*Transactions of the Korean Nuclear Society Autumn Meeting*
*PyeongChang, Korea, October 30-31, 2008*

# Reassessment of ESF Atmosphere Cleanup System's Moisture Control with 10-hour Operability Test

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## 1. Introduction

In USNRC Reg. Guide 1.52(Rev.2) for ESF(Engineered Safety Feature) ACS(atmosphere cleanup system), the maintenance clause states: "d. Each ESF atmosphere cleanup train should be operated at least 10 hours per month, with the heaters on (if so equipped), in order to reduce the buildup of moisture on the adsorbers and HEPA filters." This statement concerns the negative effect of moisture on the efficiency of filters. In YGN #5 and #6, there are 6 ESF ACSs per unit: dual ACSs for redundancy in MCR (Main Control Room), FB (Fuel Building), and ECCS (Emergency Core Cooling System) equipment room. Therefore, 6 ESF ACSs are in operation for more than ten hours per month for each unit to perform operability test. When Reg. Guide 1.52 was revised to Rev. 3, the operability test time was reduced to 15 minutes from 10 hours eliminating the moisture removal scheme[1,2,3]. In this paper, the 10-hour operability test is reassessed by examining the relationship between test time and ACS moisture control through tests.

## 2. Methods and Results

### *2.1 Materials and apparatus*

Nuclear grade activated carbon from domestic company NAC was used for the experiments. For the lab test, scaled-down simulator of YGN #5,6 ESF ACS was designed and built[4]. On-site tests were performed directly on one of the YGN ESF ACS. The temperature and humidity of ACS were measured and recorded in real-time with thermo recorder (T&D corp. model TR-72U). The moisture contents of the activated carbon were measured according to ASTM D-2867 (standard test methods for moisture in activated carbon) test procedure. Additional analyses were performed with halogen moisture analyzer (Mettler-Toledo, model HR83).

### *2.2 Moisture absorption/desorption tests on the simulator canister*

Moisture adsorption on activated carbon is a reversible physical adsorption. It is different from chemical adsorption such as iodine adsorption on activated carbon in that physical adsorption is affected by temperature and relative humidity (RH).

Four 4-inch-deep-bed canisters in ESF simulator were filled with humidified activated carbon before the simulator was started. During the simulator operation, the rate of moisture desorption was measured. As shown in Figure 1, the result showed that moisture desorption occurred mostly near the onset of the operation. This implies that longer operation does not necessarily mean better moisture desorption contrary to the conventional knowledge.

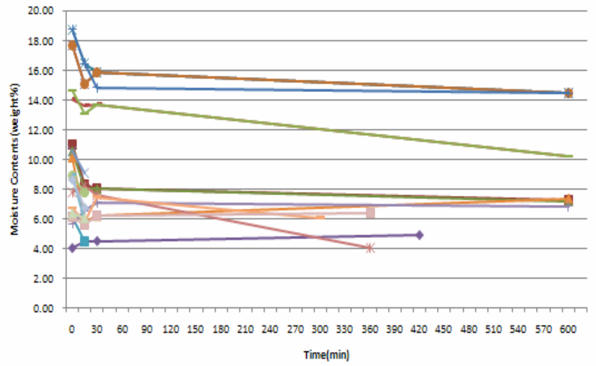



Fig. 1. Moisture desorption on the simulator

### *2.3 On-site moisture desorption tests*

Tests were performed on YGN #6 FB ESF ACS train B canister. The results before/after the actual operability test showed minor decrease of moisture after the test as shown in Table 1. However, when the next test started the level of moisture almost came back to initial state.

Table 1: Moisture desorption in on-site tests

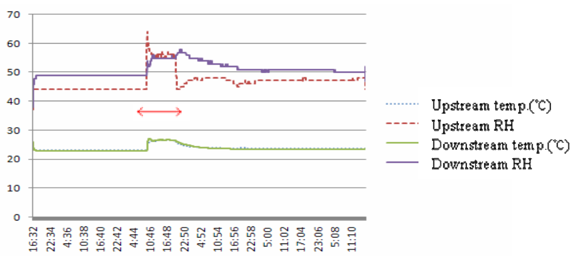
| sample | moisture contents (weight%) | |
|---|---|---|
| | Test 1 | Test 2 |
| New carbon | 5.90 | 5.73 |
| After 15 minutes | 4.84 | 4.60 |
| After 10 hours | 3.45 | 3.45 |
| Just before the next test | 4.85 | 4.73 |

### *2.4 Real-time measurement of temperature and RH of ESF ACS before/after the operability test*

The thermo recorders were installed in the system to measure and record temperature and humidity inside the system before the operability tests started until one week after the tests. One of the thermo recorders were placed between the pre-HEPA filter and the charcoal adsorber and the other was placed between the charcoal adsorber and the post-HEPA filter. Figure 2 (a), (b) are the results measured at MCR ESF ACS. Arrowed lines show the 10-hour operability test periods. Even though heaters designed to maintain 5℃ difference during the operability tests were in operation, actual temperature fluctuated along the air temperature flowing into the system during the tests. In case of (a), RH decreased during the test period and it was recovered to the initial value one day and 3-4 days after the test at the downstream and upstream of the charcoal bed respectively. In case of (b), the temperature and RH rather increased during the test period due to inflow of hot and humid air of August and decreased back to initial state after the test. Figure 3 and 4 are the results on ESF ACSs of FB and ECCS equipment room. The RH at the downstream of charcoal bed in all cases recovered to initial state in a few days after the operability tests. Some of the RH at the upstream showed values somewhat lower than the initial state at the end of the measurements. However, since the initial RH at the upstream and downstream is the same in most cases, the RH at the upstream may also go back to initial level after some period.

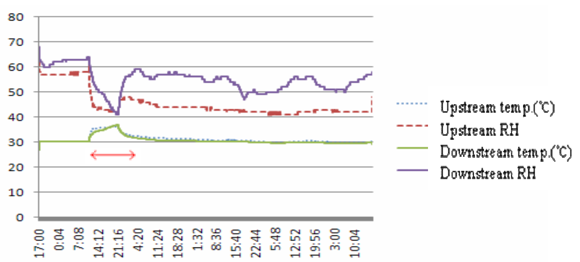
* ⟷ : *the 10-hour operability test periods*


(a) Train A of YGN #6 (2008.03.03 09:30~03.07 09:30)

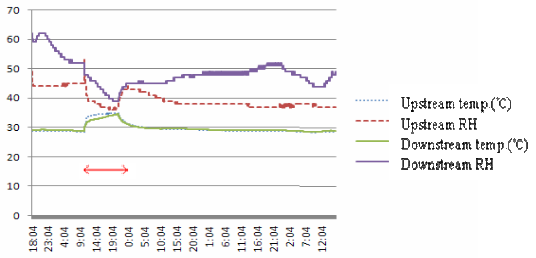



(b) Train B of YGN #5 (2008.08.01 16:30~08.06 16:30)

Fig. 2. Change of temperature and RH during the operability test in MCR ESF ACSs




(a) Train B of YGN #5 (2008.08.01 17:00~08.06 17:00)




(b) Train A of YGN #6 (2008.08.22 18:00~08.26 16:30)

Fig. 3. Change of temperature and RH during the operability test in FB ESF ACSs

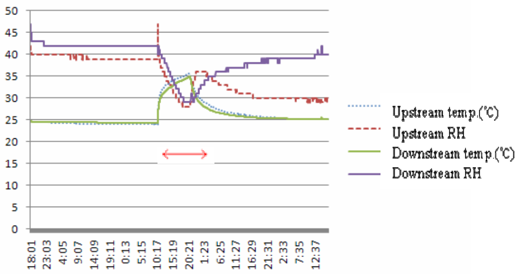



Fig. 4. Change of temperature and RH during the operability test in ECCS equipment room ESF ACS train B of YGN #6 (2008.08.22 18:00~08.26 17:00)

## 3. Conclusions

There was no consistent tendency of moisture reduction by heaters during the 10-hour operability test. The 10-hour heating during the test cannot reduce the humidity for a long time period. It is proved that the outside air affects the humidity more than the heating condition. The perturbed temperature and RH after the operability test recovered to initial state in 3-4 days. Therefore, it is not adequate to operate the system for a long time to remove moisture from the activated carbon. And longer than 15 minutes of the operability test is enough to demonstrate the function of the system [5].

## 4. Acknowledgement

The authors appreciate KHNP YGN III for the support to allow the on-site tests on ESF ACSes in YGN #5,6.

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