Room Temperature Heat-up Test of RHR Pump Room upon Loss of Room Cooling in Kori Unit-2

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1. Introduction

In PSA Models, a HVAC (Heating, Ventilation & Air Conditioning) system is essential for the various vital mitigation safety systems operating during a mission time. In various PSA models, upon Loss of Room Cooling, the operability of equipment in the room is assumed to immediately be failed conservatively or a simple recovery action (door opening in the equipment room by operator) for the equipment operation has been applied optimistically based on expert judgment. But, the consistent operability of equipment and more realistic approach are needed for the Korean regulatory PSA models (for Risk informed regulation in Korea). Hence, the CFD (Computational Fluid Dynamics) code was utilized to define the operability criteria of equipment in the room for all types of reactor for Korean regulatory PSA model. Several CFD calculations had been performed to confirm the room temperature exceed over design temperature or not. To verify the CFD code calculations, the real room heat-up test was performed without any HVAC system supporting at a RHR pump room in Kori Unit-2 nuclear power plant also. The different aspect was obtained from the real room heat-up test comparing with the CDF code calculation. To address the discrepancy between the real test result and the CFD code calculation, the pump motor thermal stress analysis was performed.

2. Room Temperature Heat-up Test in RHR Pump Room

To verify the results from CFD code calculation and calibrate the CFD code calculation, the real room heat-up test was performed while the performance testing after refueling outage in Kori Unit-2 nuclear power plant. We selected the RHR (Residual Heat Removal) pump (200hp capacity, centrifugal, single stage and vertical pump).

The 19 thermo-couples and the computerized data acquisition device were installed at various locations in the RHR pump room at Kori Unit-2 plant. The temperature measurement locations installed in RHR pump room shows in Figure 1. The thermal-couples are calibrated against a reference thermo-meter with an error of $\pm$ 0.04°C. We measured the trend of temperature increasing each thermo-couple. While this real test, the RHR pump room door was opened and any of HVAC systems was not working. In this test, the RHR pump had been run for about four hours without any of HVAC system working. During the test period, temperatures were measured by K-type thermal-couples (Omega Co.) at various locations.

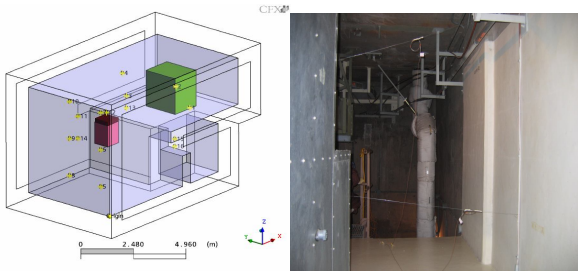

Fig. 1. The Thermo-couples locations in RHR Room.

The temperature increasing data from 18 thermo-couples was obtained and the result of the test is presented in Figure 2.

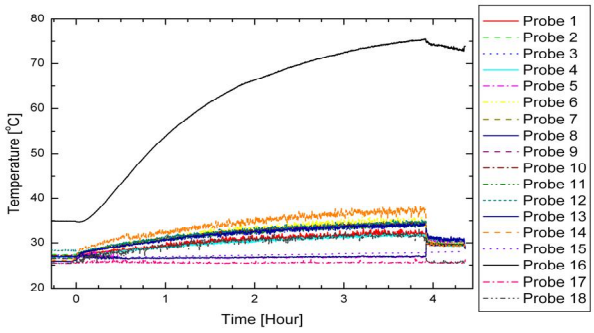

Fig. 2. The Result for RHR Pump Room Heat-up Test

As shown in Figure 2, the room temperature increasing rate measured from 17 thermo-couples was slow and the maximum temperature did not exceed over the design limit temperature for 4 hours pump operation. During the test, the corridor temperature

outside the pump room was measured to be constant 26.5°C.

But the surface temperature of pump body measured from 1 thermo-couple showed different trend. The pump body surface temperature increased rapidly after pump started and reached about 75°C at 4 hours later. We also found that the pump body surface temperature decreased rapidly after the HVAC started.

3. The Prediction of Pump Internal Part Temperature

The operability of RHR pump upon Loss of Room Cooling could not decide because the discrepancy between the real test result and the CFD code calculation. So, a consultation for the motor thermal stress analysis was performed by motor vendor to define how the pump body temperature could be affected the pump operation during mission time. We requested them to predict the temperature increasing rate of pump motor body and motor internal parts such as coil or bushing, etc. We also requested that which component is the most vulnerable part against heat generation and its limit design temperature.

The simulation was performed to predict the temperature of motor internal coil as the pump body temperature increasing based on motor vendor's performance test experiences and the RHR pump room heat-up test results. The result of simulation is summarized in Table 1.

Table 1: The Temperature Prediction of RHR Pump Internal

time(hrs)	4	5
Temperature of Pump Body (°C)	75	130
Temperature of Motor Coil (°C)	126	205

The temperature of pump body and motor coil could reached 75 °C, 130 °C at 4 hours later and 126 °C, 205 °C at 5 hours later respectively in shown Table 1. The most vulnerable part of this types pump against heat generation is motor coil insulator and its limit design temperature would be is about 130 °C. It is concluded that this RHR pump could not be meet its capability at about 5 hours later without HVAC working because of the coil insulator degradation.

4. Conclusion

Only ambient room temperature increasing has been concerned to assess the operability of equipment in the room upon Loss of Room Cooling so far. To predict more realistic room temperature, the CFD calculation was performed, upon Loss of Room Cooling. In this CFD calculation, every room ambient temperature did not exceed over the design temperature for pump operation. The real room heat-up test at RHR pump room was also performed in Kori Unit -2 plant to verify the CFD calculation. In real RHR pump room heat-up test, the room temperature did not exceed over the design temperature, but the pump body surface temperature increased rapidly after pump started and reached about 75 °C at 4 hours later. To address the discrepancy between two studies, a consultation for the motor thermal stress analysis performed by motor vendor.

It is concluded that the high temperature induced effect has to be concerned to the vulnerable internal part of RHR pump for assessing the operability of equipment realistically in the room upon Loss of Room Cooling based on the consultation result. It is found that a simple recovery action (door opening in the equipment room by operator) may not be credited upon Loss of Room Cooling in PSA also. This insight would be applied to regulatory PSA model for Korean nuclear power plant.

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