Application of Emery® 3004 as a substitute for DOP in the HANARO HEPA filter In-place leakage test

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1. Introduction

HEPA (High Efficiency Particulate Air) filter system is installed on the outlet duct of the Reactor hall HVAC system of HANARO and it filters the particulate from the exhaust air. Although most HEPA filter manufacturers guarantee a minimum 99.97% efficiency when challenged with an aerosol of $0.3 \pm 0.03\,\mu m$, an in-place leakage test of a HEPA filter is still required after a filter replacement, after any maintenance activity in the filter housing, or every 18 months to verify that the filters have been installed properly, that there are no leaks in the mounting frame, and that the system contains no bypassing.

DOP (dioctylphtalate) had been widely used as a tracer gas for a HEPA filter in-place leak test. In April, 1986, U.S. Army's Office of the Surgeon General (OTSG) announced that the DOP posed potentially serious health risks to workers, and placed severe restrictions upon a testing with it. For this reason, they commenced study for finding a substitute material for DOP and finally found a synthetic lubricant named Emery® 3004 from the class of compound called poly-alpha olefin. We could find from the DOE conference proceeding that it was approved by the OTSG after a successful completion of a mutagenicity testing in Jan. 8, 1992[1]. And we could find that Emery® 3004 has already been used for the Brookhaven National Laboratory's HEPA Filter In-place Leakage Test procedure [2] and HEPA Filter and In-place Leak Testing Standard of Lawrence Livermore National Laboratory [3].

In HANARO, we performed the HEPA Filter In-place Leakage Test using both tracer agents in order to compare the performance of Emery® 3004 with that of DOP. As a result, we found that the characteristics of Emery® 3004 is very much similar to that of DOP and it was easy to handle the chemical compound since it has no toxicity. We finally came to the conclusion that Emery® 3004 will be a good substitute for DOP through the test result and we are trying to revise the relevant documents and test procedures.

2. Methods and Results

In this section, we will study the configuration of the HEPA filter system and the In-place Test Procedure, and compare the physical characteristics of DOP with that of Emery® 3004. We also compare the results of the test using Emery® 3004 with that of DOP as a tracer agent.

2.1 The configuration of HEPA filter system

The HVAC system of HANARO consists of three sub-systems consisting of a reactor hall, support area and a reactor concrete island (RCI) HVAC system. They are operating for 24 hours a day. Among these systems, the reactor hall HVAC system configuration is as shown in figure 1 and the HEPA filter system is installed at the upstream of the exhaust fan and on the outlet duct of the reactor hall. The HEPA filter system consists of three HEPA filter banks and four HEPA filters are installed in each of the banks. The specification of the HEPA filter is as shown in table 1.

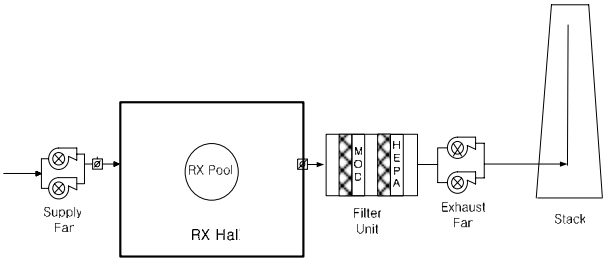

Figure 1. The configuration of HANARO's Reactor Hall HVAC system

Table 1. The specification of HEPA filter [4]

Media	Water proof micro glass fiber					
Frame	Aluminum					
Sealer	Self-extinguishing sealant					
Gasket	Neoprene sponge					
Max. Temp	60˚C					
Max. Humidity	100%RH					
Rated Flow (CMM)	Diff. Pr (mmAq)		Dimension (mm)			Wt. (kg)
56	Initial	Final	H	W	D	25
	25.4	50	610	610	292	

2.2 The Method of HEPA Filter In-place Leak Test

According to the ANSI N510 and our periodic test procedure, a HEPA filter in-place leakage test is required during acceptance test of a HEPA filter system, after a replacement of all or part of a HEPA filter in a system, or after any maintenance activity in the filter housing, or every 18 months. The purpose of the in-place test is to verify the robustness of the system, particularly to examine the leaks or damage of the filter and housing. The test configuration is as shown in figure 2.

While the HVAC system is in operation, we inject the tracer agent (hot aerosol) into the upstream duct of the HEPA filter system and measure the concentrations of the aerosol at the upstream and downstream of the HEPA filter system from the penetrometer. Using the following formula 1, we calculate the % penetration of the aerosol.

$$\% \; P = 100 \times \frac{C_d}{C_u} \quad \text{--- (1)}$$

Where % P: percent penetration

Cd : the concentration of downstream aerosol
Cu : the concentration of upstream aerosol

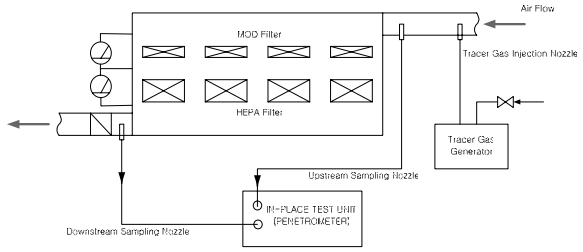

Figure 2. The configuration of HEPA filter in-place leak test

2.3 Physical characteristics of DOP and Emery 3004

DOP is has been used as a tracer agent for the HEPA filter in-place test for a long time and mainly as a plasticizer. Organizations continued to use DOP in the HEPA filter in-place test even after that DOP was reported as a carcinogen. However, the co-workers who used DOP for the test often complained of a sore throat even if they wore a protective mask. Therefore we had a case study of the application of Emery® 3004 as a substitute for DOP and found that it was already used in the Brookhaven National Laboratory and Lawrence Livermore National Laboratory in U.S.A. by their established test procedures [2,3]. A synthetic lubricant named Emery® 3004 from the class of compounds called poly-alpha olefins (PAOs) was originally developed by the multinational company named Henkel Corporation. Now it is produced by a company named Cognis Corporation.

Table 2. Physical characteristics of DOP and Emery® 3004 [5,6]

	DOP	Emery® 3004
Specific gravity	0.983 @25°C	0.82 @15.6°C
Viscosity @ 0°C	373.4 cSt	94.5 cSt
Viscosity @ 20°C	79.8 cSt	N/A
Viscosity @ 40°C	21.6 cSt	16.9 cSt
Viscosity @ 100°C	N/A	3.9 cSt
Pour point	-46°C	-69°C
Flash point	218°C	219°C
Fire point	N/A	249°C
Auto ignition point	390°C	343°C
Surface Tension @25°C	31.3 dynes/cm	29.0 dyne/cm

2.4 The Comparison of the test results using the DOP and Emery® 3004

Recently, we had an in-place test after a replacement of HEPA filters in the RX hall HVAC system as per our periodic test procedure which was established based on ANSI N510. We made a test configuration as shown in figure 2 and injected hot DOP aerosol from the DOP generator into the upstream port of the HEPA filter system. We measured the upstream concentration and downstream concentration of the DOP aerosol in the HEPA filter system and calculated the % penetration. After finishing the test using DOP, we cooled down the generator and emptied the DOP completely. And we injected Emery® 3004 into the same generator and heated it up to 400°C of the setting temperature. With the same method of test, we measured the concentration of each tracer agent five times respectively and obtained the test results as shown in table 3.

Table 3. Comparison of the test results

	DOP		Av.	Emery 3004		Av.
Upstream Penetrometer reading	1	40x100	4400	1	50x100	4000
	2	45x100		2	40x100	
	3	30x100		3	45x100	
	4	50x100		4	30x100	
	5	55x100		5	35x100	
Downstream Penetrometer Reading	1	15x0.01	0.19	1	30x0.01	0.22
	2	20x0.01		2	20x0.01	
	3	25x0.01		3	25x0.01	
	4	15x0.01		4	15x0.01	
	5	20x0.01		5	20x0.01	
%penetration	0.0043			0.0055		

3. Conclusions

As mentioned above, when we had an in-place test with DOP, the co-workers were reluctant to join in the test even if they had a protective mask and often complained of a sore throat. On the other hand, Emery® 3004 has no toxicity, is not a carcinogen and is easy to handle. And the good thing is that we could perform the in-place test without a modification or replacement of the existing test equipments while using the Emery® 3004. When we compared the test results of both tracer agents, we found that they showed similar results. Only difference is the consumption of Emery® 3004 is higher because the viscosity of Emery® 3004 is lower. As a result, we found that our HEPA filter system was robust and the efficiency of the system exceeded the value that was guaranteed by the HEPA filter manufacturer. Since we could established the basis for using Emery® 3004 as a tracer agent in the HEPA filter in-place leak test, we are now trying to revise the relevant document and test procedures.

REFERENCES

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[6] Emery® 3004 Technical Data Sheet #2033A-7/2000, Cognis Corporation