Performance Verification of Semi-Plant Scale Facility for TEDA Impregnated Activated Carbon Aging Test

Hyun-Chul Lee[a], Gyu-Tae Kim[a], Doo-Yong Lee [a*] Hak-Soo Kim[b], Cho-Rong Kim[b]
[a] *FNC Technology Co. Ltd, Heungdeok IT Valley, Heungdeok 1-ro, Giheung-gu, Yongin-si, Gyeonggi-do, 446-908, Korea*
[b] *Korea Hydro & Nuclear Power Co., Ltd., Central Research Institute, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, 34101, Korea*

1. Introduction

Air Cleaning Unit (ACU) in nuclear power plants (NPP) as an Engineering Safety Feature (ESF) is adopted to remove and retain toxic and radioactive gases. The NPPs are equipped with ACU containing Tri-Ethylene-Di-Amine-impregnated Activated Carbon (hereinafter TEDA-AC) to remove radioiodine. This phenomenon has been known as aging to deteriorate in performance with respect to the retention of radioiodine.

The semi-plant scale facility was developed to test the TEDA-AC aging effects from temperature, relative humidity as well as several poisoning gases. The performance verification according to the KEPIC-MH requirements [1] was conducted to confirm the design adequacy.

2. Semi-Plant Scale Facility

The semi-plant scale facility equips with similar configuration and components of NPP's ACU. The semi-plant scale facility includes the following components: strainer, demister, air heater, pre-filter, HEPA-filter, and Type-III adsorber. Fig.1 shows the 3d drawing of Type-III adsorber. Size of adsorber is determined to meet design requirement of 0.5 seconds residence time corresponding to 0.2 m/s face velocity and 4 inches bed depth. The Type-III adsorber is consisting of 4 beds of TEDA-AC and 12 canisters which provide representative of sampling of total bed thickness. The height of reservoir is 90 mm is to meet rule of minimum volume of adsorbent equivalent to 5% of the bed volume [1].

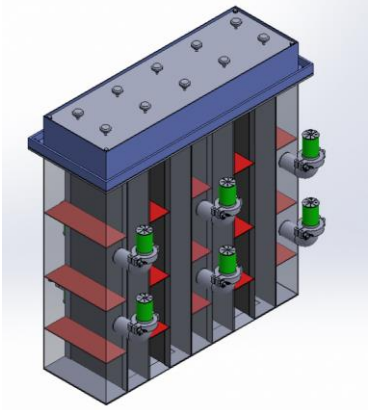

Fig. 1. 3D drawing of Type-III adsorber

Fig. 2 shows the 3D drawing of 3 semi-plant scale facilities in the thermo-hygrostat room and Fig. 3 is some pictures which is installed semi-plant scale facilities.

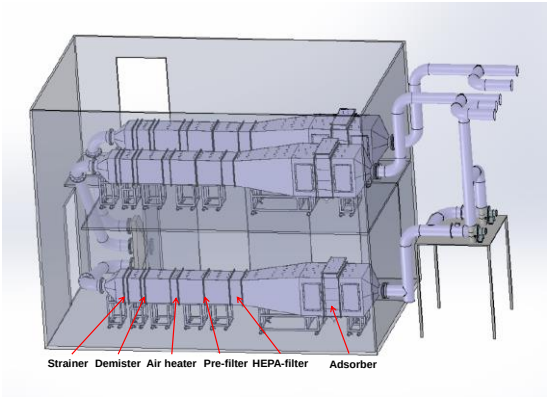

Fig. 2. 3D drawing of semi-plant facilities

Fig. 3. Pictures of installed semi-plant facilities

3. Performance Verification Test

According to the KEPIC-MH code, there are several necessaries that should be satisfied for the real nuclear power plant. In the semi-plant scale facilities, performance verification test was carried out to verify design requirements by certified testing organization. The test consists of 4 contents, which were following as:

1. Duct and housing leak test
2. Air flow distribution test
3. Air-Aerosol or challenge gas mixing test
4. HEPA filter bank in-place leak test

All of these tests were performed by methodology which is described in KEPIC-MH code [1].

3.1 Duct and Housing Leak Test

Duct and housing leak test is conducted to prove airtightness of total system volume of installed three semi-plant scale facilities. The inlet and outlet of each semi-plant facility are blocked. And the system pressure is increased up to 1.25 times of maximum static pressure of a fan. In this condition, facilities should maintain the static pressure of system for 15 minutes. Results are demonstrated in Table II.

Table I. Duct and Housing Leak Test Data

	semi-1	semi-2	semi-3
Initial Temperature [^{o}C]	20.9	21.0	21.4
Final Temperature [^{o}C]	20.7	21.0	21.5
Initial Pressure [Pa]	102510	102480	102490
Final Pressure [Pa]	102415	102314	102231
Leak Volume [m^3/h]	0.004	0.025	0.045
Result	Pass	Pass	Pass

Acceptable leak volume: 0.259 m^3/h (0.1% of design volumetric flow)

3.2 Air Flow Distribution Test

The air flow distribution test is performed to verify the face velocity uniformity by observing distribution of the face velocity flowing into the adsorber. The maximum difference of the incoming air flow should be smaller than 20% for success. The measure points of the face velocity are shown in Fig 3. Results are demonstrated in Table III.

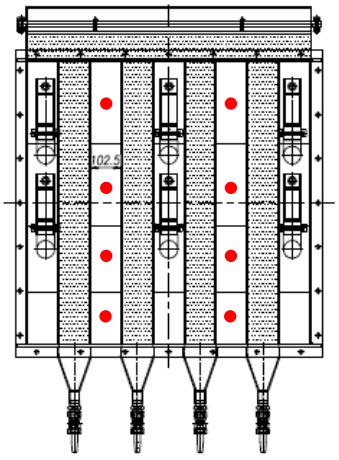

Fig. 3. Face velocity measure points of adsorber

Table II. Face velocity data of adsorber

semi-1		semi-2		semi-3	
[m/s]		[m/s]		[m/s]	
0.13	0.14	0.14	0.17	0.19	0.18
0.14	0.14	0.14	0.14	0.18	0.15
0.12	0.12	0.14	0.16	0.16	0.17
0.12	0.11	0.14	0.15	0.17	0.15
Pass		Pass		Pass	

semi-1 acceptable face velocity: 0.102 ~ 0.154 m/s
semi-2 acceptable face velocity: 0.118 ~ 0.178 m/s
semi-3 acceptable face velocity: 0.132 ~ 0.202 m/s

3.3 Air-Aerosol or challenge gas mixing test

This test is designed to verify the uniformity of challenge gas (R-11) concentration flowing to adsorber. R-11 gas generator (NUCON Inc, USA) is installed at air suction duct from outside aiming to thermo-hygrostat and generator releases the R-11 gas to inlet of semi-plant scale facility number 2 (semi-2).

Halide detector (NUCON Inc, USA) and sampling probe is set up in front of the HEPA filter to measure the R-11 concentration distribution. The cross-sectional gas concentrations are obtained in front of the HEPA filter and each value is compared to average of the cross-sectional area.

The success criteria of this test is the range of measured concentration. It should be distributed from 10.9 to 16.3 ppm, which have 20% difference from the average value. As a result, concentration of the challenge gas was represented from 13.4 to 13.8 ppm, thus our facility passed the test.

3.4 HEPA-filter bank In-Place Leak Test

The HEPA filter bank in-place leak test is a kind of repeat test to measure the filtration efficiency of the installed HEPA filter. Even if there is a proven efficiency in manufacturing the HEPA filter, the performance of the HEPA filter may be deteriorated if it is damaged during transportation or installation procedure. Test was also carried out by semi-plant facility number 2 (semi-2), and filtration efficiency is measured as 99.97%. This result means that the installed HEPA filter is not damaged during transportation and installation process.

4. Conclusion

The semi-plant scale facility was developed to observing aging effect of TEDA-AC in various condition. To verify the design of test facility, several verification test was carried out according to the KEPIC-MH code. As a result, the test facility passed in system leak test, air flow distribution test, gas mixing test, and HEPA-filter leak test. Long-term experiments to evaluate effect of the temperature, humidity, and poisoning gases will be performed by this test facility.

REFERENCES

[1] KEPIC-MH, “Nuclear Air and Gas Treatment”, 2010