, operator actions to provide Main Control Room cooling by aligning Service Water (SWP) to the Control Building Chilled Water system (HVK) piping, per AOP-0060, would have been accomplished if needed and would have been highly effective.

During the March 9, 2015, loss of control building cooling event during Refueling Outage 18, Operations briefed aligning Service Water (SWP) to Control Building Chilled Water (HVK) system piping to provide cooling for the Control Building HVAC (HVC) system in accordance with procedure AOP-0060, "Loss of Control Building Ventilation." This was done shortly after Operations had manually initiated operation of a Main Control Room (MCR) Air Conditioning Unit, which resulted in successful MCR temperature control. The operations crew had been briefed and were ready to go to the Control Room chiller room to perform the realignment when Operations Management stopped this action since MCR temperature control had already been successfully established, thus this cross-tie was no longer needed for MCR cooling and contamination of Chilled Water system chemistry would be avoided.

AOP-0060 revision 9, effective June 17, 2014, contained instructions for mitigating a Loss of MCR cooling. Step 5.1.1 provides instructions for restoring the HVC and HVK systems. Step 5.1.2, the second step in the procedure, called for consideration of the SWP-HVK cross-tie.

Conclusion:

In conclusion, the HVCTA01 indicated temperatures from HVC-RTD140 when HVC-ACU1A was not running, are not indicative of actual MCR temperature. They are duct temperatures affected primarily by back flow from CRFA heated air, as well as temperature loss or cooling from the duct itself, or perhaps other factors such as leakage by closed dampers, but not indicative of MCR temperature. This would be indicative of backflow which is being directed to what is the normal return path for MCR air, via the upper plenum of the main control room, above the false ceiling. However, when HVC-ACU1A is running, the HVCTA01 indicated temperature from HVC-RTD140 will stabilize quickly (within a few minutes) and be representative of the average MCR temperature which is the physical sum of the mixture of all the air being pulled from the MCR.

Before the event, HVCTA01 indicated 64.5 degrees. HVC-ACU1A started and ran for three minutes and tripped. Indicated temperature after the trip was 65.1 degrees and began to rise at 10:52 After HVC-ACU1A was re-started with no chiller, and temperature stabilized, HVCTA01 indicated 70.0 degrees at 11:44. This is only a 4.9 degree F rise in about 52 minutes. From the second PDS trace HVCTA01 temperature slowly rose from 69.4 degrees at 11:46 to 72.2 degrees at 14:29 when the chiller started. This is indicative of the slow temperature rise in the MCR of 2.8 degrees over the approximately 2 hours and 43 minutes when the air handling unit was running with no

chiller running or approximately 1 degree per hour. During this time some heat gain would be expected due to main control room heat loads and due to CRFA running and some heat loss through the airflow in the ductwork.

The temperature rise demonstrated by review of 3/9/2015 data is significantly less than the temperature increase predicted by using design heat loads and the GOTHIC room heat up models and is representative of the realistic magnitude of the temperature rise in the MCR with HVC-ACU1A running without a chilled water supply over the course of the event, and indicative of the much lower values of actual heat load in the MCR compared to the conservative design values.

Timeline:

10:47 LOP/LOCA test of STP-309-0601 was initiated. HVCTA01 from HVC-RTD140 indicating 64.5 degrees before the test

10:47 HVC-ACU1A and HVK chiller C load shed off from the LOP signal

10:47 Control Room Fresh Air (CRFA) initiation from the LOCA signal

10:48 HVC-MOV1A, isolation valve for CRFA closed as part of initiation

10:48-10:51 HVC-ACU1A load sequences on, but tripped off again due to an interlock when the chiller failed to start.

10:52 Indicated temperature at HVCTA01 from HVC-RTD140 begins to rise rapidly. CRFA was running with no forced CR ventilation flow path. CRFA is taking outside air, heating it, filtering it, and discharging it into the common suction duct for HVC-ACU1A/B. With HVC-ACU1A/B off, their suction dampers closed, and HVC-MOV1A closed, then the air is forced through HVC-AOD106/148 and attempts to go in a reverse flow path into the MCR or mechanical equipment room. This passes through the duct by HVC-RTD140, so HVCTA01 rises accordingly.

10:55-10:57 Operations attempted to swap to Div. 2 HVK/HVC, but HVC-ACU1B failed to start.

11:04-11:07 Operations attempted to start Div. 1 HVK/HVC again. HVC-ACU1A started, but tripped off again on interlock when the chiller failed to start.

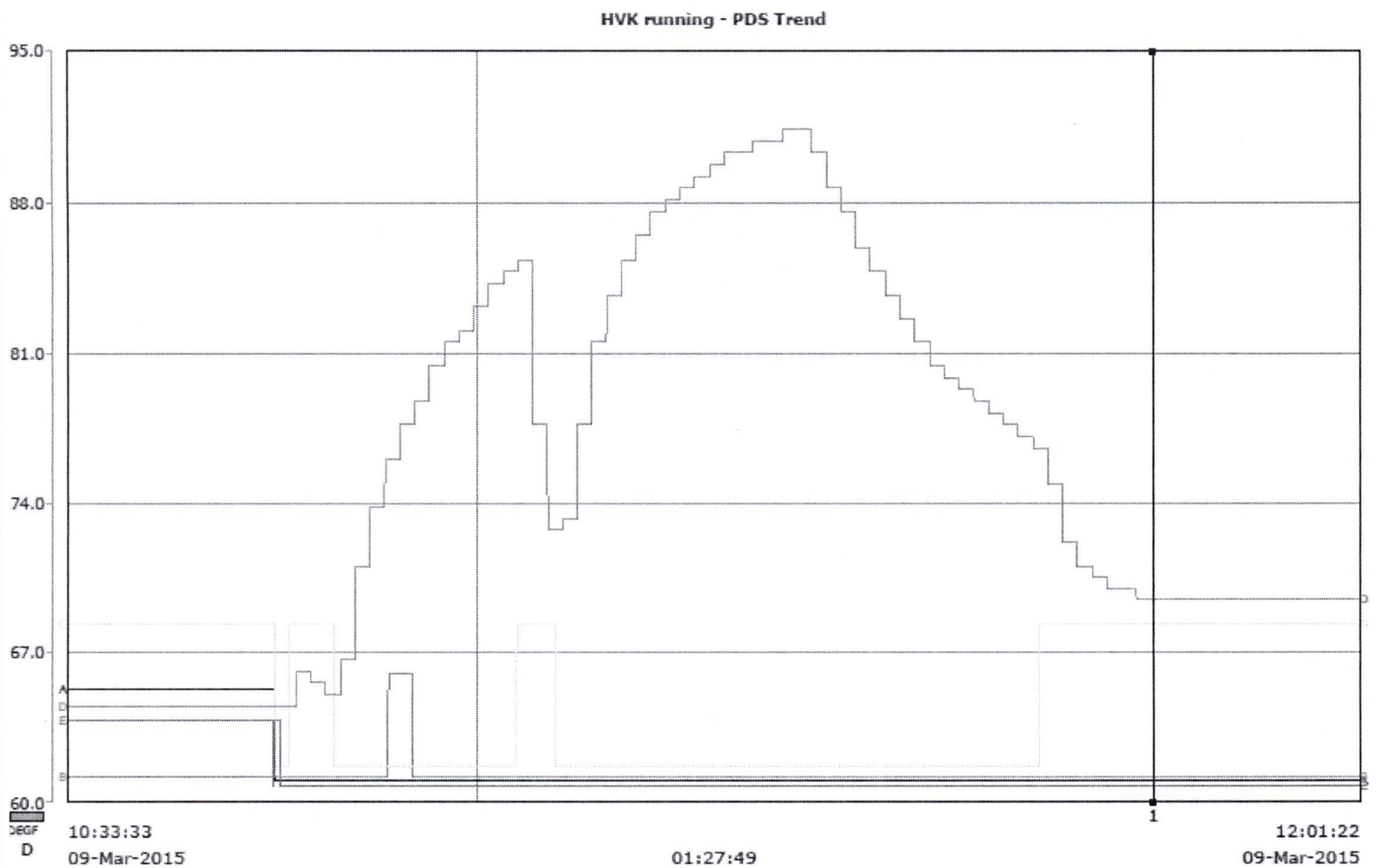
11:05-11:08 While HVC-ACU1A was running, it reversed the air flow past HVC-RTD140 to the normal flow path from the MCR, so that HVCTA01 temperature indication drops sharply back toward the actual MCR temperature.

11:08	HVC-ACU1A is off, so the CRFA flow is again forced backwards through the duct past HVC-RTD140, so HVCTA01 rises again accordingly.
11:23	Indicated temperature at HVCTA01 reaches a peak of 91.4 degrees and begins to drop rapidly. There is still no forced CR ventilation flow path and no cooling. Temperature drop was likely due to the CRFA internal heater cycling off. There is no computer point or recorded indication of heater cycles.
11:39	Indicated temperature at HVCTA01 has dropped to 76.5 degrees. Indicated temperature dropped 14.9 degrees in 16 minutes with no cooling. Not indicative of real MCR temperature.
11:39	Operations started HVC-ACU1A without a chiller and it ran for the duration of the event, but it ran with no chiller until 14:29.
11:40	Indicated temperature at HVCTA01 has dropped to 74.9 degrees.
11:41	Indicated temperature at HVCTA01 has dropped to 72.2 degrees.
11:44	Indicated temperature at HVCTA01 has dropped to 70.0 degrees.
11:46	Indicated temperature at HVCTA01 has stabilized at 69.4 degrees due to the forward flow of MCR exhaust air through the duct.
11:46-14:29	Indicated temperature at HVCTA01 slowly trends up from 69.4 degrees to 72.2 degrees due to a combination of MCR heat load, heat added by CRFA, and heat losses to the environment. HVC-ACU1A continues to run with no chiller. This is a rise of 2.8 degrees in approx. 2 hours and 43 minutes.
14:29	Chiller HVK-CHL1C is started to provide cooling to the MCR.
14:29-15:01	Indicated temperature at HVCTA01 drops from 72.2 degrees to 69.4 degrees with proper cooling of the MCR. This is 2.8 degrees in 32 minutes.
15:01	CRFA is secured after the completion of the LOP/LOCA test of STP-309-0601
16:20	Indicated temperature at HVCTA01 continues to drop slowly and reaches 66.7 degrees.
18:45	Indicated temperature at HVCTA01 continues to drop slowly and reaches 65.6 degrees.

PDS Trend Data, Control Room Exhaust Temp (3/9/2015)
(from Masterpact Breaker Risk Summary provided to NRC, March 2015;
WT-WTRBS-2015-0171)

Date/Time HVCTA01		
3/9/2015 7:30 64.5	3/9/2015 11:11 83.7	3/9/2015 11:36 78.2
3/9/2015 10:49 64.5	3/9/2015 11:11 85.4	3/9/2015 11:37 78.2
3/9/2015 10:49 66.2	3/9/2015 11:12 85.4	3/9/2015 11:37 77.7
3/9/2015 10:50 66.2	3/9/2015 11:12 86.5	3/9/2015 11:38 77.7
3/9/2015 10:50 65.6	3/9/2015 11:13 86.5	3/9/2015 11:38 77.1
3/9/2015 10:51 65.6	3/9/2015 11:13 87.6	3/9/2015 11:39 77.1
3/9/2015 10:51 65.1	3/9/2015 11:14 87.6	3/9/2015 11:39 76.6
3/9/2015 10:52 65.1	3/9/2015 11:14 88.1	3/9/2015 11:40 76.6
3/9/2015 10:52 66.7	3/9/2015 11:15 88.1	3/9/2015 11:40 74.9
3/9/2015 10:53 66.7	3/9/2015 11:15 88.7	3/9/2015 11:41 74.9
3/9/2015 10:53 71.1	3/9/2015 11:16 88.7	3/9/2015 11:41 72.2
3/9/2015 10:54 71.1	3/9/2015 11:16 89.2	3/9/2015 11:42 72.2
3/9/2015 10:54 73.8	3/9/2015 11:17 89.2	3/9/2015 11:42 71.1
3/9/2015 10:55 73.8	3/9/2015 11:17 89.8	3/9/2015 11:43 71.1
3/9/2015 10:55 76	3/9/2015 11:18 89.8	3/9/2015 11:43 70.5
3/9/2015 10:56 76	3/9/2015 11:18 90.3	3/9/2015 11:44 70.5
3/9/2015 10:56 77.7	3/9/2015 11:20 90.3	3/9/2015 11:44 70
3/9/2015 10:57 77.7	3/9/2015 11:20 90.9	3/9/2015 11:46 70
3/9/2015 10:57 78.8	3/9/2015 11:22 90.9	3/9/2015 11:46 69.4
3/9/2015 10:58 78.8	3/9/2015 11:22 91.4	3/9/2015 12:19 69.4
3/9/2015 10:58 80.4	3/9/2015 11:24 91.4	3/9/2015 12:19 70
3/9/2015 10:59 80.4	3/9/2015 11:24 90.3	3/9/2015 12:40 70

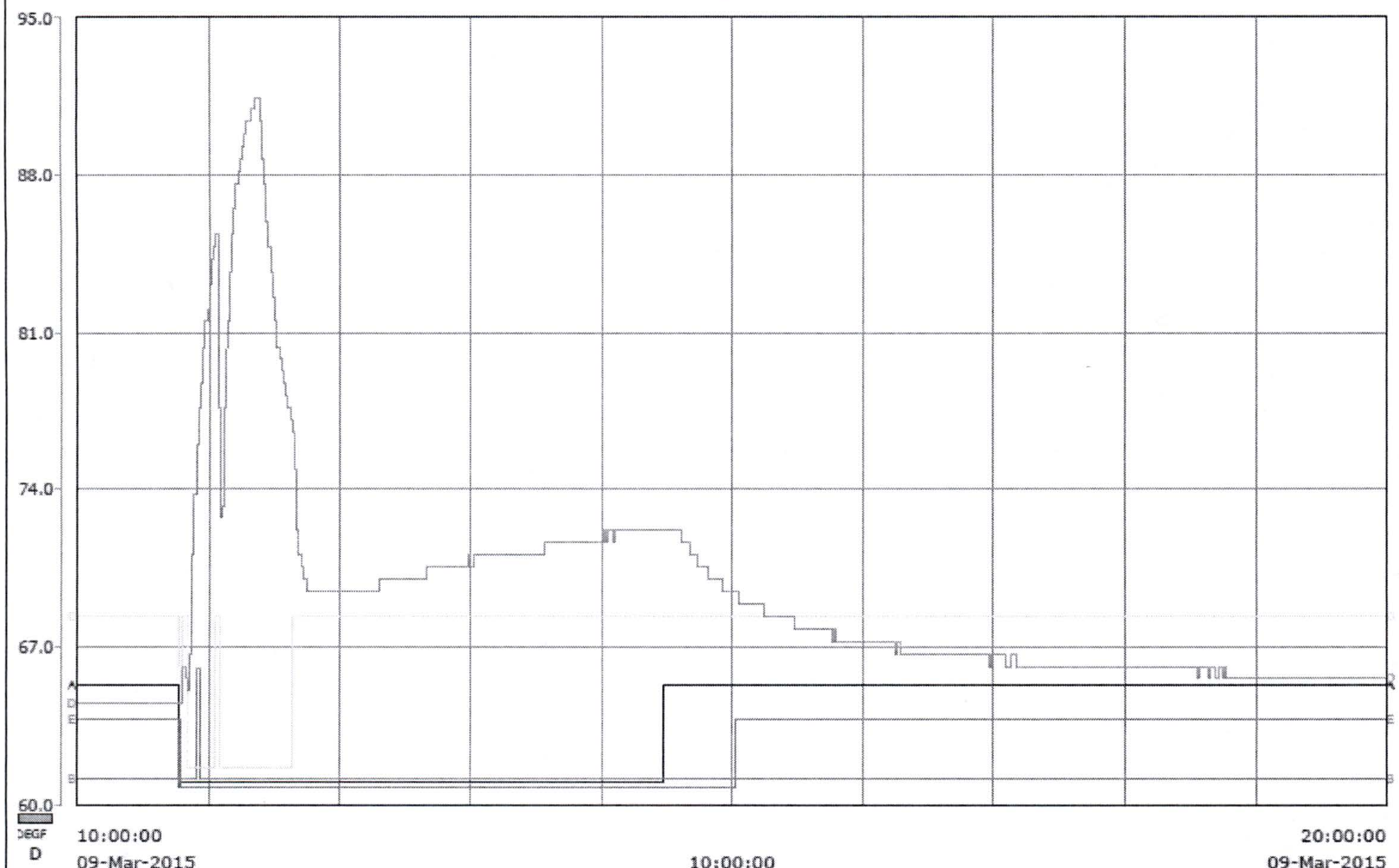
3/9/2015 10:59 81.5	3/9/2015 11:25 90.3	3/9/2015 12:40 70.5
3/9/2015 11:00 81.5	3/9/2015 11:25 88.7	3/9/2015 12:59 70.5
3/9/2015 11:00 82.1	3/9/2015 11:26 88.7	3/9/2015 12:59 71.1
3/9/2015 11:01 82.1	3/9/2015 11:26 87.6	3/9/2015 13:00 71.1
3/9/2015 11:01 83.2	3/9/2015 11:27 87.6	3/9/2015 13:00 70.5
3/9/2015 11:02 83.2	3/9/2015 11:27 85.9	3/9/2015 13:02 70.5
3/9/2015 11:02 84.3	3/9/2015 11:28 85.9	3/9/2015 13:02 71.1
3/9/2015 11:03 84.3	3/9/2015 11:28 84.8	3/9/2015 13:34 71.1
3/9/2015 11:03 84.8	3/9/2015 11:29 84.8	3/9/2015 13:34 71.6
3/9/2015 11:04 84.8	3/9/2015 11:29 83.7	3/9/2015 14:01 71.6
3/9/2015 11:04 85.4	3/9/2015 11:30 83.7	3/9/2015 14:01 72.2
3/9/2015 11:05 85.4	3/9/2015 11:30 82.6	3/9/2015 14:02 72.2
3/9/2015 11:05 77.7	3/9/2015 11:31 82.6	3/9/2015 14:02 71.6
3/9/2015 11:06 77.7	3/9/2015 11:31 81.5	3/9/2015 14:03 71.6
3/9/2015 11:06 72.7	3/9/2015 11:32 81.5	3/9/2015 14:03 72.2
3/9/2015 11:07 72.7	3/9/2015 11:32 80.4	3/9/2015 14:05 72.2
3/9/2015 11:07 73.3	3/9/2015 11:33 80.4	3/9/2015 14:05 71.6
3/9/2015 11:08 73.3	3/9/2015 11:33 79.9	3/9/2015 14:06 71.6
3/9/2015 11:08 77.7	3/9/2015 11:34 79.9	3/9/2015 14:06 72.2
3/9/2015 11:09 77.7	3/9/2015 11:34 79.3	3/9/2015 14:37 72.2
3/9/2015 11:09 81.5	3/9/2015 11:35 79.3	3/9/2015 14:37 71.6
3/9/2015 11:10 81.5	3/9/2015 11:35 78.8	
3/9/2015 11:10 83.7	3/9/2015 11:36 78.8	



Printed by: RBS-DDXS2ZV1\jparke9 Historical Printed: 11-Nov-2015 14:14:08

	Point ID	Description	E Units	Cursor 1 09-Mar-2015 11:47:16.386		09-Mar-2015 11:47:19.276	Retrieval Method
A	HVKBC07	CHILL WTR CPRSR 1C		0.00	0.00	QNA	LTA Event
B	HVKBC08	CHILL WTR CPRSR 1D		0.00	0.00	QNA	LTA Event
C	HVCBC13	CONT RM ACU 1A		0.00	0.00	QNA	LTA Event
D	HVCTA01	CONT RM EXHAUST	DEGF	69.4	69.4	QNA	LTA Event
E	HVCBX003	CONTROL RM AC UNIT ISOL MOV-1A		0.00	0.00	QNA	LTA Event

HVK running - PDS Trend



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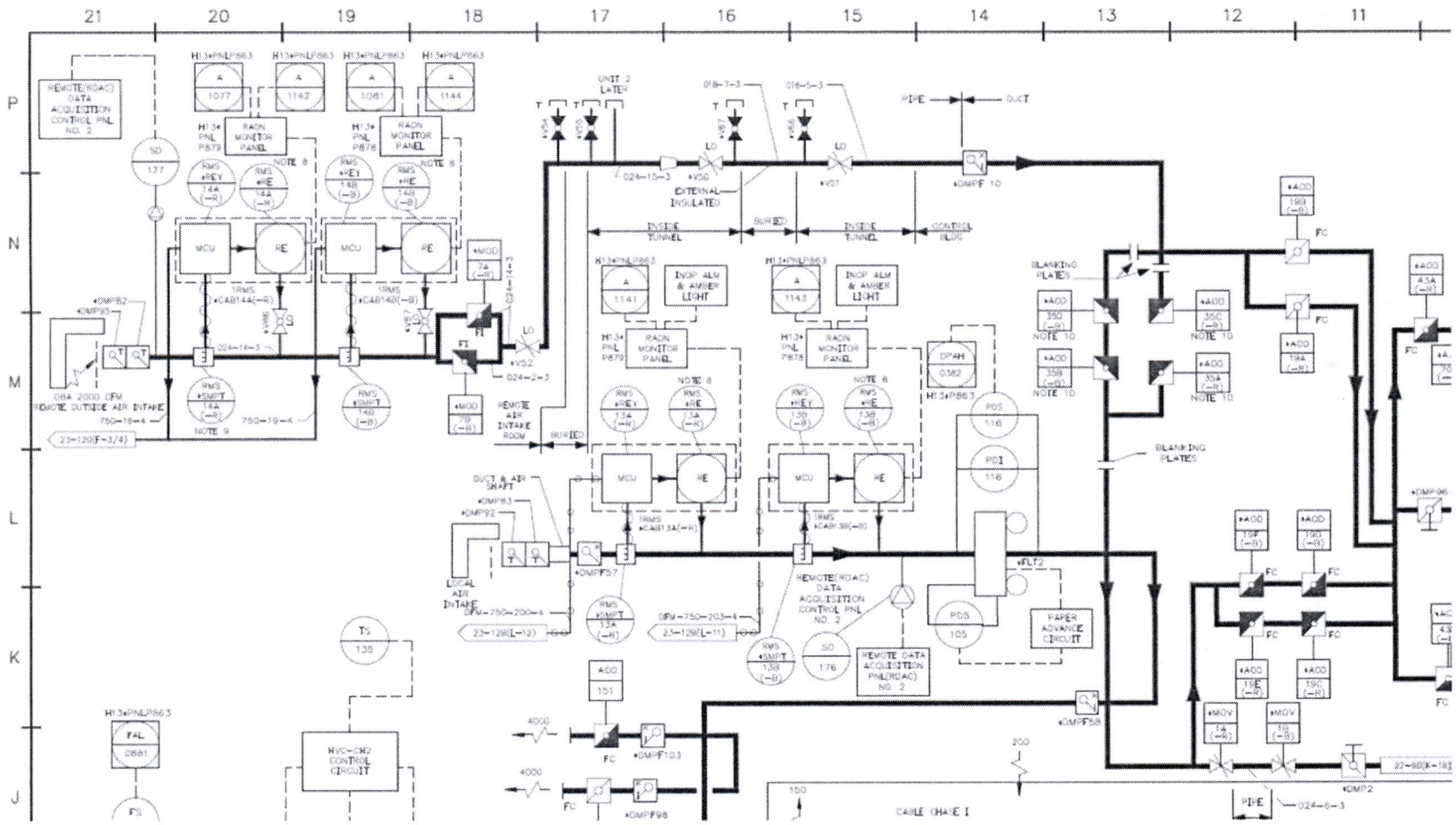
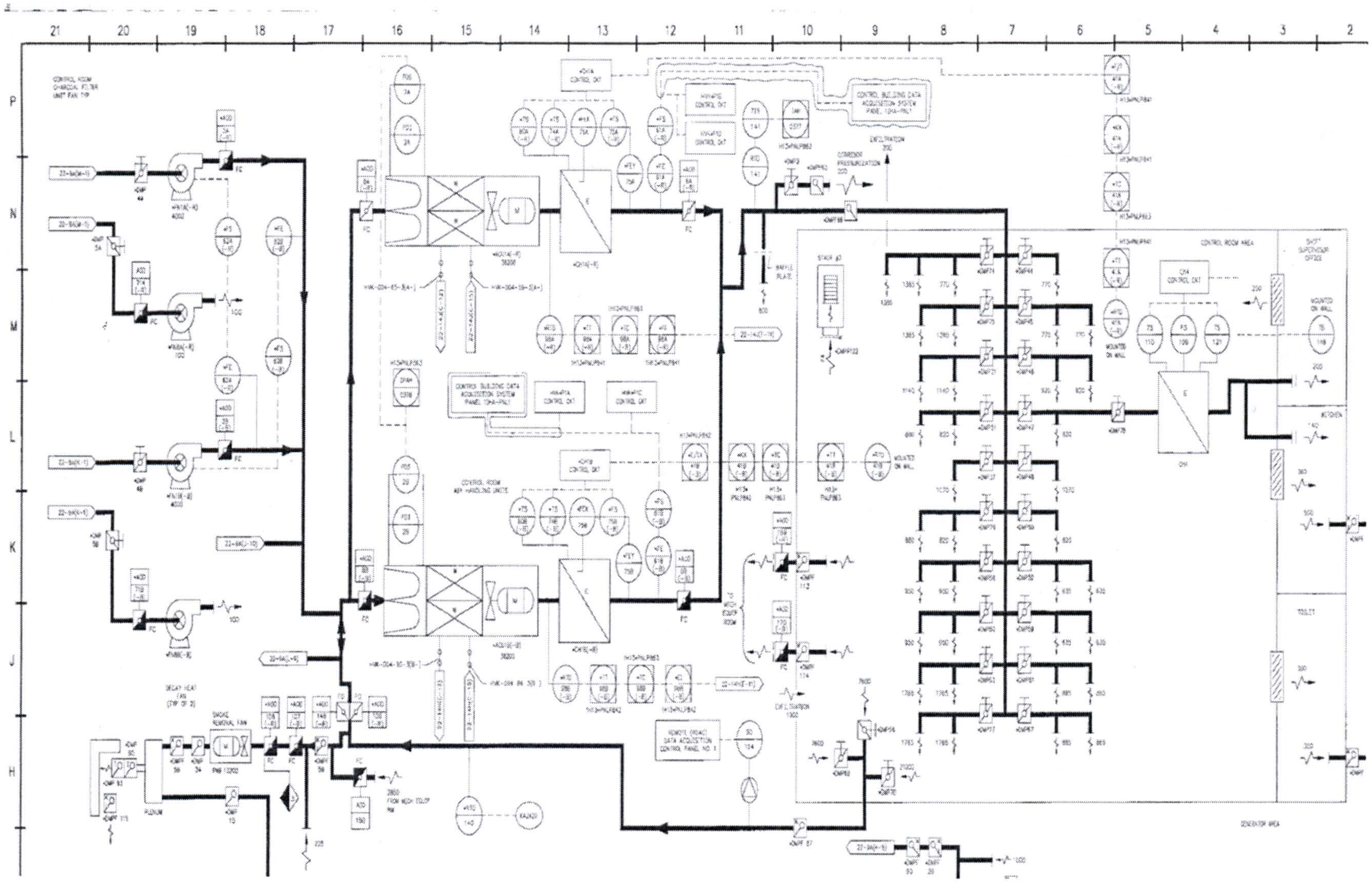
	Point ID	Description	Y Min	Y Max	E Units	Val Min	Val Max	Val Avg
A	HVKBC07	CHILL WTR CPRSR 1C	-0.25	8.00		0.00	0.00	0.00
B	HVKBC08	CHILL WTR CPRSR 1D	-0.25	7.00		0.00	0.00	0.00
C	[illegible]	CONT RM ACU 1A	-0.25	[illegible]		0.00	0.00	0.00
D	HVCTA01	CONT RM EXHAUST	60.0	95.0	DEGF	64.5	91.4	75.0
E	HVCBX003	CONTROL RM AC UNIT ISOL MOV-1A	-0.25	11.25		0.00	0.00	0.00

Excerpt from PID-22-09A showing Control Room Fresh Air (filtration) trains:



Excerpt from PID-22-09B showing Control Room Fresh Air (filtration) trains:



Determination of Main Control Room Heat Load by Measurement of HVAC Air Flow and Temperature Data

1. Scope and Objective

Background:

River Bend Station (RBS) Calculation E-226, "Control Building Electrical Equipment Heat Release", in part, calculates the heat loads in the Main Control Room (MCR) in various scenarios such as Normal Conditions, LOCA, Loss of Offsite Power (LOOP), and various combinations. For all conditions, the Normal Condition was found to be the highest heat load at 112,679 watts per page 15, Rev. 5 of calculation E-226 dated 4/23/2015.

On March 9, 2015, during a scheduled refueling outage, RBS experienced a loss of all cooling to the MCR during the Division I LOP/LOCA test of STP-309-0601 (Division I ECCS Test). This portion of the STP is designed to trip the running Division 1 safety-related main control room chiller, HVK-CHL1C, on loss of power and demonstrate that it will restart and sequence onto the diesel generator. When the test was performed, the chiller failed to restart and attempts to start the standby chiller on the other division were not successful.

Initiation of the Division I LOP/LOCA test of STP-309-0601 also started the Control Room Fresh Air (CRFA) fan and cycled certain MCR dampers to route MCR suction flow through the filter train and cause realignment of cooling flow paths as part of simulating a Loss of Power (LOP)/ Loss of Coolant Accident (LOCA) event. The failure of HVK-CHL1C to restart and subsequent failures in Division 2 HVC/HVK caused entry into AOP-0060, Loss of Control Building HVAC. After attempts to start a MCR chiller were unsuccessful for several minutes, air handling unit HVC-ACU1A was successfully restarted. Because no chiller was running, there was cool water standing in the coils but no cooling water flow through the coils. Starting HVC-ACU1A caused MCR temperature to stabilize. After HVC-ACU1A was started and temperature indication stabilized HVCTA01 indicated 70.0 degrees. This is only a 4.9 degree rise in approximately 52 minutes (from 65.1 degrees at 10:52 to 70.0 degrees at 11:44.). Data could be very conservatively interpreted to have risen to less than 72.2°F over 49 minutes. Regardless of slight differences in interpretation of data, the data shows an actual temperature rise much lower than calculated.

Subsequently HVCTA01 temperature slowly rose 2.8 degrees in the next 2 hours and 43 minutes (from 69.4 degrees at 11:46 to 72.2 degrees at 14:29) with recirculation of air by HVC-ACU1A, but no cooling from an operating HVK chiller. During this time CRFA continued to run. It would have been bringing in outside air at about 66 degrees, and heating it to supply it to the HVC-ACU1A suction as described in Attachment 10.1. The CRFA discharge temperature was measured at 96 degrees when it was running for testing on Feb. 2, 2016. Therefore, CRFA would have been adding heat to the MCR environment. A chiller was subsequently restarted at 14:29 restoring MCR cooling. The 4.9 degree temperature rise over 52 minutes is a much lower change than would be expected based on the calculated heat load used in calculation ENTR-078-CALC-004 (Entergy report RBS-ME-16-00002). The equipment heat load used in that calculation of 105,637 watts was developed in EC 61975 and derived based upon E-226 revision 5. Based on engineering

knowledge of the conservatism in the calculation and the measured temperature change during the event, it was decided to take flow and temperature measurements to measure the worst case actual MCR heat load. This provides information pertinent to establishing realistic heat-up rates if Control Building HVAC is lost, similar to what occurred on March 9, 2015 (Ref: CR-RBS-2015-1830). The highest heat load occurs for conditions with offsite power available. Thus, a decision was made to measure the actual steady state heat load generated in the MCR under normal conditions.

2. Design Inputs

2.1 PID-22-9B, Rev. 14, Engineering P & I Diagram, System 402, HVAC Control Bldg.

2.2 E-226, Rev. 005, Control Building Electrical Equipment Heat Release During LOCA Condition with Offsite Power Available and also Control Building Electrical Equipment Heat Release during LOCA Condition without Offsite Power (LOOP) and with Diesel Generator EGS-EG1B Not Responding

2.3 Drawing No. EB-039D, Rev. 9, Ventilation & Air Conditioning Plan, El. 135'-0" Control Building

3. Assumptions

None

4. Detailed Discussion

Existing STP-402-4203, HVC-ACU1A Performance Monitoring, contains steps to measure the flow rate through HVC-ACU1A to the MCR during design accident conditions. It measures the air flow rate in two locations, and adds them for a total flow rate into the MCR. The first flow measurement is the makeup and pressurization flow rate from the Control Room Fresh Air (CRFA) filter train, in a 24 inch by 24 inch duct, using 5 duct access ports for a 25 point Pitot tube flow traverse. The second flow measurement is the return air leaving the MCR going back to HVC-ACU1A to be cooled, in a 78 inch by 32 inch duct, using 5 duct access ports on each side for a 60 point Pitot tube flow traverse. (See Attachment 10-A, Simplified Flow Path)

For performing an actual MCR heat balance in the normal heat load conditions, these flow measurement points from STP-402-4203 were used and accurate M&TE temperatures were obtained during the flow measurements. This was performed on February 2, 2016 under WO 52509588 with the MCR ventilation flow path reduced to a simpler flow path than STP-402-4203 to eliminate any possible unmeasured flows or errors. HVC-ACU1A was run without CRFA running so that the makeup air measured in the first traverse location was only the makeup air from outside required to keep the MCR pressurized with the nominal leakage through doors, closed dampers, etc. In addition, the Control Room Kitchen Exhaust Fan, HVC-FN5, and the Control Room Toilet Exhaust Fan, HVC-FN4, were secured and their dampers closed since these exhaust the MCR separately and their

flow rate is not measured. In this case, the sum of the measured makeup air flow and the measured return air from the MCR is the supply air flow to the MCR from HVC-ACU1A.

The temperatures measured were the colder air in the duct leaving HVC-ACU1A going to the MCR (Supply Duct) and the warmer air leaving the MCR at the second traverse point (Return Duct) to determine the differential temperature across the MCR. The same M&TE thermocouple probe was used to measure both temperatures to cancel out any potential error in temperature measurement. This method shows how much air is going into the MCR and how much it is being heated up while there. This flow rate and temperature rise can then be converted into BTU/hr or watts of normal heat load in the MCR.

Temperature measurements were made with RBS M&TE #DTT-095A, a Fluke Model 51 II Single Input Digital Thermometer using a type K thermocouple probe. The vendor stated accuracy is 0.05% of reading + 0.5 °F. For a conservative 70 °F, this would be 0.035 + 0.5 = 0.535 °F. In practice, since we measured two temperatures with the same instrument and subtracted for a differential temperature, any error would be less significant since the absolute temperature accuracy is not important, only the differential, resulting in a higher accuracy.

Flow measurements were made by Pitot tube traverse of the HVAC duct with the Pitot tube supplying the velocity pressure and static pressure to RBS M&TE #MAN-032A, a Dwyer model 125-AV 20 inch inclined manometer with a range of 0 to 1.0 inch of water pressure with 0.005 inch minor scale increments. As such, it measures the velocity pressure directly on the manometer scale. With average recorded velocity pressures of 0.20 to 0.25 inches, the 0.005 inch minor scale increments equates to a readable accuracy of 2.2%. In addition, by recording and averaging multiple points for the traverse, 25 points for the makeup air duct and 60 points for the return air duct, the average velocity in the duct will be more accurate than individual readings. The accuracy of Pitot tube duct traverses is given in Reference 9.1 as 2 to 5%. The accuracy is dependent on factors such as turbulence in the duct and the number of traverse points used. Again, by reading and averaging multiple data points, the accuracy of the readings is improved.

During the test performance, temperature monitoring was performed at multiple locations inside the MCR to ensure temperatures remained constant indicating heat removal was equal to heat addition. The total test duration was only about 1 hour, so temperature data was collected twice in multiple locations. As can be seen from the data table in Attachment 10-B, the temperature varied no more than 1.4 °F, with most ranging from 0.0 to 0.3 degrees. The average temperature varied by only 0.1 °F. The measurements taken from computer point HVCTA01 and local temperature indicator TIS141 did not vary over the course of the test. The population of individuals inside the MCR was initially 12 people, but at approximately 20 minutes into the test, a new crew of operators began arriving in the Control Room for Shift Turnover. From this point until the end of the test, the population in the Control Room was approximately 21 persons. There was no apparent difference in the results due to the number of people in the MCR and the relatively small time they were present during test performance.

Note that the heat load in the MCR is essentially the same during normal at power conditions or during shutdown periods such as existed during the March 9, 2015 event. The

MCR contains mainly the instrumentation and controls used to monitor and operate the plant. There may be a significant difference in the systems and components running in the plant itself, and the heat load produced in those buildings, but the instrumentation, controls, and circuitry used to control them in the MCR are still operating and using effectively the same power. This may be impacted for relatively short periods when a UPS, station inverter or a load panel is removed from service for maintenance impacting a portion of the loads in the MCR. However, this happens infrequently and was not the case on February 2, 2016 when this data was taken and was not the case on November 9, 2015 during the loss of HVK/HVC event.

5. Raw Data Results

The following is the flow and temperature data obtained:

MCR makeup air flow to the suction of HVC-ACU1A:	450.4 cfm
Return air flow from MCR to the suction of HVC-ACU1A:	33464.1 cfm

Total supply air flow to MCR from HVC-ACU1A is then:

450.4 cfm + 33464.1 cfm = 33914.5 cfm

Temperature of the return air from MCR to the suction of HVC-ACU1A		67.0 °F
Temperature of the supply air to the MCR from HVC-ACU1A		61.6 °F
Differential temperature across the MCR is	67.0 – 61.6 =	5.4 °F

M&TE data for the flow traverses is documented in the referenced Work Order, temperatures were recorded by the Engineer during the test and the STP-402-4203. See Attachment 10-D for detailed documentation.

6. Operating Experience

CR-RBS-2015-1830, Entered AOP-0060, Loss of Control Building Ventilation, due to HVK-CHL1C failing to re-start after initiation of STP-309-0601, DIVISION I ECCS TEST, and failure to start of HVK-CHL1D and HVK-CHL1B due to a failure of HVC-ACU1B to start. The failure of HVC-ACU1B to start was due to the Masterpact breaker's position switch (52PS) contacts opening due to the breaker tripping open. When this happened, control power was lost to the start circuit and the breaker could not close when given a demand signal. The cause was that the 52PS linkage rod in the Masterpact breaker cradle was not lengthened enough to ensure solid switch contact was made when the breaker was racked in.

Also, it was found that a Masterpact breaker with a standing close signal could intermittently fail to close, due to the pressure from the anti-pump latch pushing on the close coil plunger causing the rear of the lever to rock up in the back and intermittently catch on the top frame of the mechanism. The main control room was without any forced

air flow for approximately 52 minutes and without a running chiller for 3 hours and 42 minutes. Operators took actions per AOP-0060 and subsequently restarted HVK-CHL1C.

7. Summary of Results

Calculation of Heat Load:

An accepted equation for determining heat load from air flow and temperature is found in Reference 9.1. The values of density and specific heat for air at the average temperature are also obtained from Reference 9.1. The total MCR heat load is calculated using:

Q = (density) x (volumetric flow rate) x (specific heat capacity) x (temperature increase).

The dry air properties used for this calculation are associated with the average supply/return air temperature and atmospheric pressure. Incorporating moist air properties would slightly increase the calculated heat load but would not change the conclusions drawn from this analysis:

Q_{MCR} = density X flow X specific heat capacity X (outlet temperature – inlet temperature)

Q_{MCR} = 0.07578 lbm/ft^3 X flow X 60 min/hr X 0.2405 BTU/lbm F X (outlet – inlet temperature)

Q_{MCR} = 1.094 (BTU/ ft^3 X min/hr) X flow (ft^3/min) X (outlet temperature – inlet temperature)

Therefore, using the heat balance data obtained on February 2, 2016:

Q_{MCR} = 1.094 (BTU/ ft^3 X min/ hr) X 33914.5 (ft^3/min) X (67.0 F - 61.6 F) = 200,353 BTU/hr

Since 1 BTU/hr = 0.293 watt,

200,353 BTU/hr X 0.293 watt/BTU/hr = 58,703 watts

Therefore, the steady state heat load generated in the MCR under normal conditions assuming dry air is 58,703 watts.

Impact of Humidity on Calculation:

The initial calculation was performed using properties of dry air. The effects of adding water vapor in the air are small. To quantify this affect, the calculation was re-performed using a relative humidity level of 70% which is the maximum relative humidity for the MCR during normal operation per the Engineering Design Criteria (EDC). Note that the actual humidity of the MCR air on the date of the test was not recorded. Humidity measurements taken in the MCR during November 2015 indicated relative humidity values of approximately 60%.

To account for the heat transfer of moist air vs. dry air, the specific humidity (ω) must be taken from a standard psychrometric chart. With the given temperature of 67.0 °F and a relative humidity (φ) of 70%, a specific humidity value of ω≅0.0099 can be found. (From Reference 9.6, equation 38.25)

$$q = m_a(C_{P,air} + \omega C_{P,moisture})(T_2 - T_1)$$

For the case discussed above:

$m_a = \rho * V = 0.07578$ (lbm/ft^3) * 33914.5 cfm*60 min/hour = 154202.4 (lbm/hr)

$C_{P,air} = 0.241$ Btu/(lbm-°F)
$C_{P,moisture} = 0.444$ Btu/(lbm-°F)
$T_1 = 61.6$ °F
$T_2 = 67.0$ °F
$\omega \cong 0.0099$

This yields

Q = 154202.4 x (0.241+0.0099*0.444) X (67.0-61.6) = 204,339 Btu/hr

204,339 Btu/Hr x 0.293 watts/ Btu = 59,871 watts

This differs from the previous evaluation, which neglected humidity, by +4,077 BTU/hr which is about 2 % deviation from the previous calculation.

(References and constant values provided in this section are from Reference 9.6, Mechanical Engineering Reference Manual for the PE Exam, 13th Edition)

8. Conclusions and Recommendations

The calculated value of MCR heat load is significantly lower than the conservatively calculated Normal Condition heat load of 112,679 watts found in Calculation E-226, Rev 5. The measured value of 58,703 watts compared to this value is:

(58,703 W / 112,679 W) x 100 = 52.1%

Assuming 70% humidity, the result is:

(59.871 W / 112,679 W) x 100 = 53.1%

For comparison, the total heat load that was used, supported by EC 61975 (Reference 9.3), in ENERCON calculation ENTR-078-CALC-004 was 105,637 watts. A spatial distribution of the E-226 heat loads was developed in EC61975, which also included refinements to the heat loads and corrections to account for issues identified in CR RBS 2015 8967; the

corresponding heat load per EC61975 is 105,673 watts. Comparing the heat load determined by testing to the value established per EC 61975:

(59,871 W / 105,637 W) x 100 = 56.7%

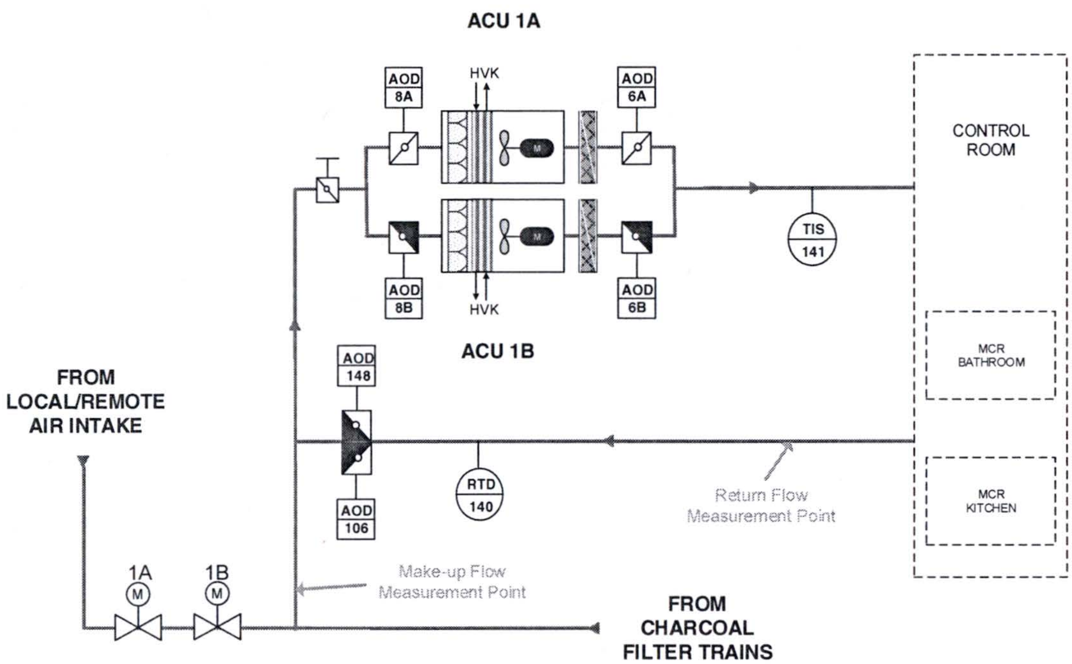
This reflects a more accurate assessment of the actual MCR heat load value and can be used in additional GOTHIC model calculations to determine MCR heat up rate and maximum temperatures.

9. References

9.1 2013 ASHRAE Handbook, *Fundamentals*, Inch-Pound Edition, Atlanta, Georgia
9.2 STP 402-4203 R. 0, HVC-ACU1A (DIV 1) Performance Monitoring
9.3 EC 61975, "References for E-226 Calculation Revision" developed to address issues identified in the E-226 R. 5 calculation documented in CR-RBS-2015-8967.
9.4 ENTR-078-CALC-004 (RBS-ME-16-0002), "Main Control Room Heat-Up Analysis during Loss of HVAC Conditions for 24 Hours"
9.5 RBS Work Order 52509588
9.6 Mechanical Engineering Reference Manual for the PE Exam, 13th Edition, Michael R. Lindeburg, PE
9.7 INPO ICES Report #316193, "Loss of Control Building Ventilation While Performing Emergency Core Cooling Surveillance Testing"

10. Attachments

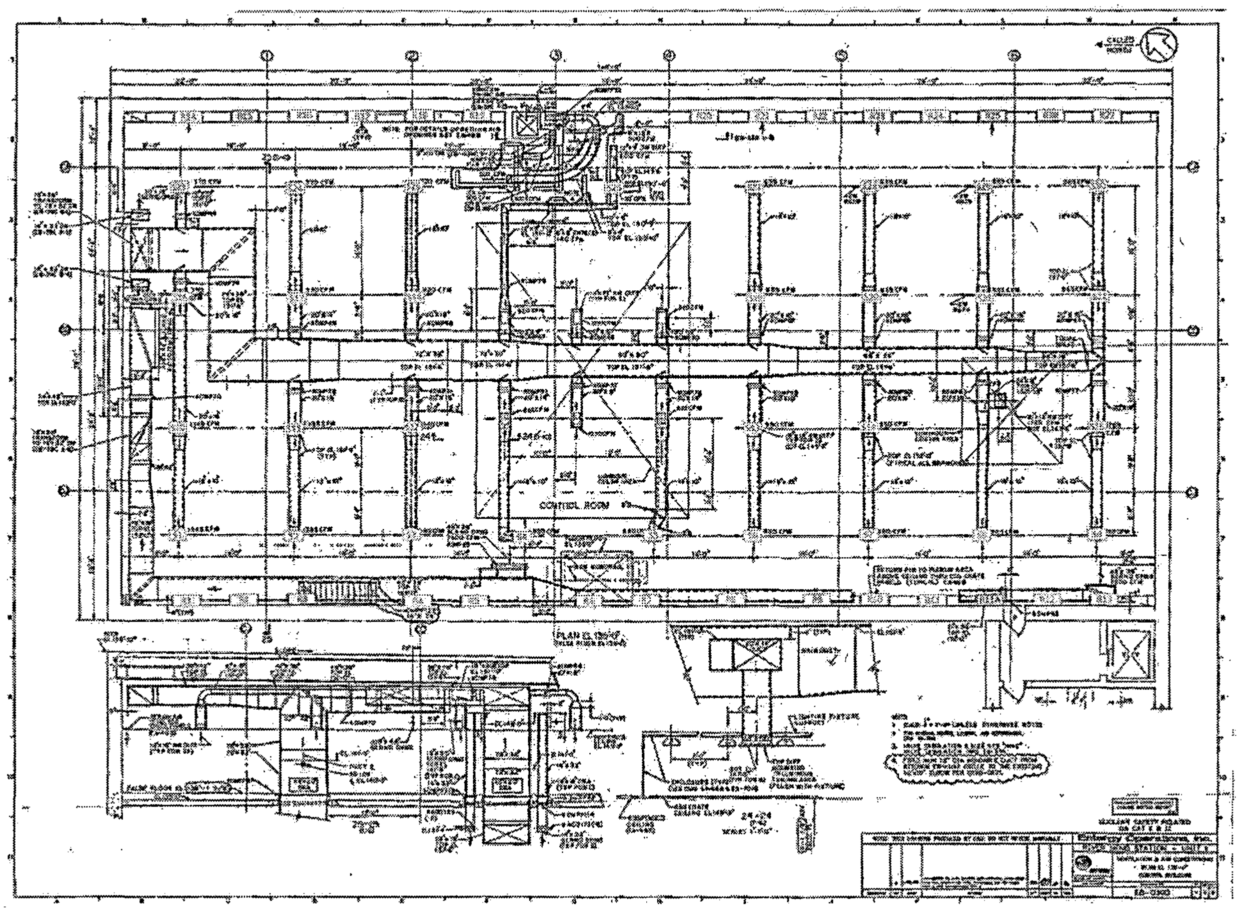
10-A: Simplified MCR Ventilation Flow Path with Measurement Points



10-B: Recorded Values of MCR temperature during test performance

Start Time	16:45	17:20	Difference
Section 100	69.5	68.1	1.40
Section 36	69.3	69.3	0.00
Section 72	69.9	69.8	0.10
Section 43	69.3	69.3	0.00
Section 109	69.5	69.2	0.30
Section 45	68.1	68.1	0.00
Register 15	68.5	68.3	0.20
Register 3	66.1	66.3	-0.20
Register 25	68.3	68.5	-0.20
Register 11	65.3	65.6	-0.30
Register 15 Overhead	68.8	68.6	0.20
Register 3 Overhead	67	66.7	0.30
Register 25 Overhead	68.5	68.5	0.00
Register 11 Overhead	65.4	65.8	-0.40
Average	68.11	68.01	0.10
HVCTA01 Return Duct Temp	66.2	66.2	0.00
TIS141 MCR local temp	62.5	62.5	0.00

10-C: Measurement Locations inside MCR



10-D: STP-402-4203 and WO 52509588 Task 5 Data Summary

WO 52509588 Task 5 Summary Data:

This is with HVC-ACU1A running, Control Room Fresh Air (CRFA) off, HVC-FN4, CR TOILET EXH FAN off, and HVC-FN5, CR KITCHEN EXH FAN off. In this condition HVC-ACU1A is the only motive force for air into and out of the MCR, with some leakage from the MCR envelope and some makeup of outside air to HVC-ACU1A to keep the MCR at positive pressure. The two flow measurements are the warmer air leaving the MCR to the HVC-ACU1A suction, and the makeup air for leakage coming from outside to the HVC-ACU1A suction. The sum of the two numbers is then the HVC-ACU1A cooler supply to the MCR.

Makeup air flow (Duct #1) 450.4 cfm at a temperature of 71.3 F by M&TE TC probe.

Return air flow from MCR (Duct #2) 33464.1 cfm at a temperature of 67.0 F by M&TE TC probe.

Supply air flow to MCR (Duct #1 + #2) 33914.5 cfm at a temperature of 61.6 F by M&TE TC probe near HVC-RTD141 or 60.6 F by M&TE reading of HVC-RTD141.

HVC-TC98A output meter indicated 48%.

HVCTA01, Control Room Exhaust Temperature (Return air), indicated 66.2 F.

HVC-TIS141, supply air temperature indicated 63 F.

The Supply air temperature by M&TE TC probe of 61.6 F is using the same device as that was used for the Return air temperature. So any error in measurement would be on both readings and would subtract out in the difference of the two temperatures. So using the M&TE TC probe for both the supply air and return air should be a more accurate differential temperature. The Supply air temperature for comparison is by I&C measuring the temperature of HVC-RTD141 with appropriate M&TE at the termination on HVC-TIS141, located on the North wall of the MCR was 60.6 F. For comparison at that time during the test, HVC-TIS141 indication read 63 F (5 degree increments on the indicator scale) and the temperature in the duct near HVC-RTD141 with a M&TE hand held thermocouple probe was 61.6 F.

STP-402-4203 (WO 52509588 task 1) Summary and Additional Data:

CRFA supply air flow (Duct #1) 3441 cfm at a temperature of 96.0 °F by M&TE TC probe.

Return air flow from MCR (Duct #2) 33846 cfm at a temperature of 66.5 °F by M&TE TC probe.

Supply air flow to MCR (Duct #1 + #2) 37287 cfm at a temperature of 61.6 °F by M&TE TC probe near HVC-RTD141.

HVC-TC98A output meter indicated 55%

HVCTA01, Control Room Exhaust Temperature (Return air), indicated 66.2 F.

HVC-TIS141, supply air temperature indicated 63 F.

M&TE used:

For flows, pitot tube traverse of the HVAC ducts per STP-402-4203 with the pitot tube supplying the velocity pressure and static pressure to RBS M&TE #MAN-032A a Dwyer model 125-AV 20 inch inclined manometer with a range of 0 to 1.0 inch of water pressure with 0.005 inch minor scale increments.

For temperatures, RBS M&TE #DTT-095A a Fluke Model 51 II Single Input Digital Thermometer using a type K thermocouple probe.

For comparison reading of input to HVC-TIS141, RBS M&TE #FPC-017A a Fluke Model 743B Process Calibrator.

Additional considerations:

During the STP-402-4203 performance the CRFA supply air flow (Duct #1) was 3441 cfm at a temperature of 96.0 F by M&TE TC probe. This would correlate well with the source of the higher temperatures seen in the ducts during the 3/9/15 event with HVC-ACU1A off.

The return air temperature computer point, HVCTA01, Control Room Exhaust Temperature, and the supply air temperature indication on HVC-TIS141 did not change during the entire STP and data gathering of task 5. From before the STP, during STP-402-4203 with CRFA A running, during the data gathering of task 5, and after the test was complete, HVCTA01 indicated 66.2 F and HVC-TIS141 indicated 63 F. This is expected since the temperature controller HVC-TC98A for HVK-TV16A would adjust for the different load. During the STP-402-4203 performance with CRFA and the associated heater and filter train on, HVC-TC98A output meter indicated 55% and during the task 5 data gathering with CRFA off HVC-TC98A output meter indicated 48%.

10-E: WO 52509588 Task 05 - Work Order Selected Pages (12 pages)

Facility: RBS RIVER BEND STATION **Unit:** 1
Tsk Pri: 4A **Task Dspln:** I&C
Crew: I&CA

Planner: JVILLA1 VILLARREAL JUAN
W/O Title: STP-402-4203: HVC-ACU1A (DIV 1) PERFORMANCE MONITORING

W/O Task Title: USING STP-402-4203 OBTAIN MCR HEAT BALANCE DATA HVC-ACU1A

PMID - RQ: 00010027 01 **Early Date:** 20150207
Interval-Days: 731 **Due Date:** 20150808
Late Date: 20160206

Completed By:

52509588 05

MASTER

W/O Type: PM
Job Type: TT
Pkg Type: 2
Printed: 1/18/2016 14:35

Entergy

Page 1 of 4

Work Order Task Written To

Work Item: STP-402-4203PRO **Eqt. List:**

Work Item Name: PROC STP-402-4203-PRO

Ops Review Reqd: Y **Crew Size:** 2 **Duration:** 2.00

CR Comm Reqd: NOTIFY WORK CONTROL CENTER VIA PHONE PRIOR TO START OF WORK

Location:

Cost Centr: NSBM5 **Activity:** NMST **User Def:** F5PPNRMSTK
Percentage: 100.000000 **Acct No:** GL RBS

Rework/Approval

Rework Job: N **Comments:**

QC Requirements/Comments

NO QC REQUIREMENTS FOR THE WORK ORDER TASK

WO Pkg 52509588 05 Pg 1 of 46

EN-WM-105	*RIVER BEND STATION 1*	
Work Order # / Sub Type	***52509588-05***	***LEVEL 2***
Work Entity / Component	***HVC-ACU1A***	
Discipline	***I&C***	***Date 01/18/2016***

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SECTION **PAGE NO.**

EN-WM-105	***RIVER BEND STATION 1***	
Work Order # / Sub Type	***52509588-05***	***LEVEL 2***
Work Entity / Component	***HVC-ACU1A***	
Discipline	***I&C***	***Date 01/18/2016***

1. PURPOSE AND SCOPE

1.1 The intent of this job plan is to obtain MCR heat balance data during performance of STP-402-4203.

2. PRECAUTIONS AND LIMITATIONS

2.1 OBTAIN the appropriate Work Management Center or OSM/CRS permission to start work as identified on the Work Order cover page.

2.2 CONTROL the disassembly of components per MSP-0021, Equipment Tagging.

2.3 MAINTAIN configuration control for all lifted leads, jumpers, tubing, and valve manipulations per GMP-0042, Lifted Leads and Jumpers.

2.4 Any non-conforming quality item, material, or component that is removed from plant service shall be identified and controlled by Maintenance in accordance with EN-MA-101-02, Control of Material Outside Facility Warehouse.

2.5 This job plan has been evaluated for potential hot leads that may require lifting.

2.6 This work has been reviewed for the impact of DAISY CHAIN components. (No daisy chains exist that affect the operation of the plant.)

2.7 Trash, used cleaning rags, and any non-usable parts shall be bagged, tagged, and removed from the work site as personnel leave the area.

2.8 WHEN obtaining any material from the warehouse, THEN remove the FME covers and any additional shipping or packaging materials prior to installation.

2.9 This Work Order may involve working on or near energized circuits. Use the necessary safety precautions in accordance with Industrial Safety procedure to minimize the risk of electrical shock, shorts, or grounds.

2.10 The sequence of steps can be determined by the technicians with the concurrence of Maintenance Supervision or the OSM/CRS provided the intent remains unchanged and adequate plant and personnel protection is present.

3. PREREQUISITES

3.1 PREPARE HVC-ACU1A as follows:

3.1.1 ESTABLISH the Zone 2 foreign material exclusion requirements in accordance with the attachment of EN-MA-118, Foreign Material Exclusion, and cleanliness requirements in accordance with ADM-0081.

G / 2-2-16
Initial Date

EN-WM-105	RIVER BEND STATION 1	
Work Order # / Sub Type	*52509588-05*	*LEVEL 2*
Work Entity / Component	*HVC-ACU1A*	
Discipline	*I&C*	*Date 01/18/2016*

4. WORK PLAN DETAILS

4.1 VERIFY that STP-402-4203 is complete and that Main Control Room Fresh Air system has been restored to its normal standby lineup. (Ref SOP-0058)

CA / 2-2-16
Initial Date

4.2 REQUEST Operations Verify or Shutdown HVC-FN5, CR KITCHEN EXH FAN. (Ref SOP-0058 section 6.1.7)

CA / 2-2-16
Initial Date

4.3 REQUEST Operations Verify or Shutdown HVC-FN4, CR TOILET EXH FAN. (Ref SOP-0058 section 6.1.8.)

CA / 2-2-16
Initial Date

4.4 WHILE performing the flow measurements in the step below, obtain an average temperature of the air in the Duct #1 using the hand held temperature instrument with long probe. ~~67.0~~ T 2-2-16 71.3

CA / 2-2-16
Initial Date

Note	*STP-402-4203 is used for reference only and recording data. Only steps listed in WO should be used.*

4.5 PERFORM the flow measurements of section 7.4 thru 7.6 to measure the flow in Duct #1 of STP-402-4203.

T / 2-2-16
Initial Date

4.6 WHILE performing the flow measurements of the step below, obtain an average temperature of the air in the Duct #2 using the hand held temperature instrument with long probe. 67.0 ~~71.3~~ T 2-2-16

T / 2-2-16
Initial Date

4.7 PERFORM the flow measurements of section 7.7 thru 7.9 to measure the flow in Duct #2 of STP-402-4203.

T / 2-2-16
Initial Date

4.8 At HVC-TIS141, located on the North wall of the MCR, measure the temperature at HVC-RTD141 with appropriate M&TE. 60.6°F

L / 2-2-16
Initial Date

FPC-017A
8-13-16

EN-WM-105	RIVER BEND STATION 1	
Work Order # / Sub Type	**52509588-05**	**LEVEL 2**
Work Entity / Component	**HVC-ACU1A**	
Discipline	**I&C**	**Date 01/18/2016**

4.9 TAKE any additional local temperature readings desired in the MCR and / or HVC equipment room.

T / 2-2-16
Initial Date

4.10 VERIFY all desired data is taken, and no repeat data is necessary.

T / 2-2-16
Initial Date

4.11 REQUEST Operations place HVC-FN5, CR KITCHEN EXH FAN in its desired/normal lineup. (Ref SOP-0058 section 4.2.4)

T / 2-2-16
Initial Date

4.12 REQUEST Operations place HVC-FN4, CR TOILET EXH FAN in its desired/normal lineup. (Ref SOP-0058 section 4.2.4)

T / 2-2-16
Initial Date

4.13 PERFORM and DOCUMENT an FME Close-out Inspection of all components on EN-MA-118, Foreign Material Exclusion.

T / 2-2-16
Initial Date

4.14 VERIFY housekeeping items are addressed at the completion of the work activity.

T / 2-2-16
Initial Date

5. RESTORATION

5.1 SEE STP-402-4203.

TemRev 0 AddCounter 25 Att Enc DS Rev KWN OFF

Entergy	NUCLEAR MANAGEMENT MANUAL	QUALITY RELATED	EN-MA-118	REV. 10
		INFORMATIONAL USE	PAGE 1 OF 1	
Foreign Material Exclusion				

ATTACHMENT 9.6 **COMPONENT CLOSE-OUT DATA SHEET**

Sheet 1 of 1

WO No./Work Activity: 52509588

List all completed component, system, structure, and subcomponent closeouts performed: HVC - Duct

1. **Proper FME controls were maintained, system cleanliness verified to be as clean as, or cleaner than originally found, and materials have been removed from the area.**
2. **All temporary covers, dams, and equipment have been removed from the system.** N/A
3. **Applicable FME accountability logs are complete and indicate no unevaluated foreign material has been introduced.**
4. **Applicable grit blasting requirements have been met.**
5. **Chemical Use Control and clean-up requirements for all consumable materials are satisfied.**

Closeout Performed By: [signature] 2-3-16 — Signature/Date; I&C — Dept

Closeout Performed By Concurrent Verifier: [signature] 2-3-16 — Signature/Date; I&C — Dept

Other Performing Closeout (if applicable) N/A

Signature/Date — Dept

Signature/Date — Dept

Signature/Date — Dept

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WO Pkg 52509588 05 Pg 28 of 46

CONTINUOUS USE

*G12.1.15

ENTERGY

RIVER BEND STATION
STATION OPERATING MANUAL
*SURVEILLANCE TEST PROCEDURE

*HVC-ACU1A (DIV1) PERFORMANCE MONITORING

PROCEDURE NUMBER: *STP-402-4203

REVISION NUMBER: *0

Effective Date: *6-21-04

NOTE : SIGNATURES ARE ON FILE.
CONTINUOUS USE
*INDEXING INFORMATION

⚠1 Applicable steps performed per W.O. 52509588 Task 05

CONTINUOUS USE

6 PREREQUISITES

6.1 Each performer indicates that he has read and understands this procedure by completing the following:

(Signature)	(Print Name)	(Initials)
[illegible]	[illegible]	[illegible]
[illegible]	T. Little	T
[illegible]	John Arseneaux	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

6.2 Obtain OSM/CRS permission to perform this test. _____ *(Initials)*

6.3 Inform NCO that this test is in progress. _____ *(Initials)*

6.4 Operations verify that the Division I Control Building HVAC system in service _____ *(OPS)*

6.5 Operations verify that Division I Control Room Chilled Water (SOP-0066) is operating with flow through Control Room Air Handling Unit HVC-ACU1A and that Control Room Air Handling Unit (SOP-0058) HVC-ACU1A is in operation. _____ *(OPS)*

CONTINUOUS USE

NOTE

Location of Duct #1 (24" by 24") is CB 116' through door CB116-25 "HVC FILTER ROOM" 15' into the room, 13' in the overhead, just over HVC-ACU1A. The 5 access plugs are located on bottom of duct. It is acceptable to stand on HVC-ACU1A while accessing the duct plugs.

7.4 Measure the Velocity Pressure at 4", 8", 12", 16", and 20" into Duct #1, at each of the 5 duct access locations, 25 total measurements, and perform the following:

NOTE

A measurement of 0.010 in. WC can be recorded as 10
Simplifies the amount of writing and loses the decimal point.

7.4.1. Move the decimal over to the right 3 places and record as VP. ______ *(Initials)*

7.4.2. Restore access plug integrity. ______ *(Initials)*

______ *(IND VERIF)*

7.4.3. For each VP reading, calculate the Velocity, using the formula ______ *(Initials)*

V = 4005 X (Square Root of (VP/1000)) and record as V ______ *(VERIFIED)*

	Duct access 1		Duct access 2		Duct access 3		Duct access 4		Duct access 5	
	VP	V	VP	V	VP	V	VP	V	VP	V
4"	0	0	0	0	2.5	200	0	0	2.5	200
8"	0	0	0	0	0	0	0	0	2.5	200
12"	0	0	0	0	0	0	0	0	5	283
16"	2.5	200	2.5	200	0	0	0	0	5	283
20"	5	283	5	283	2.5	200	2.5	200	5	283

Calculation Aid, values of V for typical VP's

VP	V	VP	V	VP	V	VP	V
5	283	20	566	35	749	45	850
10	401	25	633	40	801	50	896
15	491	30	694				

7.5 Add all 25 V's together and record as the V Total below: ______ *(Initials)*

V Total = 2815

______ *(VERIFIED)*

CONTINUOUS USE

7.6 Multiply V Total by 0.16 and record as Air Flow below:

Air Flow = 450.4

(Initials)

(VERIFIED)

CONTINUOUS USE

NOTE:
Duct #2 (78" X 32") is in Cont Rm, North End (1HVC-SD124 is mounted on it). There are 5 access plugs located at either end of the 78" span.

7.7 Measure the Velocity Pressure at 6", 12", 18", 24", 30", 36", 42", 48", 54", 60", 66", and 72" into Duct #2, at each of the 5 duct access locations, 60 total measurements, and perform the following:

NOTE
A measurement of 0.37 in. WC can be recorded as 37
Simplifies the amount of writing and loses the decimal point.

7.7.1. Move the decimal over to the right 2 places and record as VP: CC *(Initials)*

7.7.2. Restore access plug integrity. CC *(Initials)* CC *(IND VERIF)*

7.7.3. For each VP reading, calculate the Velocity, using the formula CC *(Initials)*

V = 4005 X (Square Root of (VP/100)) and record as V. CC *(VERIFIED)*

	Duct access 1		Duct access 2		Duct access 3		Duct access 4		Duct access 5	
	VP	V	VP	V	VP	V	VP	V	VP	V
6"	27	2081	31	2230	23.5	1941	20.5	1813	22	1879
12"	24	1962	32	2266	24.5	1982	25.5	2022	20	1791
18"	28	2119	32.5	2283	25	2003	30	2194	24	1962
24"	20	1791	31	2230	25	2003	30	2194	20	1791
30"	26	2042	30	2194	24	1962	26	2042	18.5	1723
36"	15	1551	22	1879	21	1835	20	1791	17	1651
42"	23.5	1941	27	2081	22	1879	24	1962	20	1791
48"	24	1962	26	2042	23	1921	22	1879	20.5	1813
54"	26	2042	25	2003	24	1962	26	2042	24	1962
60"	25.5	2022	24.5	1982	23.5	1941	26	2042	24	1962
66"	23	1921	24	1962	23	1921	25	2003	22	1879
72"	12.5	1416	14	1499	20.5	1813	15.5	1577	13	1444

Calculation Aid, values of V for typical VP's

VP	V	VP	V	VP	V	VP	V	VP	V
12	1387	18	1699	24	1962	30	2194	36	2403
13	1444	19	1746	25	2003	31	2230	37	2436
14	1499	20	1791	26	2042	32	2266	38	2469
15	1551	21	1835	27	2081	33	2301	39	2501
16	1602	22	1879	28	2119	34	2335	40	2533
17	1651	23	1921	29	2157	35	2369	41	2564

CONTINUOUS USE

7.8 Add all 60 V's together and record as the V Total below:

V Total = 115873

(Initials) ______ (VERIFIED)

7.9 Multiply V Total by 0.2888 and record as Air Flow below:

Air Flow = 33464.

(Initials) ______ (VERIFIED)

TS 7.10 Add the air flow from Duct #1 to the air flow from Duct #2 and record as Total Air Flow below:

450.4 + 33464 = 33914.4

Duct #1 Air Flow Step 7.6	+	Duct #2 Air Flow Step 7.9	=	Total HVC-ACU1A Air Flow (cfm) (MIN is ≥ 38,200 cfm)
450.4	+	33464	=	33914.4

(Initials) ______ (VERIFIED)