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Formaldehyde Test Report

Manufacturer: Genesis

Product Name: Populated Catalyst Panel

RTI Report Number: A03230901

Test Laboratory:

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Formaldehyde Test for Genesis Populated Catalyst Panel

The objective of this test was to expose the Genesis air cleaner to a challenge containing formaldehyde at approximately 750 ppb in air at flowrates of 1200, 2000, and 2500 cfm (300, 500, and 625 fpm for this 24 x 24 " unit).

The air cleaner, the Populated Catalyst Panel, was a UV PCO system and is shown in the attached figure. This unit was installed in RTI's ASHRAE 52.2 test rig with a light baffle upstream. This baffle was installed to prevent light from the unit interfering with the upstream sampling location. The baffle does not interfere with the working of the unit. The pressure drops reported for the unit were determined by subtracting the pressure drop of the baffle from the combined pressure drop during the tests.

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.

Gas-phase air cleaners were installed upstream of the test section along with the particulate filters required for ASHRAE 52.2. These gas-phase air cleaners were intended to remove any contaminants from the inlet room air.

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, Formalin was used to produce the formaldehyde challenge. Formalin is a liquid mixture that is approximately 4% formaldehyde, 1% methanol (as a stabilizer), and water.

All sampling for the tests was done with simultaneous upstream and downstream samplers. For each case, 3 samplers were set up upstream and downstream. However, due to pump failure one of the triplicate samples was not collected in one of the tests. This sample's values are shown in the data tables as NA.

To determine the formaldehyde 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, and scrubbers to remove ozone from the air stream were placed upstream of the sampling cartridges. 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.

To determine the background levels in the test rig, the upstream and downstream airflows were sampled with the unit installed and OFF, the challenge injection OFF, and the rig on at 1200 cfm. These background values were used for data analysis for both the formaldehyde and the office mixture tests (see separate test report).

After background sampling, the air cleaner was turned on and Formalin, at the feed rate required to give approximately 750 ppb, was injected using the VOC generator. Upstream and downstream samples were taken as described above. After sampling was completed, the rig air flowrate and the formalin injection rate were adjusted as appropriate, and samples were obtained for the other two flowrates.

The data for these runs is shown in tables after the discussion. Data for each run, averages, and relative standard deviations are shown. Detection limits are shown for each compound. To allow for comparison of concentrations found in the downstream air to the accepted safety limits, ACGIH TLVs and other recommended limits are shown for those compounds where they were readily available.

Statistical analysis of the data using a T-test for comparison of the upstream and downstream means for each compound showed that the upstream and downstream concentrations can be considered the same except for one compound at one flowrate. At 1200 cfm, acetaldehyde showed a very small increase of 0.4 ppb; this increase was enough to make the upstream and downstream averages statistically different at the 95% confidence level. The rate of increase as related to the level of the formaldehyde in the rig was 0.001 ppb increase in measured concentration per ppb of formaldehyde.

Since efficiencies were included as a goal for the project, these are calculated based on the numbers and shown to be low or negative. The efficiencies were calculated as (upstream concentration – downstream concentration)/upstream concentration x 100%. Also, a production rate of the compounds that show up in higher concentrations in the downstream than the upstream were calculated using the increase in concentration divided by the upstream formaldehyde concentration. These values are provided for informational purposes even though, they are actually statistically equivalent to no production.

In conclusion, formaldehyde was introduced into the Genesis Air Cleaner at approximately 750 ppb. Sampling for aldehydes showed no significant reduction in formaldehyde or production of other target aldehydes. Some very small carbonyl derivatives were noted from the chromatograms; however, these occurred in both the upstream and downstream samples.

Airflow Rate (cfm)	Temp. (F)	Relative Humidity %	Pressure Drop (in. H ₂ O)
1200	72	42	0.22
2000	73	40	0.59
2500	73	41	0.92

The Genesis Populated Catalyst Panel as installed in the RTI test duct.



Target Analytes, Exposure Limits (8 h) and Method Detection Limits

Analyte	ACGIH TLV (ppm)	OSHA TWA (ppm)	Detection Limit (ppb)**
Formaldehyde	0.3 (ceiling)	0.75	1.5
Acetaldehyde	25	200	1.0
Acetone	500		0.8
Acrolein	0.1		0.8
Propionaldehyde	20		0.8
Crotonaldehyde	0.3	2	0.6
n-Butyraldehyde			0.6
Benzaldehyde			0.4
iso-Valeraldehyde			0.5
Valeraldehyde	50		0.5
m-Tolualdehyde			0.4
o,p-Tolualdehyde			0.4
Hexanaldehyde			0.4
2,5-Dimethylbenzaldehyde			0.3

* not all compounds had established limits.

**note that the detection limits are 3 orders of magnitude lower than the TLV/TWAs.

Background Sampling for Carbonyls+

Analyte	Upstream					Downstream							
	#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		
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		
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		
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	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0				
o,p-Tolualdehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0				
Hexanaldehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0				
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.

Formaldehyde Test: Flow Rate 1200 cfm+

Analyte	Upstream					Downstream							
	#1	#2	#3	Average (ppb)	Confidence Interval*	#1	#2	#3	Average ¹ (ppb)	Confidence Interval*			
Formaldehyde	666	743	727	712	666 758	NA	694	708	701	687	714		
Acetaldehyde	4.3	4.4	4.2	4.3	4.1 4.5	NA	4.7	4.6	4.7	4.6	4.8		
Acetone	14.2	15.8	13.8	14.6	13.4 15.8	NA	15.2	14.8	15.0	14.6	15.4		
Acrolein	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
Propionaldehyde	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
Crotonaldehyde	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
n-Butyraldehyde	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
Benzaldehyde	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
iso-Valeraldehyde	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
Valeraldehyde	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
m-Tolualdehyde	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
o,p-Tolualdehyde	0.0	0.0	0.0	0.0		NA	0.0	0.0	0.0				
Hexanaldehyde	0.4	0.2	0.5	0.4	0.2 0.6	NA	0.0	0.3	0.1	-0.1	0.4		
2,5-Dimethylbenzaldehyde	0.0	0.0	0.0	0.0		NA	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.

Formaldehyde Test: Flow Rate 2000 cfm+

Analyte	Upstream					Downstream						
	#1	#2	#3	Average ¹ (ppb)	Confidence Interval*	#1	#2	#3	Average ¹ (ppb)	Confidence Interval*		
Formaldehyde	686	735	703	708	679 736	710	729	732	724	710	737	
Acetaldehyde	3.0	3.1	2.6	2.9	2.6 3.2	2.9	3.1	3.3	3.1	2.9	3.3	
Acetone	10.9	10.6	11.2	10.9	10.6 11.3	11.2	10.4	10.7	10.8	10.3	11.2	
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	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
o,p-Tolualdehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Hexanaldehyde	0.4	0.3	0.3	0.3	0.2 0.4	0.2	0.2	0.4	0.3	0.2	0.4	
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.

Formaldehyde Test: Flow Rate 2500 cfm+

Analyte	Upstream					Downstream						
	#1	#2	#3	Average ¹ (ppb)	Confidence Interval*	#1	#2	#3	Average ¹ (ppb)	Confidence Interval*		
Formaldehyde	690	775	760	742	690 793	688	704	702	698	688	708	
Acetaldehyde	3.6	3.7	3.7	3.7	3.6 3.8	3.7	3.5	4.1	3.8	3.4	4.1	
Acetone	11.2	10.9	8.6	10.2	8.6 11.8	9.4	8.1	10.5	9.4	8.0	10.7	
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	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
o,p-Tolualdehyde	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0			
Hexanaldehyde	0.4	0.4	0.3	0.4	0.3 0.4	0.0	0.4	0.4	0.3	0.0	0.5	
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.

Formaldehyde Test: Airflow 1200 cfm

Analyte	Upstream Average (ppb)	Downstream Average (ppb)	Statistically different by T-test⁺	Efficiency % *	Increase ppb of compound/ppb of formaldehyde upstream
Formaldehyde	712	701	no	2	
Acetaldehyde	4.3	4.7	yes		0.001
Acetone	14.6	15.0	no		0.001
Acrolein	0	0	no		
Propionaldehyde	0	0	no		
Crotonaldehyde	0	0	no		
n-Butyraldehyde	0	0	no		
Benzaldehyde	0	0	no		
iso-Valeraldehyde	0	0	no		
Valeraldehyde	0	0	no		
m-Tolualdehyde	0	0	no		
o,p-Tolualdehyde	0	0	no		
Hexanaldehyde	0.4	0.1	no		
2,5-Dimethylbenzaldehyde	0	0	no		

+ at $\alpha = 0.05$

Formaldehyde Test: Airflow 2000 cfm

Analyte	Upstream Average (ppb)	Downstream Average (ppb)	Statistically different by T-test⁺	Efficiency % *	Increase ppb of compound/ppb of formaldehyde upstream
Formaldehyde	708	724	no		0.02
Acetaldehyde	2.9	3.1	no		0.0003
Acetone	10.9	10.8	no	1	
Acrolein	0	0	no		
Propionaldehyde	0	0	no		
Crotonaldehyde	0	0	no		
n-Butyraldehyde	0	0	no		
Benzaldehyde	0	0	no		
iso-Valeraldehyde	0	0	no		
Valeraldehyde	0	0	no		
m-Tolualdehyde	0	0	no		
o,p-Tolualdehyde	0	0	no		
Hexanaldehyde	0.3	0.3	no		
2,5-Dimethylbenzaldehyde	0	0	no		

+ at $\alpha = 0.05$

* not statistically significant

Formaldehyde Test: Airflow 2500 cfm

Analyte	Upstream Average (ppb)	Downstream Average (ppb)	Statistically different by T· test+	Efficiency % *	Increase ppb of compound/ppb of formaldehyde upstream
Formaldehyde	742	698	no	6	
Acetaldehyde	4	4	no		0.0001
Acetone	10	9	no	8	
Acrolein	0	0	no		
Propionaldehyde	0	0	no		
Crotonaldehyde	0	0	no		
n-Butyraldehyde	0	0	no		
Benzaldehyde	0	0	no		
iso-Valeraldehyde	0	0	no		
Valeraldehyde	0	0	no		
m-Tolualdehyde	0	0	no		
o,p-Tolualdehyde	0	0	no		
Hexanaldehyde	0.4	0.3	no	26	
2,5-Dimethylbenzaldehyde	0	0	no		

+ at $\alpha = 0.05$

* not statistically significant