Summary Report

June 16, 2004

For

Glas-Craft Company

Non-Atomized Gel-Coat Application Equipment

Emissions Tests Performed at CMTI's Coatings Applications Research Laboratory (CARL) Located at Purdue University June 1-4, 2004

CARL Test Personnel
S. J. Hall
J. R. Noonan

Indiana Clean Manufacturing Technology And Safe Materials Institute

(CMTI/CARL)
Purdue University
2655 Yeager Road
Suite 103
West Lafayette, IN
47906

Confidentiality Statement

Confidentiality Information:

Purdue does not desire to receive information, which is confidential to Glas-Craft Company However, should it be necessary for personnel of the Coating Applications Research Laboratory (CARL) to receive such confidential information in order to perform the technical assistance needed, Purdue and its researchers agree to use their best effort to prevent the disclosure of such information furnished by Glas-Craft Company, provided such confidential information is clearly indicated in writing as confidential, or given orally and reduced to writing within thirty (30) days. If requested, Purdue and Glas-Craft Company will develop and sign a Confidentiality Agreement.

No Warranties:

Purdue makes no warranties, expressed or implied, as to any matter whatsoever, including without limitation, the condition of the technical assistance or deliverable or any invention(s) or product(s), whether tangible or intangible, conceived, discovered, or developed under this project agreement; or the ownership, merchantability, or fitness for a particular purpose of the assistance or any such inventions or product or deliverables. Purdue shall not be liable for any direct, indirect, consequential, special or other damages suffered by Glas-Craft Company or by any licensee or any others resulting from the use of the deliverables or any such inventions or product.

Use of Purdue's Name:

Glas-Craft Company cannot use the name of Purdue nor of any member of Purdue's staff in any publicity, advertising, or news release without the prior written approval of an authorized representative of Purdue. Glas-Craft Company will not under any circumstance advertise or otherwise state or imply that Purdue has tested or approved any product or process.

Use of CMTI and/or CARL Name

Glas-Craft Company may reference, in technical and research reports and documents, that the Indiana Clean Manufacturing Technology and Safe Materials Institute (CMTI) and its Coating Applications Research Laboratory (CARL), located at Purdue University, performed testing on products (material) supplied by Glas-Craft Company

Non-Atomized Gel Coat Application
Emission Testing
June 1 – 4, 2004
Glas-Craft Company

Introduction:

From June 1 through June 4, 2004, Glas-Craft Company personnel were present at the Coating Applications Research Laboratory (CARL) located at Purdue University. There, a series of VOC emissions tests were performed according to the requirements of EPA Method 25A. The tests were performed to detect emissions resulting from a new non-atomized gel coat application system. Five different gel coats were applied to an American Composite Manufacturers Association (ACMA) approved mold via a Glas-Craft 4.97 to 1 ratio pump, utilizing Glas-Craft's new non-atomizing tip design. The application equipment utilized externally sprayed catalyst and shaping air to contain and shape the non-atomized fan pattern. Five different gel coat products were tested so as to compare the non-atomized application equipment's emission performance to the ACMA Unified Emissions Factors (UEF).

In all cases, the gel coat material was applied to an ACMA approved mold. This ACMA mold was specially designed by the ACMA to simulate standard industrial production molds. ACMA emission testing protocols require that its standard mold be used for all applicable emissions tests. The emission tests performed at CARL meet all of the ACMA protocols. The spray application process, as practiced during the tests, was designed to simulate the industry's gel coat application process. During the spray set up process, prior to each set of tests, the spray application equipment was adjusted to apply an acceptable spray pattern (as determined by Glas-Craft personnel) onto the ACMA mold. The distance from the pattern target to the spray gun was approximately 12 to 18 inches, utilizing a flow rate of approximately 2.5 to 3.5 pounds per minute. During spray application for each test, the gel coat material was sprayed utilizing the ACMA "Controlled Spray" technique, banding the mold's perimeter. However, each gel coat material was sprayed midway onto the mold's flange leaving approximately half of the flange uncoated. The ACMA's Controlled Spray process limits spray to within (not beyond) the mold flange's confines.

Each gel coat product was applied to the mold using Glas-Craft non-atomized spray application equipment and applied by Glas-Craft personnel. The gel coat flow rate, application pump pressure, resin temperature, and spray-booth/stack temperature were all selected to simulate typical production characteristics. The above application parameters were held as constant as possible for each of the emission test sets. The emissions testing process was grouped into emission test sets. A test set is a group of repeated tests using the same gel coat. Tests 1, 2, 3, and 4 is a test set; tests 5, 6, 7, 8, and 9 is a test set; tests 10, 11, and 12 is a test set; test 13, 14, 15, 16, and 17 is a test set and tests 18, 19, and 20 is a test set (see Table-1).

The emissions testing process and its relationship to *real world* conditions:

All emissions testing was performed in a standard industrial paint coating spray booth modified so that 100% of all emissions generated from the fiber reinforced plastics spray-up process are collected (meeting EPA Method 204). The exhaust emission stack was also modified to achieve a stable, non-cyclonic flow condition within. An ACMA-designed, male mold surface was used for all the test-runs and each test-run had a wet mil thickness build-up of approximately 22 to 24 mils. The pounds of gel coat applied (dispensed) to the part and the application equipment's air pressure to the Glas-Craft non-atomized-spray application unit were closely monitored, and maintained as uniform as possible within each test set except for the fourth test set (Tests 13, 14, 15, 16, and 17) which utilized increased fluid pressures on the last three tests verses the first two tests (this was done to improve the quality (as judged by smoothness of appearance) of the gel coat's film build-up. Therefore, because Tests 13 and 14 were performed with below-optimum fluid pressure settings they have been discarded from the average emissions calculations of their test set.

Conclusions and Comments:

The ACMA Unified Emissions Factors (UEF) for Open Molding of Composites (Issue Date: July 23, 2001, see Appendix 1) estimates the emissions factors for similar styrene containing gel coats and those factors are listed below. Further, we compare those UEF estimates to the emission factors determined at the CARL lab during the week of June 1, 2004 in Table 2 below.

Table 2

Styrene Percent by Weight in The Noted Styrene-Containing Gel Coat Materials	ACMA UEF Estimate % Styrene Emissions per pound of Styrene-Containing Polyester Resin Applied (Controlled Spray)	CARL Average Estimate as % Styrene Emissions per pound of Styrene-Containing Gel Coat Applied for Glas-Craft [Week of 6/1/04] (Non-Atomized Spray)	Glas-Craft % Agreement with ACMA UEF Emissions Estimate
39%, HK 2500	12.5%	13.4%	106.9% - Acceptable
32.1%, Valspar	9.4%	9.5%	101.4% - Acceptable
49%, HK Clear Marble	17.1%	15.9%	92.7 - Acceptable
28.7%, AOC	7.9%	4.8%	61.6% - Acceptable
25.6%, Ferro LVOC	6.5%	6.6%	101.0% - Acceptable

Utilizing the data from Table 2 it can be said that when one compares the styrene emissions from the tested gel coats applied with the Glas-Craft equipment, to the ACMA's Unified Emissions Factor (UEF) emissions estimates, not all tested materials produced emission averages below their comparable UEF, but overall, the Glas-Craft equipment yielded average emissions 7.3% below that which the UEF would have predicted.

Resin and Materials Used:

Glas-Craft tested the non-atomizing spray equipment's emissions generation (or suppression) characteristics by applying a variety of different gel coat products manufactured by several manufacturers. Glas-Craft indicated that styrene was the sole monomer in the polyester resin based gel coats. However, once telephone calls were placed to the individual gel coat manufacturers it was learned that some of the gel coats may have had methyl methacrylate (MMA) monomer blended in at concentrations of less than one percent. The gel coat manufacturers stated that they were not required to list any MMA concentration on MSDS's (Material Safety Data Sheet) as long as its concentration was below one percent. Any monomer, other than styrene, contained in the gel coat is detected by the TCA analyzers as "extra carbon" and is subsequently quantified as styrene. Therefore, any monomer other than styrene in the tested gel coats will tend to increase the styrene emission factor calculated for the subject gel coat. The CARL lab and Glas-Craft specifically requested that the supplied gel coats, which were used for the emissions tests, be free of any monomer other than styrene. Certificate of Analysis sheets were requested from each gel coat manufacturer but only one was received and it did not contain any monomer information. One gel coat manufacturer (Ferro), via phone contact with their lab, quantified the MMA content in their gel coat at 0.84%. The other gel coat manufacturers, upon phone contact, did not comment on MMA content. If MMA was present in any of the gel coats tested it probably would result in slightly increased styrene emission estimates. This would serve to mildly penalize Glas-Craft in a direct comparison to ACMA's, "styrene containing only" based UEF factors (see Table 1 for further information).

Specific Materials Used in the Tests (all test materials supplied by Glas-Craft):

- HK Resin 2500 White – Batch No. 4051907, 2.00% MEKP-9 Peroxide catalyst
- Valspar Gray, Product No. 5779E90247 – Batch No. 456400088, 2.00% MEKP-9 Peroxide Catalyst
- HK Clear Marble, Product No. G1175 – Batch No. 4051301, 2.00% MEKP-9 Peroxide Catalyst
- AOC Gel Coat, Product No. G309LQ11000W, Lot No. 1310, 1.75% MEKP-9 Peroxide Catalyst
- Ferro Lt. Gray LVOC, Product No. 89-810430, 2.00% MEKP-9 Peroxide Catalyst

Five separate test sets were performed using the five different styrene polyester resin gel coats (see below & Table 1):

1) Tests 1, 2, 3, 4
   Performed using HK 2500 White, at 39% (by wt.) styrene

2) Tests 5, 6, 7, 8, 9
Performed using Valspar Gray, at 32.13% (by wt.) styrene
3) Test 10, 11, 12
Performed using HK Clear Marble, at 49.00% (by wt.) styrene
4) Test 13, 14, 15, 16, 17
Performed using AOC Gel Coat, at 28.7% (by wt.) styrene
5) Test 18, 19, 20
Performed using Ferro Lt. Gray, at 25.62% (by wt.) styrene

Application Equipment Operational Settings (all application equipment was supplied and operated by Glas-Craft personnel):

The Tests Utilized the Following Application Equipment and Settings:

Glas-Craft non-atomized spray equipment (external-mix catalyst, air assisted airless application spray gun, utilizing a 4.97 : 1 air powered fluid pump)

Test 1, 2, 3, 4 application specifications:
Air pressure to fluid (psi)
38 dynamic
40 static
Air pressure to catalyst atomizer (psi)
10 dynamic
10 static
Air pressure to air assisted airless shaping air
30 dynamic
32 static
Tip size:
0.030, 0.015, 0.030 (inches) orifice size, P3 (three hole tip)

Test 5, 6, 7, 8, 9 application specifications:
Air pressure to fluid (psi)
48 dynamic
50 static
Air pressure to catalyst atomizer (psi)
10 dynamic
10 static
Air pressure to air assisted airless shaping air
30 dynamic
32 static
Tip size:
0.030, 0.015, 0.030 (inches) orifice size, M3 (three hole tip)

Test 10, 11, 12, application specifications:
Air pressure to fluid (psi)
40 dynamic

42 static
Air pressure to catalyst atomizer (psi)
12 dynamic
12 static
Air pressure to air assisted airless shaping air
25 dynamic
27 static
Tip size:
0.030, 0.015, 0.030 (inches) orifice size, M3 (three hole tip)

Test 13, 14, 15, 16, 17 application specifications:
Air pressure to fluid (psi)
51 to 70 dynamic (see Table 1)
53 to 72 static
Air pressure to catalyst atomizer (psi)
2 to 13 dynamic (see Table 1)
2 to 13 static
Air pressure to air assisted airless shaping air
30 to 58 dynamic (see Table 1)
32 to 60 static
Tip size:
0.030, 0.015, 0.030 (inches) orifice size, P3 or M3 (three hole tip) (see Table1)

Test 18, 19, 20, application specifications:
Air pressure to fluid (psi)
58 dynamic
60 static
Air pressure to catalyst atomizer (psi)
10 dynamic
10 static
Air pressure to air assisted airless shaping air
58 dynamic
60 static
Tip size:
0.030, 0.015, 0.030 (inches) orifice size, P3 (three hole tip)

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

- 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
- Method 204 - Permanent or Temporary Total Enclosure (TTE) -- Collection of 100 % Emissions

The emissions data in this report, expressed as percentages, are determined as Pounds of Styrene Emitted compared to the Pounds of Gel Coat Resin Applied.

Equipment Used During Test:

Glas-Craft application equipment (as noted above)
J.U.M. Engineering, Inc. flame ionization detector (FID), model 3-100, 2 units
Dwyer Instrument, Inc. - standard-design pitot tubes, model 160 series, 2 units
Dwyer Instrument, Inc. primary standard manometer, model #424
Dwyer Instrument, Inc. primary standard manometer, model #200.5
Dwyer Instrument, Inc. temperature meter-voltage readout, model 4151D
Dwyer Instrument, Inc. pressure transducer, model 607-4 --- converts air-pressure as columnar-inches-of-water to a corresponding linear voltage readout
National Instruments, LabVIEW, version 5.1 data acquisition software
National Instruments LabVIEW DAQCARD AI-16XE-50 voltage to digital converter
National Instruments SCB-68 voltage to digital interface
NEC data-logging Pentium portable computer
Alnor Velometer series 6000—air velocity/pressure measurement instrument
Barnant temperature & relative humidity monitor, model 6919000
Binks standard paint booth modified for 100% emissions capture per 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
Denver Instruments Scale – Model XS-2100, 4.6 pound maximum capacity, 0.01 gram sensitivity
ACMA certified male mold with over-spray capture flange
Paul N. Gardner Company, Standard Model Gel Timer, Serial No. 6312
Omega Infrared Temperature Gauge

Emissions Test Procedure:

Two total carbon analyzer – flame ionization detectors (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. These instruments detect the volatile organic compound (VOC) emissions, which exhaust from the spray booth. One FID monitored stack emissions in parts per million (ppm) and the other monitored the laboratory's background-ppm (both in propane equivalent).

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).

Resin material was applied to the ACMA designed, male, mold surface and midway onto the mold's flange. Thus, the applied resin was sprayed within the confines of the mold flange with half of it not receiving direct coating.

The resin material was applied to an approximate wet-mil thickness average target of 24 mils (1 mil is 1/1000 of an inch). The resin application process followed a set protocol whereby the application of resin to each surface is timed and cadenced to achieve a proportional coverage over the entirety of the mold.

Typical application time was approximately 52 - 71 seconds. The actual application time varied depending on the resin flow rate from the application equipment and the selection of the flow rate was dictated to achieve the lowest fluid pressure needed to achieve an acceptable coating appearance.

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 3% is deemed acceptable by the EPA for Method 25A emission tests.

The resin (gel coat) material, applied to the ACMA male mold, was monitored for emissions (data was logged every two seconds) during each complete test, from the start of the resin application process, through cure of the material, to the point where resin had cured and emissions had returned to original baseline levels. Only then was each emissions test deemed complete. The entire emission test process, for each of the tests run, ranged from approximately 30 to 60 minutes. Gel time tests were performed for each type of gel coat material using the standard gel time test.

The laboratory environment and the average air temperature moving through the booth ranged from 78.3-85.8° F for all tests. Resin temperature during the testing and application process ranged from 71° F to 74° F. The above temperatures were specifically selected to mimic typical industry production temperatures.

Please see following tables:

Table-1

Please see following charts:

Charts 1 through 5 – are statistically generated Styrene emissions distribution estimates for each test set

Please See Appendix:

Appendix 1 – ACMA Emission Factor Table