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Evaluation of RBS Remote Shutdown Panel Rooms following a Loss of Control Building HVAC

Purpose

Evaluate the temperatures in the Remote Shutdown Panel rooms (Division 1 and Division 2 RSS) following a loss of Control Building HVAC.

Background

On March 9, 2015, during a scheduled refueling outage, RBS experienced a temporary loss of Control Building and Main Control Room (MCR) cooling due to trip of the associated chilled water system (HVK). The NRC has raised concerns regarding the reliability of electrical equipment and the long-term habitability of the Main Control Room (MCR) following a loss of cooling. RBS has developed detailed GOTHIC thermal-hydraulic models of the RBS Main Control Room and Control Building and evaluated the MCR heat-up following a loss of all cooling assuming various mitigating actions (References 1, 2, and 6). The MCR heat-up evaluations include cases with design basis normal operating MCR heat loads (Ref. 3) and with measured heat loads determined from a steady-state MCR heat balance performed during normal operations (Ref. 4). The measured heat loads are 57% of the design normal operating heat load. The MCR heat-up evaluations show that the MCR average temperature reaches 116^{o}F within two hours of a loss of HVAC with design heat loads. However, using the actual, measured heat loads, the MCR temperature remains below 113^{o}F for six hours following a loss of HVAC. Should mitigating actions to provide cooling to the MCR prove unsuccessful and the environmental conditions in the MCR worsen such that operator habitability is challenged, operators could evacuate to the Division 1 or Division 2 Remote Shutdown (RSS) rooms and shutdown the plant from the remote shutdown panels. This evaluation determines if the Division 1 and Division 2 RSS rooms will remain habitable and equipment remain available during a loss of control building HVAC event.

Conclusions

Both the Division 1 and Division 2 RSS rooms would remain habitable and equipment would remain available following a loss of HVAC in the control building. Should the MCR be abandoned due to a loss of control building HVAC, operators would open the doors to the RSS rooms to allow access. Opening of these doors would provide mixing via natural circulation with the air in the adjacent control building rooms. As shown in Reference 6, the Control Building Switchgear Area heat loads under a LOCA-LOOP condition is lower than the heat loads for a LOCA with offsite power, which would reduce the temperatures in the RSS rooms. Page 167 of Reference 7 shows that the heatup for these rooms is minimal under LOOP conditions. The MCR heat-up calculations show that the MCR would remain habitable for at least 6 hours assuming measured heat loads and 2 hours assuming design heat loads. Without taking credit for metal heat sinks in the RSS rooms, temperatures in the most limiting RSS room are expected to remain below 108°F during the first 2 hours and below 114°F at 6 hours. Therefore, in the unlikely event of a rapid MCR heat-up requiring early MCR evacuation (within 2 hours), the temperature in the limiting RSS room after opening doors is

expected to be less than 108^{o}F. For the slower MCR heat up using measured heat loads, MCR evacuation is less likely due to the increased time (6 hours) available to implement mitigating actions. However, if evacuation to the RSS rooms occurs at 6 hours, the temperature in the limiting RSS room after opening doors is expected to be less than 114^{o}F. The temperatures predicted for the RSS rooms are lower than the values reported in G13.18.12.3*161 (Reference 7), due to the refined heat loads and modeling techniques applied in ENTR-078-CALC-001 (Reference 6) and this evaluation.

Evaluation

RSS Room Description

The Division 1 (CB098-11) and Division 2 (CB098-13) RSS rooms are located on the 98 foot elevation of the control building. The volume of the Division 1 RSS is approximately 971 ft^3 while the Division 2 RSS is approximately 1626 ft^3. The control panels in these rooms as listed in the tables below provide a substantial amount of steel mass that would act as a heat sink during heat up of the rooms following a loss of HVAC. The Division 1 RSS room includes a single door that opens to the general area of the 98 foot elevation (CB098-10). The Division 2 RSS room includes two doors that open to the Standby Switch Gear Room 1B (CB098-12).

Division 1 RSS Heat Loads

The E-226 R5 calculation (Ref. 5, pg. 44) provides the following heat loads for the Division 1 RSS (note that normal heat loads and LOCA with offsite power are identical).

Table 1: Div. 1 RSS E-226 Heat Loads

Div. 1 Equipment	Heat Load	
	Normal (Watts)	LOCA with Offsite Power (Watts)
C61-PNLP001	200	200
RSS-PNL101	540	540
Lighting (5)	480	480
TOTAL	1220	1220

A review of the panels and walk downs were performed to evaluate the panels and lighting to ensure that the heat loads documented in the E-226 R5 calculation were accurate. The panel review was performed by reviewing ESK-4RSS101. The individual parts and components of the RSS-PNL101 were reviewed in ESK-4RSS101 and the heat load of the heat generating components was determined based on the wattage rating of each item. The total heat load for RSS-PNL101 is found by summing up the heat loads of the individual components. The lighting review was performed by walk downs. The Div. 1 RSS room contained 4 light fixtures with each fixture containing two 40W light bulbs. Based on the review, the revised heat loads are presented in Table 2.

Table 2: Div. 1 RSS Revised Heat Loads

Div. 1 Equipment	Heat Load	
	LOCA with Offsite Power (Watts)	Reduction (%)
C61-PNLP001	200	0%
RSS-PNL101	180	67%
Lighting (4)	320	33%
TOTAL	**700**	**43%**

Division 2 RSS Heat Loads

The E-226 R5 calculation (Ref. 5, pg. 44) provides the following heat loads for the Division 2 RSS (note that normal heat loads and LOCA with offsite power are identical).

Table 3: Div. 2 RSS E-226 Heat Loads

Div. 2 Equipment	Heat Load	
	Normal (Watts)	LOCA with Offsite Power (Watts)
RSS-PNL102	540	540
Lighting (2)	192	192
TOTAL	732	732

A review of the panels and walk downs were performed to evaluate the panels and lighting to ensure that the heat loads documented in the E-226 R5 calculation were accurate. The panel review was performed by reviewing ESK-4RSS102. The individual parts and components of the RSS-PNL102 were reviewed in ESK-4RSS102 and the heat load of the heat generating components was determined based on the wattage rating of each item. The total heat load for RSS-PNL102 is found by summing up the heat loads of the individual components. The lighting review was performed by walk downs. The Division 2 RSS room contained 2 light fixtures with each fixture containing two 34W light bulbs. Based on the review, the revised heat loads are presented in Table 4.

Table 4: Div. 2 RSS Revised Heat Loads

Div. 2 Equipment	Heat Load	
	LOCA with Offsite Power (Watts)	Reduction (%)
RSS-PNL102	200	63%
Lighting (2)	136	29%
TOTAL	**336**	**54%**

RSS Room Temperatures Following Loss of HVAC

The temperatures in the Division 1 and 2 RSS rooms following a loss of HVAC were calculated using the Control Building (GOTHIC) model that opens the doors in the Control Building at 30 minutes developed in Reference 6. The temperatures of the RSS rooms did not change at 2 and 6 hours for the case with no doors opened from Reference 6. The control building heat loads for the LOCA with offsite power case were used as they result in the bounding heat loads for LOCA and non-LOCA cases. The revised heat loads from Table 2 and 4 are used in the RSS rooms. The model does not credit metal heat sinks in the RSS rooms which would reduce the temperature in these rooms. The model also does not consider opening the doors to these rooms, which would allow mixing with the adjacent rooms. The case with inverters operating in the Standby Switchgear Rooms is selected to conservatively maximize the temperature in Standby Switchgear Room 1B located outside the Division 2 RSS room.

Table 5 shows the temperatures in the RSS rooms and adjacent rooms outside the Division 1 RSS room (98 foot General Area, CB098-10) and the Division 2 RSS room (Standby Switchgear room 1B, CB098-12) at 2 and 6 hours. The temperatures in the Division 1 RSS rooms remain below 115^{o}F at 2 hours and below 119^{o}F at 6 hours. Temperatures in the Division 2 RSS room remain below 100^{o}F at 2 and 6 hours. The temperature outside the Division 1 RSS room is 97.2^{o}F at 2 hours and 101.8^{o}F at 6 hours. The temperature in the Standby Switchgear Room outside the Division 2 RSS room is 108.5^{o}F at 2 hours and 114.4^{o}F at 6 hours. Should the MCR be abandoned, operators would open the doors to the RSS rooms to allow access. Due to the small size of these rooms, opening the room doors would be a highly effective means of providing mixing of the room air with the larger adjacent rooms. The RSS rooms would be expected to stabilize at a temperature within a few degrees of the temperature of the area outside the room. Therefore, the temperature in the Division 1 RSS room will decrease after the door is opened for operator access and is estimated to be no more than 100^{o}F at 2 hours and 110^{o}F at 6 hours. The temperature in the Division 2 RSS room will increase after the door is opened for operator access. The temperature would be no more than 108^{o}F at 2 hours and 114^{o}F at 6 hours.

Table 5: RSS and Adjacent Room Temperatures

Room	Temperature (^{o}F)	
	2 hours	6 Hours
Div 1 RSS (CB098-11)	114.2	118.7
General Area (CB098-10)	97.2	101.8
Div 2 RSS (CB098-13)	97.8	99.7
Stby SG Room 1B (CB098-12)	108.5	114.4

References

1. Calculation ENTR-078-CALC-003, Rev. 4, “Main Control Room Heat-Up Under Loss of HVAC Conditions for 24 Hours.”
2. RBS-ME-16-00002, Rev. 0 (ENTR-078-CALC-004, Rev. 0), “Main Control Room Heat-Up Analysis During Loss of HVAC Conditions for 24 Hours.”
3. EC61975, “References for E-226 Calculation Revision.”
4. RBS-ME-16-00003, Rev. 0, “Evaluation of Main Control Room Heat-up on Loss of HVAC Based on Empirical Temperature and Flow Data.”
5. Calculation E-226, Rev. 5, “Control Building Electrical Equipment Heat Release During LOCA Condition With Off Site Power Available and Also Control Building Electrical Heat Release During LOCA Condition Without Offsite Power (LOOP and with EGS-EG1B Diesel Generator Not Responding.”
6. Calculation ENTR-078-CALC-001, Rev. 1, “Control Building Heatup Analysis Following Loss of HVAC.”
7. Calculation G13.18.12.3*161, Rev. 2, “Standby Switchgear Room Temperatures following Loss of Offsite Power and Loss of HVAC”.