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Review of the Operability for the Components Under the Loss of the HVAC System of the Pump Room

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1. Introduction

In this paper, we estimated the temperature of the pump rooms and reviewed the operability of the components under the loss of the HVAC (Heating, Ventilation, and Air Condition) system.

The issues relevant to the HVAC system in the PSA (Probabilistic Safety Assessment) FT (Fault Tree) model are as follows:

(1) Does the loss of the HVAC system bring about a function failure of other components?
(2) Can the operator take action to reduce the temperature of the room in case of a HVAC function failure?

At present we do not know whether a component will lose its function or not under the loss of the HVAC. ASME Standard [1] describes that a recovery action can be credited if the related recovery action is included in the procedure or there are similar recovery experiences in the plant. However, there is no description about the recovery action of the HVAC in the EOP (Emergency Operation Procedure) of the UCN3, 4 under the situation of a loss of the HVAC. Even though we consider this assumption positively, it would be limited to the rooms such as the Switchgear Room, Inverter Room, and Main Control Room etc. where a real recovery action can be performed easily.

However, if we consider the HVAC failure in the PSA FT model according to the above background, the problem is that the unavailability induced from the loss of a HVAC is highly unrealistically.

From a viewpoint of the PSA, it is not true that the related system always fails even though the HVAC system fails. Therefore, we reviewed the necessity of the HVAC model through the identification of the operable temperature of the components' within the pump room and the change of the temperature of the pump room under the situation of a loss of the HVAC system.

2. Review of the Operable Temperature of the Components

We reviewed references [2, 3, and 4] for the identification of the operable temperature of components under a loss of the HVAC.

The representative components in a pump room are pumps, valves, and sub-components. Thus, we estimated that the following components and materials exist in a pump room; valve stem, valve body, bonnet, disk, gasket, actuator, cable, motors, motor starter, switches & relays, sensors, transmitter, bearing, seal, lube oil, turbine, and turbine governors (within AFW pump room). Table 1 shows the operability condition by the equipment category. Because the NUMARC 87-00[2] provides a background of the temperature, we estimated the operable temperature based on the NUMARC 87-00[2]. Table 2 shows the estimated operability condition for the pump room.

3. Heat up Calculation for the Pump Room in Case of the Loss of the HVAC

We calculated the change of the temperature in a pump room after a loss of the HVAC using RATT and CFX-5.7.

3.1 Basic Input Data

The initial and boundary conditions, and the basic assumptions are as follows:

- The initial temperature of the air and the temperature of the concrete wall is 104^{o}F
- Inside a pump room, natural convection is induced by heating from the pump surface.
- The shapes of a room and a pump are hexahedral and the pump occupies 35% of the room volume.
- The total heat load from the pump is 177.36 Btu/hr (= 51.98 kW).

3.2 The Results of Heat up Calculation Using the RATT

The RATT cannot handle the configuration of the room in detail. Therefore, we estimated the room temperature under a conservative condition that the room is shut tightly. Table 3 shows the room temperature after 24 hours under a loss of the HVAC.

3.3 The Results of Heat up Calculation Using the CFX-5.7

Room heat up calculation using CFX-5.7 was performed only for the CS pump room to compare the case of the closed-door condition with the open-door condition.

For the closed-door case, we estimated the change of the temperature for 24 hours after a loss of the HVAC. The computation for the open-door case has been performed for over 8 hours so far and will be continued until 24 hours after the event. Figure 1 shows the change of the volume-averaged temperature of the CS pump room.

The temperature differences between the two cases are about 3~5^{o}C during the transients, which are not as remarkable as expected. From the simulation results, the reasons of these small temperature differences are found as follows: For the open-door case, the cold air coming through the open door stays in the lower part of the room, due to buoyancy force. Moreover, the temperature of the upper part of the room gets higher than that of the closed-door case, because the existence of cold air layers near the floor suppresses the recirculation loops of natural convection smaller. Further investigation is needed with the detailed geometric data, to find out whether these interesting phenomena are caused by the simple geometric assumptions.

4. Conclusions

The results of the pump room heat up calculation show that a loss of the HVAC can bring about a function failure of the pumps except for the charging pump and ESW pump. Moreover, the time over the operable temperature of the components is very short. However, because the condition of the pump room after a loss of the HVAC was assumed very conservatively, we performed the room heat up calculation under the assumption that an operator can open the door for the CS pump room. The result of the comparison shows that the effect of the open-door is very small. Therefore, if we accept these evaluation results, we should consider the HVAC model in a PSA FT model, or we should reconsider the appropriateness of the HVAC system.

Thus, it is judged that it is necessary to estimate the change of the temperature of the pump rooms by considering in more detail the pump shape and condition of the pump room. Also, a duct or window in the upper part of the room, would be more effective for reducing the temperature of the room under a loss of the HVAC.

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Table 1 Operability Conditions by Category [2]

Equipment		Operable Temp.
Mechanical Equipment	Pumps (Bearing, Seal)	180 °F (180 °F, 200 °F)
	Valves	200 °F (93.3°C)
MOV Actuators	Limitorque	200 °F (93.3°C)
	Other	180 °F (82.2°C)
Electrical and Electronic Equipment	Cables	185 °F (85°C)
	Switches and Relays	185 °F (85°C)

Table 2 Operability Condition by the Pump Room

Pump Room	Operable temp. of comp. NUMARC87-00[2]
LPSI, CS, Charging, CCW, EDG, AACDG, ESW	180^{O}F (82.2°C)
AFW MDP, AFW TDP	160^{O}F (71.1°C)

Table 3 Temperature of the Rooms After 24 hours

Pump Room	Temp. of the room after 24 hour(^{O}F)	The time to reach at operable temp. of the comp.
LPSI Pump	198.24 (92.35°C)	Within 6 hours
CS Pump	219.75 (104.3°C)	Within 1 hour
HPSI Pump	204.04 (95.58°C)	Within 4 hours
AFW MDP	205.12 (96.18°C)	Within 1 hour
EDG	478.11 (247.84°C)	Within 1 hour
AAC DG	408.78 (209.32°C)	Within 1 hour
ESW	145.07 (62.82°C)	-

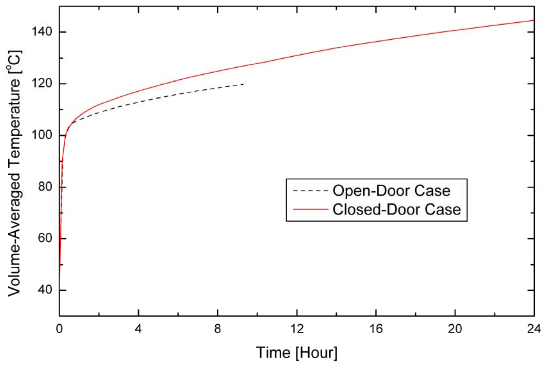

Figure 1. Temperature of the CS Pump Room w/o HVAC

References

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