NoVOC Performance Resins, LLC

Formerly known as

Composite Technology Polymers Group, LLC

Alternative Gel-Coat Technology
Emission Testing

October 17 – October 19, 2000

Emission Tests Performed at
Coating Applications Research Laboratory
(CARL)

CARL Test Personnel
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Summary Report
November 21, 2000

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New Gel-coat
Emission Testing
October17-19, 2000

Composite Technology Group

Introduction:

From October 17 through October 19 Composite Technology Group personnel were present at the Coatings Application Research Laboratory (CARL), located at Purdue University, to perform a series of emission tests on an alternate type of gel-coat designed to be free of hazardous styrene and other VOC/HAP air pollutant emissions. The laboratory performed five (5) emission tests on the gel-coat supplied. Emissions of all tests were then compared. Two different operators applied gel-coat during the tests and an ANOVA comparison was made to examine for any detectable difference in emissions due to "operators."

The resultant emissions data suggest that the gel-coat does indeed reduce emissions to a very low level, relative to styrene based gel-coats tested in the past. The exact identity of these very low emissions is not known to CMTI personnel at this time, but could be due in part, or wholly, to the MEKP catalyst or derivative compounds which develop as a result of its chemical reaction with the gel-coat resin during polymerization. After the five tests, a continuous 5½-minute application of the gel-coat was applied to the mold. During this period an 18-liter gas sample of the emissions was collected from the stack into a Tedlar bag for gas chromatograph mass spectroscopy (GC/MS) evaluation. The content of VOC/HAP in the sample was very small and results of GC/MS testing proved inconclusive. However, the results provided strong evidence of extremely small amounts of organic compounds such as benzene and toluene. Composites Technology Group has provided CARL personnel with a new sample of the gel-coat material which will used to perform further GC/MS tests in an attempt to gain more useful information than the first GS/MS test provided.

Gel-coat and Catalyst Used:

The emission tests were performed using Composite Technology Group's "No-VOC Gel-coat – Number 1600 Base Resin". The catalyst was Methyl Ethyl Ketone Peroxide (MEKP).

Application Equipment operational settings (all application equipment supplied and operated by Composite Technologies Group, LLC):

Tests 1, 2, 3, 4, 5

Magnum Air-Assisted-Airless, External mix
512 tip size
20 to 1 pump, 90 psi air
2% (by volume) catalyst mix (specific gravity approximately equal to 1.0)
10 psi shaping air pressure for the catalyst

All tests were performed in accordance with the following EPA methods:

- Method 204 - Temporary/permanent enclosure -- Collection of 100 % Emissions

- Method 1 - Sample and Velocity Traverse for Stationary Sources
- Method 2A - Standard Pitot Tube
- Method 25A - Determination of Total Gaseous, Organic Concentration, Using Flame Ionization Analyzer

The emissions data in this report is given as equivalent percent styrene emission as compared to the total pounds of gel-coat applied.

Equipment Used During Test

Magnum application equipment, External-mix Air Assisted Airless
J.U.M. Engineering, Inc. flame ionization detector (FID), model 3-100 -- (2 units)
Dwyer Instrument, Inc.-2 standard-design pitot tubes, model 160 series
Dwyer Instrument, Inc. primary standard manometer, model #424
NEC data-logging Pentium-II portable computer
National Instruments: LabVIEW, version 5.1 Graphical Programming Software, data acquisition software
National Instruments: LabVIEW DAQCARD AI-16XE-50 voltage to digital converter
National Instruments: SCB-68 voltage to digital interface
Dwyer Instrument, Inc. pressure transducer, model 607-4—convert inches of water pressure to linear voltage readout
Alnor Velometer series 6000—air velocity measurement instrument
Barnant temperature & relative humidity logger, model 6919000
Dwyer Instrument, Inc. temperature meter-voltage readout, model 4151D
Binks standard paint booth modified for 100% emission capture, stack airflow approx. 5950 cfm.
EPA method 204 temporary/permanent enclosure—collection of 100% of emissions
Sartorious scale—360 pounds maximum, 2 gram sensitivity (computer readout)
Sartorious scale—150 pounds maximum, 1 gram sensitivity
CFA certified male mold with overspray capture flange

Emission Test Procedure:

Two TCA-FIDs were calibrated using EPA certified propane gas standards prior to the beginning of each test and were rechecked at the end of each test. One FID monitored Stack-ppm and the other monitored Background-ppm.

Application took place only after the lab had reached a VOC PPM baseline level of approximately 1-PPM (as indicated on the TCA-FIDs using propane as the calibration standard).

Gel-coat material was applied to a CFA designed, male, mold surface (35.66 sq. ft. including flange and application was applied up to and beyond the flange, in a manner similar to production methods, but not with excessive, indiscriminate over-spray.

The gel-coat material was applied to an approximate wet-mil thickness of 16 to 20 mils.

Typical application time was approximately 70 to 84 seconds allowing a targeted gel-coat deposition onto the mold surface of approximately 2.088 Kg. (4.272 lbs.). The actual application time varied depending on the gel-coat flow rate from the application equipment.

The TCA-FID ppm outputs were verified and re-calibrated (if required) using EPA certified propane gas standards at the end of each test. The calibration drift of the TCA-FIDs was less than 2% for every test. Calibration drift of less than 5% is deemed acceptable by the EPA for Method 25A emission tests.

Catalyst (initiator) ratio to gel-coat was two (2) percent by volume.

The gel-coat material, applied to the CFA male mold, was monitored for emissions (data was logged every two seconds) during each complete test, from the start of the gel-coat application process, through cure of the material to the point where gel-coat would not transfer to a finger when touched with light pressure. Each emission test was deemed complete, only when the gel-coat had reached this state and the emissions had returned to original baseline levels or lower. The entire emission test process, for each of the tests run, spanned approximately one hour (-0, + 3 minutes). The laboratory environment and the air moving through the booth ranged from 72-81°F for all tests. The gel-coat temperature for all tests ranged from 65 - 75°F.

Test acceptance or rejection from the emission factor calculation:

As indicated on Chart-1, an anomaly was detected in Test-1 whereby the background ppm went up slightly during a portion of the test. This was determined to have minimal effect on the percent-emissions for that test. Tests-2 & 3 were conducted using a different operator than Tests 1, 4, & 5. In the first application by operator-2, the start of application was well off the mold and the distance and time spent beyond the flanges was noticeably greater than in other tests. A limited amount of instruction, afterward, altered this operator's technique to conform similar to that of operator-1. Analysis of the data collected, indicated no substantial effect on test results. All tests were deemed acceptable for inclusion in the subsequent analyses.

Please see following chart:

Chart 1 – Graph of styrene-equivalent ppm-emission traces verses time, for each of the five gel-coat tests.

Please see following tables:

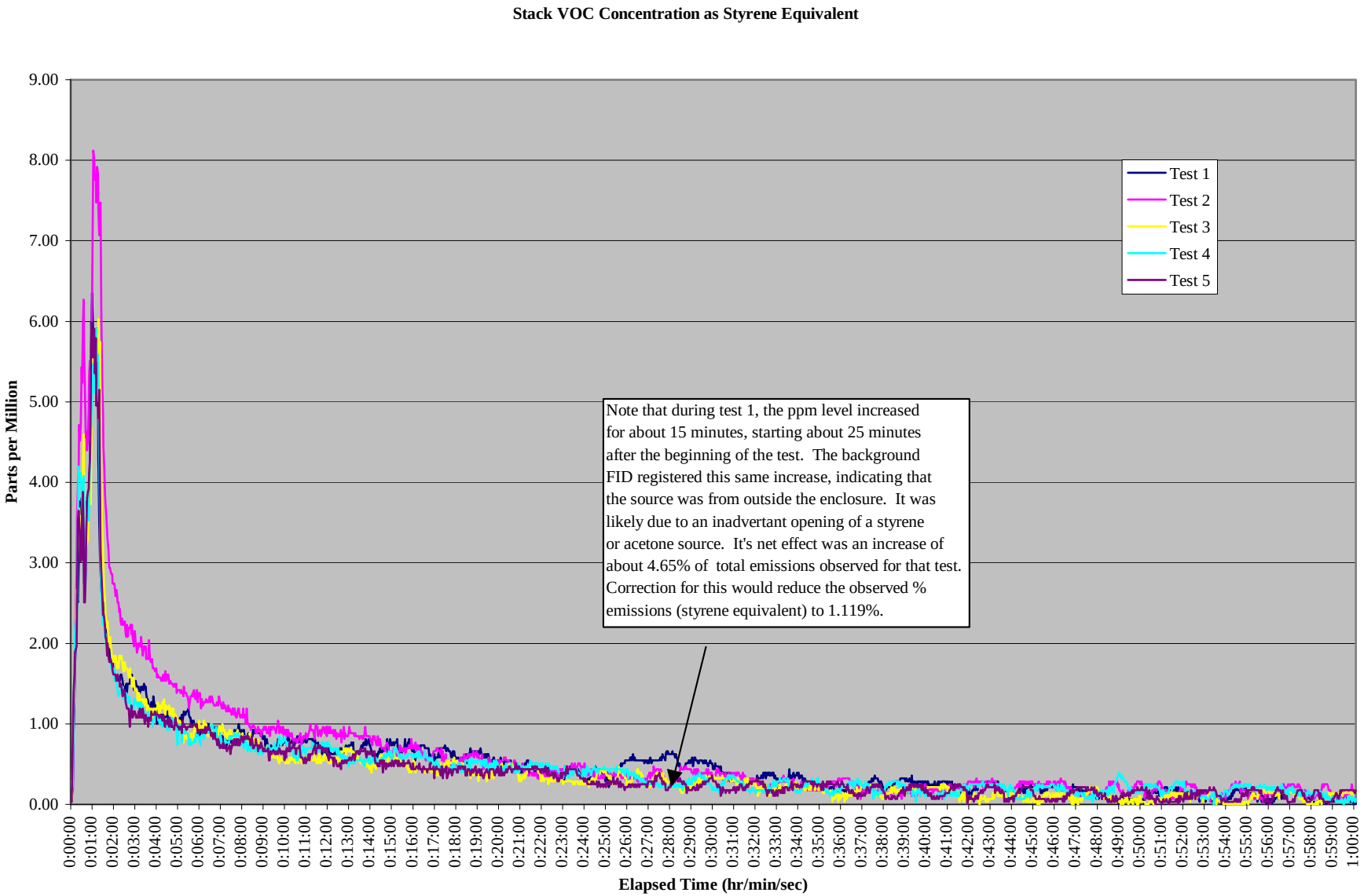
Table 1 – Stack Traverse Data.

Table 2 – Statistical Analysis of Variance (ANOVA).

Table 3 – Descriptive Statistics are supplied that indicate the minimal effect of the background ppm anomaly in Test-1. A "Normal Curve" projected for the emissions from this gel-coat is also presented. The indication is that emissions are between .0072 and .0135 i.e.: about 1% styrene equivalent (The calculation format used is based upon an established styrene/propane conversion formula. This formula recognizes the basic molecular carbon content ratio of propane to styrene (3 to 8), but is further modified to take into account the experimentally determined difference-from-theoretical unique to each FID. Since identity of the exact emissions detected is not known, the results are expressed using the laboratory's usual calculation format).

Table 4 – Application specifications for each individual test

Table 5 – Pounds gel-coat applied, VOC/HAP pounds and percent emitted for each test.


Stack VOC Concentration as Styrene Equivalent
Parts per Million
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Test 1
Test 2
Test 3
Test 4
Test 5
Note that during test 1, the ppm level increased for about 15 minutes, starting about 25 minutes after the beginning of the test. The background FID registered this same increase, indicating that the source was from outside the enclosure. It was likely due to an inadvertant opening of a styrene or acetone source. It's net effect was an increase of about 4.65% of total emissions observed for that test. Correction for this would reduce the observed % emissions (styrene equivalent) to 1.119%.
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0:57:00
0:58:00
0:59:00
1:00:00
Elapsed Time (hr/min/sec)

Chart 1

Table 1
(Stack Traverses in Inches of Water)

10/17/00	0.272	0.292	0.151	0.15	10/18/00	0.279	0.302	0.136	0.151
8:45AM	0.28	0.372	0.144	0.2	9:30AM	0.296	0.37	0.133	0.203
	0.266	0.398	0.132	0.204	StPr=+.12	0.284	0.39	0.128	0.208
	0.235	0.35	0.108	0.131		0.238	0.314	0.115	0.132
	0.158	0.207	0.1	0.07		0.168	0.197	0.117	0.077
	0.079	0.139	0.126	0.148		0.077	0.143	0.119	0.145
	0.109	0.245	0.18	0.287		0.123	0.24	0.173	0.283
	0.113	0.306	0.279	0.391		0.134	0.303	0.261	0.383
	0.091	0.334	0.305	0.353		0.096	0.334	0.279	0.341
	0.069	0.271	0.193	0.222		0.063	0.266	0.169	0.213
	1.672	2.914	1.718	2.156		1.758	2.859	1.63	2.136
	1.718	2.156				1.63	2.136		
	3.39	5.07				3.388	4.995		
	8.46	0.2115				8.383	0.209575		

10/17/00	0.26	0.307	0.152	0.149	10/18/00	0.275	0.297	0.143	0.151
1:00PM	0.292	0.36	0.142	0.22	3:42PM	0.3	0.372	0.143	0.214
StPr=+.12	0.27	0.395	0.13	0.209	StPr=+.14	0.293	0.394	0.135	0.21
	0.236	0.353	0.12	0.135		0.24	0.356	0.122	0.14
	0.158	0.215	0.112	0.072		0.153	0.219	0.129	0.076
	0.076	0.143	0.114	0.149		0.082	0.144	0.12	0.151
	0.108	0.246	0.166	0.288		0.124	0.249	0.154	0.286
	0.11	0.301	0.28	0.38		0.122	0.313	0.262	0.378
	0.089	0.34	0.302	0.347		0.096	0.337	0.291	0.36
	0.06	0.274	0.193	0.221		0.066	0.271	0.204	0.242
	1.659	2.934	1.711	2.17		1.751	2.952	1.703	2.208
	1.711	2.17				1.703	2.208		
	3.37	5.104				3.454	5.16		B4Ftr Av.
	8.474	0.21185				8.614	0.21535		0.212463

10/17/00	0.282	0.287	0.148	0.162
3:30PM	0.284	0.363	0.145	0.202
StPr=+.15	0.262	0.404	0.133	0.206
	0.233	0.348	0.112	0.14
	0.175	0.21	0.098	0.072
	0.076	0.143	0.121	0.141
	0.12	0.24	0.182	0.288
	0.125	0.301	0.275	0.377
	0.1	0.327	0.3	0.357
	0.06	0.279	0.198	0.219
	1.717	2.902	1.712	2.164
	1.712	2.164		
	3.429	5.066		B4Ftr Av.
	8.495	0.212375		0.212113

'40-point' stack traverses were taken before and after the test runs, each day. These were accomplished using a standard pitot tube and a prime-standard manometer. The values were averaged together to obtain an adjustment correction factor for the continuously monitoring pressure transducer. The pressure transducer provides continuous input to the data logging system throughout each test.

StPr = Static Pressure

Table 2 (ANOVA)

Data As Collected

		# Resin	Equiv. # Styrene	% Emiss.
Oper. 1	Test 1	4.175512	0.048875	1.171%
	Test 4	4.501793	0.045134	1.0026%
	Test 5	4.783982	0.041644	0.8705%
Oper. 2	Test 2	4.828074	0.059589	1.2342%
	Test 3	4.845711	0.043553	0.8988%

	Oper. 1	Oper. 2	
Test 1	1.171%	1.2342%	Test 2
Test 4	1.0026%	0.8988%	Test 3
Test 5	0.8705%		

A standard Analysis of Variance test at a 95% confidence level (alpha =.05) finds an "F" statistic that is smaller than the "F critical" value. Therefore we cannot conclude that the "operators" produce any difference in emissions. This was to be expected. The observation must be stated that operator 2's first application technique clearly was "off the mold" more than any other application. The results were clearly worse. Minimal instruction cleared this up immediately, as seen in the emission level of his next application.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Oper. 1	3	0.030436	0.010145	2.26E-06
Oper. 2	2	0.02133	0.010665	5.63E-06

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.24E-07	1	3.24E-07	0.095835	0.777144	10.12796
Within Groups	1.01E-05	3	3.38E-06			
Total	1.05E-05	4				

Data in Test 1 Adjusted

		# Resin	Equiv. # Styrene	% Emiss.
Oper. 1	Test 1	4.175512	0.048875	1.1186%
	Test 4	4.501793	0.045134	1.0026%
	Test 5	4.783982	0.041644	0.8705%
Oper. 2	Test 2	4.828074	0.059589	1.2342%
	Test 3	4.845711	0.043553	0.8988%

	Oper. 1	Oper. 2	
Test 1	1.1186%	1.2342%	Test 2
Test 4	1.0026%	0.8988%	Test 3
Test 5	0.8705%		

A standard Analysis of Variance test at a 95% confidence level (alpha =.05) finds an "F" statistic that is smaller than the "F critical" value. This test was applied to data that was corrected for the anomaly detected in the Test-1 data. The effect of this correction is extremely small. There is still less than 1% assurance of "operator difference" in these tests.

Anova: Single Factor

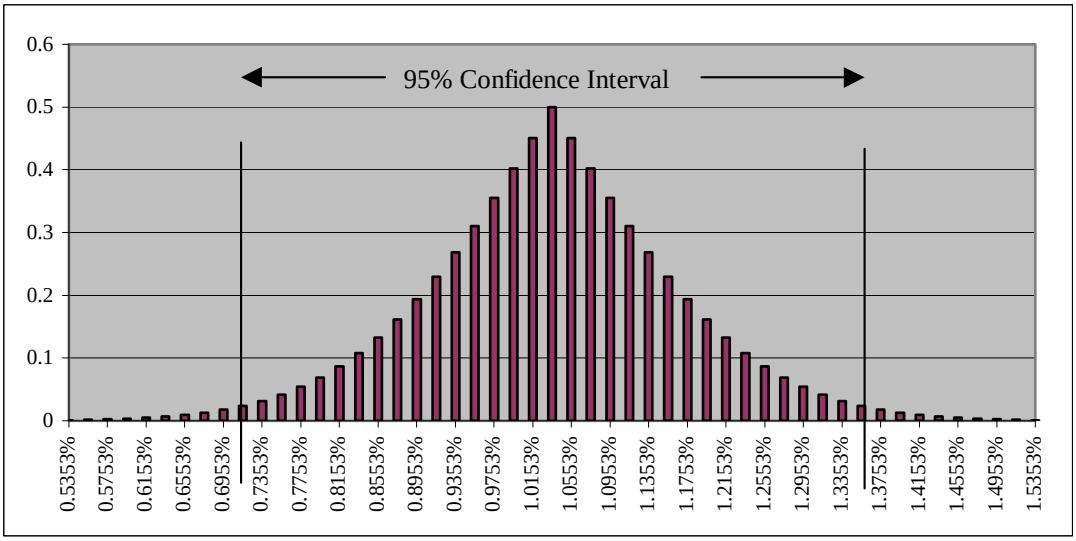
SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Oper. 1	3	0.029917	0.009972	1.54E-06
Oper. 2	2	0.02133	0.010665	5.63E-06

ANOVA

Source of Varia	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between G	5.76E-07	1	5.76E-07	0.198414	0.686186	10.12796
Within Gro	8.71E-06	3	2.9E-06			
Total	9.28E-06	4				

Table 3



Data as collected

STD(x1,x2,x3)=	0.001618
AVERAGE(x1,x2,x3)=	0.010353
NORMINV(.975,Ave,S.D.)=	0.013524
NORMINV(.500,Ave,S.D.)=	0.010353
NORMINV(.025,Ave,S.D.)=	0.007182

Data as collected	
% Emiss.	
Mean	0.010353
Standard Error	0.000724
Median	0.010026
Mode	#N/A
Standard Deviation	0.001618
Sample Variance	2.62E-06
Kurtosis	-2.554329
Skewness	0.322756
Range	0.003637
Minimum	0.008705
Maximum	0.012342
Sum	0.051766
Count	5
Confidence Level(95.0%)	0.002009

Test-1 adjusted	
% Emiss.	
Mean	0.010249
Standard Error	0.000681
Median	0.010026
Mode	#N/A
Standard Deviation	0.001523
Sample Variance	2.32E-06
Kurtosis	-1.461571
Skewness	0.504927
Range	0.003637
Minimum	0.008705
Maximum	0.012342
Sum	0.051247
Count	5
Confidence Level(95.0%)	0.001892

The above calculations of descriptive statistics is presented to show the effect of removing the background induced bump in the data collected for Test-1. The mean value of the overall tests is affected by only .0001 or 1/100th percent. This is relatively insignificant, even at the low emission level being observed. A graph of the "Normal" population distribution determined from the observed data is presented above the descriptive statistics.

Table-4

Test#	Catalyst% wt. Rato	Kg. Gel-coat Applied	Lbs. Gel-coat Applied	Ave. wet-mil Thickness Applied			Kg. Flow per Min.
				Top	Side	Front	
1	2.00%	1.894	4.176	19.6	17.2	14.8	1.619
2	2.00%	2.19	4.828	15.2	17.6	16.8	1.676
3	2.00%	2.198	4.846	18.4	20	17.6	1.751
4	2.00%	2.042	4.502	17.6	18.4	18.4	1.674
5	2.00%	2.17	4.784	17.6	16.8	18.4	1.709

See Next Page for Table 5

Table-5

Test Mass Values			
Applied		Emissions	
# Gel-coat	VOC/HAP	Eq.# Styr.	% Emiss.
4.176	---	0.04887469	1.171%
4.828	---	0.0595886	1.234%
4.846	---	0.04355262	0.899%
4.502	---	0.04513414	1.003%
4.784	---	0.04164378	0.870%
		Ave.	1.0%

Pounds of applied gel-coat is presented for each test. The corresponding pounds of VOC/HAP (as Styrene equivalent) is identified and the percentage emissions that equates to, as percent of total gel-coat applied.