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Office VOC Mixture Test Report

Manufacturer: Genesis Air

Product Name: Populated Catalyst Panel

RTI Report Number: A03230904

Test Laboratory:

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Office Mixture Test for Genesis Air Populated Catalyst Panel

The objective of this test was to expose the Genesis Air air cleaner to a challenge containing a mixture of many common office environment gases and determine production rates for aldehydes if any were produced. The unit was tested at air flowrates of 1200, 2000, and 2500 cfm (300, 500, and 625 fpm for this 24 x 24" unit).

Temperature and humidity were not controlled in the test rig itself but since the inlet air came from a temperature and humidity controlled room the result was steady conditions for the tests.

Temperature and Humidity for the Three Test Runs

Airflow Rate (cfm)	Temp. (F)	Relative Humidity %
1200	72	42
2000	73	40
2500	73	41

The Genesis Air Populated Catalyst Panel was installed in RTI's ASHRAE 52.2 test rig. With the unit installed, challenge injection OFF, and the rig on at 1200 cfm, the upstream and downstream were sampled for background levels. These background values applied to both the formaldehyde (separate test report) and the office mixture tests; however, the values are presented to show the low concentrations in the test rig but were not subtracted from the concentrations determined for the upstream and downstream samples in the data analysis.

The challenge concentration was produced by metering liquid through an HPLC pump into an approximately 75C heated chamber with 11.5 cfm nitrogen to vaporize the liquid completely before injecting it into the test rig. The resulting nitrogen/challenge gas stream is introduced into the rig through a multi-port manifold that ensures uniform distribution of the challenge. For this test, the mixture was based on one used by Lawrence Berkeley National Laboratory (LBNL) in a recent study (Hodgson et al., 2005). This mixture is described in detail following the description of the sampling procedure.

All sampling for the tests was done with simultaneous upstream and downstream samplers. For each case, 3 samplers each for carbonyls and volatile organic compounds (VOCs) were set up upstream and downstream.

To determine the upstream aldehyde and possible aldehyde byproducts at the expected low concentrations, carbonyl samples were collected onto silica tubes coated with dinitrophenyl

hydrazine where they were adsorbed and derivatized to the corresponding dinitrophenyl hydrazones. Sampling flow rates were nominally 1 L/min for 30 minutes. Derivatized carbonyls were eluted from the tubes with acetonitrile and the extracts were analyzed using High Performance Liquid Chromatography with absorbance detection. Target analytes were quantified against a suite of standard compounds. Chromatograms were inspected visually for the detection of any non-target analytes. Each sample was analyzed for formaldehyde and likely byproducts present at or above the specified Detection Limits.

VOCs were sampled for one hour with a 6-L sample volume onto Carbotrap tubes. The sampling tubes gave the concentrations of the challenge compounds and the byproducts. The VOCs were collected onto a sorbent tube, again using constant flow pumps. Sorbent tubes were kept cold until analysis using thermal desorption GC/MS. Each sample was analyzed for the challenge compounds at or above the specified LODs using the response factor for toluene. The reproducibility of a toluene standard for a sorbent tube was acceptable. Additional peaks that could be byproducts were examined. Note that isopropanol and acetone coeluted on the column used for the analysis. This was considered acceptable as the concentration of each compound by itself was not critical to the issue of aldehyde production and the column and procedure worked well for the other compounds.

Once sampling was completed, new sampling tubes were installed and the airflow and mixture feedrate were changed. Then sampling was performed for the next set of conditions.

The Office Mixture is a mixture based on an LBNL test mixture. The requested challenge list is shown in Table 1. Note that the R-11 refrigerant in the LBNL study is not included in this test due to recycling and purchase issues; this was discussed with client before removing from the list. Since the LBNL study showed different concentrations for different runs, we modeled our study on data shown in their Table 5 with a goal of being within the range of values shown in their study. The list of compounds with TLV, class, and molecular weight are shown in Table 1.

In conclusion, the Office Mixture was introduced into the Genesis Air Populated Catalyst Panel air cleaner at three air flowrates. Sampling for aldehydes showed no statistically significant production of aldehydes at the $\alpha = 0.05$ level except for a small increase in acetone at one flowrate.

REFERENCE

Hodgson, A.T., D.P. Sullivan, and W.J. Fisk. 2005. "Evaluation of Ultra-Violet Photocatalytic Oxidation (UVPCO) for Indoor Air Applications: Conversion of Volatile Organic Compounds at Low Part-per-Billion Concentrations. <http://repositories.cdlib.org/lbnl/LBNL-58936>.

Table 1 Office VOC Mixture (based on LBNL Study*)

	TLV (ppm)	Class	MW	Detection Limit (ppb)**
Ethanol	1000	Alcohol	46.07	0.9
2-Propanol (Isopropanol)	400	Alcohol	60.10	0.7
1-Butanol	20	Alcohol	74.12	0.6
2-Ethyl-1-hexanol (Ethylhexanol)		Alcohol	130.23	0.3
Phenol	5	Alcohol	94.11	0.5
2-Butoxyethanol	25	Glycol ether	118.18	0.4
tert-Butyl methyl ether MTBE	40	Ether	88.15	0.5
2-Propanone (Acetone)	500	Ketone	58.08	0.8/0.7***
2-Butanone	200	Ketone	72.11	0.6
4-Methyl-2-pentanone MIBK	50	Ketone	100.16	0.4
Hexanal		Aldehyde	100.16	0.4
d-Limonene		Terpene HC	136.24	0.3
Toluene	50	Aromatic HC	92.14	0.5
m-Xylene	100	Aromatic HC	106.17	0.4
1,2,4-Trimethylbenzene (1,2,4-TMB)		Aromatic HC	120.20	0.4
n-Nonane	200	Alkane HC	128.26	0.3
n-Decane		Alkane HC	142.29	0.3
n-Undecane		Alkane HC	156.31	0.3
n-Dodecane		Alkane HC	170.34	0.3
Dichloromethane (DCM)	25	Halo HC	84.93	0.5
1,1,1-Trichloroethane (1,1,1-TCA)	350	Halo HC	133.41	0.3
Trichloroethene	50	Halo HC	131.39	0.3
Tetrachloroethene (PCE)	25	Halo HC	165.83	0.3
1,2-Dichlorobenzene (1,2-DCB)	25	Halo HC	147.00	0.3
Carbon disulfide (CS2)	10	Sulfide	76.14	0.6
Decamethylcyclopentasiloxane (D5)		Siloxane	370.78	0.1

*Trichlorofluoromethane (R-11) was included in the LBL study but not in this one.

**Note that the detection limit units are three orders of magnitude lower than the TLVs.

*** Carbonyl method, VOC method.

Background Sampling for Carbonyls+

Analyte	Upstream					Downstream					Detection Limit (ppb)
	#1	#2	#3	Average (ppb)	Confidence Interval*	#1	#2	#3	Average (ppb)	Confidence Interval*	
Formaldehyde	2.7	2.8	2.8	2.8	2.7 2.8	2.3	2.8	1.1	2.0	1.0 3.0	1.5
Acetaldehyde	3.9	4.0	4.3	4.1	3.8 4.3	4.0	3.9	2.1	3.3	2.1 4.5	1.0
Acetone	11.0	11.0	12.2	11.4	10.6 12.2	11.9	12.1	10.5	11.5	10.6 12.4	0.8
Acrolein	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.8
Propionaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.8
Crotonaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.6
n-Butyraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.6
Benzaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.4
iso-Valeraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.5
Valeraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.5
m-Tolualdehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.4
o,p-Tolualdehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.4
Hexanaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.4
2,5-Dimethylbenzaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		0.3

*for alpha=0.05

+ 0.0 values are compounds that were not detected. Acrolein and crotonaldehyde are unstable on the DNPH sampler.

Office Mixture Test: Flow Rate 1200 cfm+

Analyte	Upstream					Downstream				
	#1	#2	#3	Average (ppb)	Confidence Interval*	#1	#2	#3	Average (ppb)	Confidence Interval*
Formaldehyde	110	122	120	117	110 125	121	116	118	118	116 121
Acetaldehyde	4.5	6.2	5.5	5.4	4.5 6.4	7	5	5	5.7	4.7 6.7
Acetone	205	239	238	227	206 249	247	226	230	235	222 247
Acrolein	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	
Propionaldehyde	0.1	0.0	0.0	0.0	0.0 0.1	0.0	0.0	0.0	0.0	
Crotonaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	
n-Butyraldehyde	0.0	0.0	0.0	0.0		0.0	0.5	0.0	0.2	-0.2 0.5
Benzaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	
iso-Valeraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	
Valeraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	
m-Tolualdehyde	27.9	31.9	32.9	30.9	27.9 33.8	37	31	30	32.6	28.4 36.9
o,p-Tolualdehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	
Hexanaldehyde	14.8	17.4	17.5	16.6	14.8 18.3	19	17	17	17.6	15.8 19.5
2,5-Dimethylbenzaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	

*for alpha=0.05

+ 0.0 values are compounds that were not detected. Acrolein and crotonaldehyde are unstable on the DNPH sampler.

Office Mixture Test: Flow Rate 2000 cfm+

Analyte	Upstream					Downstream						
	#1	#2	#3	Average (ppb)	Confidence Interval*	#1	#2	#3	Average (ppb)	Confidence Interval*		
Formaldehyde	25	29	28	27	25 29	26	26	26	26	25 26		
Acetaldehyde	7.3	8.0	7.9	7.7	7.3 8.2	7.3	7.0	7.1	7.1	7.0 7.3		
Acetone	277	317	317	304	278 329	278	264	264	269	259 278		
Acrolein	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Propionaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Crotonaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
n-Butyraldehyde	0.3	0.0	0.0	0.1	-0.1 0.3	0.0	0.0	0.0	0.0			
Benzaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
iso-Valeraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Valeraldehyde	0.0	0.1	0.0	0.0	0.0 0.1	0.0	0.0	0.0	0.0			
m-Tolualdehyde	37.8	41.9	42.6	40.8	37.8 43.8	37.6	38.6	38.8	38.3	37.6 39.1		
o,p-Tolualdehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Hexanaldehyde	17.3	20.8	21.1	19.7	17.3 22.2	18.8	18.6	18.8	18.7	18.6 18.8		
2,5-Dimethylbenzaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			

*for alpha=0.05

+ 0.0 values are compounds that were not detected. Acrolein and crotonaldehyde are unstable on the DNPH sampler.

Office Mixture Test: Flow Rate 2500 cfm+

Analyte	Upstream					Downstream						
	#1	#2	#3	Average (ppb)	Confidence Interval*	#1	#2	#3	Average (ppb)	Confidence Interval*		
Formaldehyde	23	23	23	23	23 23	22	23	23	23	22 23		
Acetaldehyde	50	48	46	48	46 50	45	45	45	45	45 45		
Acetone	265	274	282	274	265 283	289	303	291	294	286 303		
Acrolein	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Propionaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Crotonaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
n-Butyraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Benzaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
iso-Valeraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Valeraldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
m-Tolualdehyde	40	43	43	42	40 44	42	45	42	43	41 45		
o,p-Tolualdehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Hexanaldehyde	20	21	21	21	20 21	19	21	20	20	19 21		
2,5-Dimethylbenzaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			

*that the means are different

**for alpha=0.05

+ 0.0 values are compounds that were not detected. Acrolein and crotonaldehyde are unstable on the DNPH sampler.