**Data Summary**

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# Estimating Styrene Emissions from the Mechanical Non-atomized Application of Highly Filled DCPD Resins

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## 1. Introduction

The purpose of this Data Summary is to provide a basis for updating the ANSI UEF emission factors for the application of highly filled DCPD resin (including DCPD-blends).

The current UEF factors (2007); reports and technical documents available at http://www.acmanet.org/ga/reg-emissions.cfm) provide a basis for estimating emissions for the "non-atomized" application of styrene-containing polyester resin, a process used widely for the manufacture of composite products such as tub/shower units, transportation and RV components, gasoline storage and septic tanks, and thousands of other products.

The current factors are based on a set of test data that was necessarily restricted according to a finite test budget and informed judgments regarding the composite molding process variables likely to play a significant role in influencing emissions. Given the complexity of the composite open molding process, it is not surprising that updates and revisions to the UEF may be needed on occasion.

Data from source tests conducted following release of the 2001 UEF suggested that emissions from tub/shower operations were 30% higher than predicted. ACMA worked with EPA to issue an advisory (available at the web address provided above) suggesting that tub/shower operations use a correction factor of 1.3 when using the UEF to estimate emissions from non-atomized application of filled resin. More information on these source tests is provided in Section 2, below.

In 2007, ACMA conducted a series of laboratory tests designed to confirm or correct the 2001 UEF non-atomized resin application factors. This Resin Screen Test showed that the non-atomized mechanical spray application of highly filled DCPD resins does result in an emission rate that is higher than that predicted by the UEF factors.

The 2007 laboratory tests also confirmed that the 2001 UEF factors for the non-atomized application of other resin systems, including non-filled DCPD and filled non-DCPD, are accurate. It is only the combination of DCPD resin with filler that results in emissions higher than predicted by the UEF. More information on these laboratory tests is provided in Section 3, below.

The source test data (see Section 2 below) is from plants believed by ACMA to employ filler loadings of 50%. In the Resin Screen Test (see Section 3), ACMA tested DCPD resins with filler loadings of 50% and 30%. A filler loading of 50% is common for tub/shower plants, and of 30% for plants producing truck caps; these are the two common applications for filled DCPD resin. According to the data presented in this summary, both filler loadings when used with DCPD resin result in emission rates that are significantly higher than predicted by the current UEF factors. Therefore, ACMA is proposing that the new emission factor for filled DCPD resins apply to fillers loadings of 30% and higher. At 30% filler loading, the new factor may provide an overestimate of actual emission rate. At filler loadings of less than 30%, use of the current factor, as ACMA is recommending, may result in an underestimate of actual emission rate. However, ACMA does not believe that fillers loadings in the range of 1% to 29% are common, and in any case there is no data on emissions from such operations.

Recommended changes to the UEF table, to reflect these results, are provided in Section 4, below.

Note that the information is this report has no effect on NESHAP (MACT) compliance. For sources subject to the emission limits in Table 3 of Subpart WWWW (the composites NESHAP), EPA has confirmed that MACT is the use of the technology employed by the floor-setting sources and not a specific emission rate. For mechanical resin application, the floor-setting sources used non-atomized application. EPA had no direct knowledge of the emission rate at these sources. The emission limits in Subpart WWWW Table 3 and the emission factor formulas in Subpart WWWW Table 1 were provided by EPA only to allow averaging across pollution prevention technologies, based on their relative effectiveness, and for averaging across twelve months of production, and not to set strict emission limits. See the EPA memo on filled DCPD and MACT compliance at the web address provided above

**2. Source Test Data for Bathware Facilities**

All of the available source test data for filled DCPD resin emissions comes from tests conducted at reinforced plastic composite bathware facilities. For this reason, the characteristics of bathware facilities are discussed here. Most bathware facilities are remarkable similar, yet quite different from most reinforced plastic composites facilities. A typical bathware facility could be generally characterized as follows:

- Large HAP source (over 100 tpy of styrene emissions). For this reason, most bathware facilities are required to perform a source test by the local EPA authorities.
- Highly automated operated and well-ventilated work areas.
- Neat bathware resin is usually DCPD-based or a DCPD blend.
- Neat bathware resin typically contains from 33 to 42% styrene monomer by weight.
- Bathware resin as applied is heavily filled (defined as 50% or greater filler by weight).
- Filled bathware resin is heated to reduce viscosity and improve material flow through the resin delivery lines and application equipment. The filled resin is either heated directly by in-line heater units or heated indirectly by the high-shear mixing energy required to disperse and suspend the filler in the resin. Filled resin temperature is usually 90ºF or greater.
- ACMA does not know exactly what filler loadings were used by these plants. However, based on information from sources in the tub/shower industry and from resin suppliers, ACMA believes that the large majority of these sources use filler loadings of 50% or more. At filler loadings less than 50%, the resulting product does not exhibit the needed flame spread properties.

Engineering Environmental Consulting Service (Annapolis, MD; 410.268.7367; robhab@erols.com) conducted a series of source tests at large bathware facilities. The results of these tests are summarized in Table A. As shown in this table, the average styrene emission rate from these source tests is 130% of the corresponding UEF non-atomized resin application factor.

Several observations can be made regarding the circumstances of this source data, which offer a strong argument for creating a new UEF factor for estimating styrene emissions from filled DCPD resins:

- The testing procedure was styrene-specific using EPA Reference Method 18.
- The tests were approved, observed, and accepted by local EPA inspectors.
- The tests were performed at several different bathware facilities, which had different types of non-atomized resin application equipment and different equipment setups.
- The tests were conducted at different times over a seven-year period.
- The tests involved a range of different styrene contents in the neat DCPD resin.

The MAAX Marion source test data is detailed in two publicly available source test reports:

- May 29, 2004 EECS report entitled "Source Test Report for the Reinforced Plastic Composite Bathware Manufacturing Operation at the Aker by MAAX Plant in Marion, Iowa April 28 - 29, 2004 Test Period," submitted to Ms. Amy Drahos, Air Pollution Control Specialist, Linn County Air Quality Division, Linn County Public Health Department, 501 13th Street NW, Cedar Rapids, Iowa.
- May 6, 2006 EECS report entitled "Source Test Report for the Reinforced Plastic Composite Bathware Manufacturing Operation at the MAAX Marion Plant in Marion, Iowa March 27-29, 2006 Test Period," submitted to Ms. Amy Drahos, Air Pollution Control Specialist, Linn County Air Quality Division, Linn County Public Health Department, 501 13th Street NW, Cedar Rapids, Iowa.

| Table A - Source Test Results<br>for the Mechanical Non-Atomized Application<br>of Heavily Filled DCDP Resin at Bathware Facilities | | | | | |
|---|---|---|---|---|---|
| **Test Site (EPA oversight)** | **Data Pt No.** | **Test Date** | **Styrene Content in Neat Resin (% by wt)** | **Measured Percentage of UEF factor (% UEF)** | **Equivalent Filled NARA Emission Rate (lb/ton)** |
| MAAX Marion, IA (Linn Co & IA DNR) | 1 | 3/29/2006 | 34.5% | 124% | 93 |
| | 2 | 3/28/2006 | 34.5% | 131% | 99 |
| | 3 | 3/27/2006 | 34.5% | 125% | 94 |
| | 4 | 4/29/2004 | 33.1% | 144% | 102 |
| | 5 | 4/28/2004 | 33.1% | 139% | 99 |
| MAAX Martinsburg, WV (WV DEP) | 6 | 4/4/2007 | 33.1% | 148% | 105 |
| | 7 | 10/4/2006 | 35.0% | 125% | 96 |
| | 8 | 12/15/2005 | 33.5% | 140% | 101 |
| | 9 | 12/14/2005 | 33.5% | 132% | 95 |
| | 10 | 4/7/2005 | 32.8% | 123% | 86 |
| Lasco Bathware Lancaster, TX (TCEQ & Region 6) | 11 | 6/15/2005 | 42.2% | 132% | 131 |
| | 12 | 6/14/2005 | 42.2% | 128% | 127 |
| | 13 | 12/16/2004 | 42.0% | 116% | 115 |
| | 14 | 12/15/2004 | 42.0% | 124% | 123 |
| Lasco Bathware Moapa, NV (Clark Co. & Region 9) | 15 | 1/12/2000 | 35.0% | 124% | 95 |
| | 16 | 1/11/2000 | 35.0% | 131% | 101 |
| | | | **Average** | **130%** | |

The MAAX Martinsburg source test data is detailed in three publicly source test reports and a notice of violation report:

- April 15, 2007 EECS report entitled "Performance Test Report - Dürr Preconcentrator Control System - April 4, 2007 Test Period at the MAAX Bathware Facility in Martinsburg, WV," submitted to the West Virginia Department of Environmental Protection.
- October 31, 2006 EECS report entitled "Performance Test Report - Dürr Preconcentrator Control System - October 4, 2006 Test Period at the MAAX Bathware Facility in Martinsburg, WV," submitted to the West Virginia Department of Environmental Protection.
- January 24, 2006 EECS report entitled "Performance Test Report - Dürr Preconcentrator Control System - December 14 - 15, 2005 Test Period at the MAAX Bathware Facility in Martinsburg, WV," submitted to the West Virginia Department of Environmental Protection.
- May 27, 2005 MAAX letter entitled "Notice of Permit Deviation - Martinsburg Air Pollution Control

Equipment" submitted to Jesse Atkins, West Virginia Department of Environmental Protection (April 7, 2005 test results are attached).

The Lasco Bathware source test data is referenced in a March 6, 2007 letter that Lasco sent to federal EPA, and detailed in a publicly available source test report:

- August 7, 2005 EECS report entitled "Performance Test Report - Dürr Preconcentrator Control System – June 14-15, 2005 Test Period at the Lasco Bathware Facility in Lancaster, TX," submitted to the Texas TCEQ.
- Note: In a meeting with EPA/OAQPS on Dec. 12, 2008, the engineer who conducted the Lancaster source tests noted that the physical conditions of the source prevented full compliance with EPA test methods. (Very short stacks prevented laminar flows, requiring the use of certain data corrections not consistent with the EPA method.) Removing these data from consideration, however, does not change the validity of the recommended factors for filled DCPD.

The detailed source test reports can be obtained on a CD by contacting jschweitzer@acmanet.org.

Table B - CMTI Lab Test Results
for the Mechanical Non-Atomized Application
of Filled DCDP Resins

| Test Run Conditions | Test Run No. | Data Pt No. | Styrene Content in Neat Resin (% by wt) | Measured Emission Rate (% styrene) | Equivalent Filled NARA Emission Rate (lb/ton) | Measured Percentage of UEF factor (% UEF) |
|---|---|---|---|---|---|---|
| DCPD Resin filled at 30% wt 70°F | 22 | 17 | 37.2% | 12.87% | 96 | 114% |
| | 23 | 18 | 37.2% | 12.56% | 93 | 112% |
| | Third test run not completed | | | | | |
| DCPD Resin filled at 30% wt 100°F | 24 | 19 | 37.2% | 13.68% | 102 | 121% |
| | 25 | 20 | 37.2% | 14.51% | 108 | 129% |
| | 26 | 21 | 37.2% | 16.64% | 124 | 148% |
| DCPD Resin filled at 50% wt 70°F | 16 | 22 | 37.2% | 14.45% | 108 | 128% |
| | 17 | 23 | 37.2% | 16.43% | 122 | 146% |
| | 18 | 24 | 37.2% | 14.39% | 107 | 128% |
| DCPD Resin filled at 50% wt 100°F | 19 | 25 | 37.2% | 15.11% | 112 | 134% |
| | 20 | 26 | 37.2% | 14.96% | 111 | 133% |
| | 21 | 27 | 37.2% | 17.85% | 133 | 158% |
| Expected UEF NARA rate | | | | 11.26% | 84 | |
| | | | | | **Average** | **132%** |

## 3. ACMA Resin Screening Test Emission Data

ACMA conducted a series of resin emissions tests (Resin Screen Test) at the Clean Manufacturing Technology Institute laboratory at Purdue University. These tests were performed from January through March 2007. The procedures and methods used for this testing are detailed in a separate report published by ACMA (at the web address provided in Section 1, above).

The Resin Screen Test confirmed that the UEF provide accurate (in the sense of predicting stack test results) emission estimates for the non-atomized application of all common resin types except filled DCPD and DCPD-blends. The filled DCPD resins emitted at a rate similar to the rate found in the source tests described above in Section 2.

A summary of the relevant Resin Screen results is provided in Table B, above.

## 4. New emission factor for filled DCPD

The source test data described above in Section 2 was combined with the relevant laboratory test data described above in Section 3 (i.e, all the data shown in Tables A and B, above) to perform the analysis shown in Table C and Figures A and B, below.

## 5. Recommendations

Based on the analysis described above in Section 4, ACMA recommends that the 2007 UEF table (http://www.acmanet.org/ga/ANSI+ACMA+ICPA%20UEF-1-2007.pdf) be modified as shown:

A. Insert a new row in the table, below the existing row titled "Mechanical Non-Atomized with VSR":

See Table D.

B. Insert a new footnote as shown:

11. Use this factor for the non-atomized application of DCPD or DCPD-blend resin, when filled to 30% or more by weight.

| Table C - Test Data used in Filled DCPD Regression | | | |
|---|---|---|---|
| Data Set | Data No. | Styrene Content | Emission Rate |
| Source Test Data | 1 | 34.5% | 93 |
| | 2 | 34.5% | 99 |
| | 3 | 34.5% | 94 |
| | 4 | 33.1% | 102 |
| | 5 | 33.1% | 99 |
| | 6 | 33.1% | 105 |
| | 7 | 35.0% | 96 |
| | 8 | 33.5% | 101 |
| | 9 | 33.5% | 95 |
| | 10 | 32.8% | 86 |
| | 11 | 42.2% | 131 |
| | 12 | 42.2% | 127 |
| | 13 | 42.0% | 115 |
| | 14 | 42.0% | 123 |
| | 15 | 35.0% | 95 |
| | 16 | 35.0% | 101 |
| CMTI Lab Data | 17 | 37.2% | 96 |
| | 18 | 37.2% | 93 |
| | 19 | 37.2% | 102 |
| | 20 | 37.2% | 108 |
| | 21 | 37.2% | 124 |
| | 22 | 37.2% | 108 |
| | 23 | 37.2% | 122 |
| | 24 | 37.2% | 107 |
| | 25 | 37.2% | 112 |
| | 26 | 37.2% | 111 |
| | 27 | 37.2% | 133 |

**Figure A - Regression Analysis Output Table (MS Excel 2003)**

| SUMMARY OUTPUT | |
|---|---|
| *Regression Statistics* | |
| Multiple R | 0.73228 |
| R Square | 0.53624 |
| Adjusted R Square | 0.51769 |
| Standard Error | 8.91397 |
| Observations | 27 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 2296.890 | 2296.890 | 28.907 | 1.411E-05 |
| Residual | 25 | 1986.470 | 79.459 | | |
| Total | 26 | 4283.359 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* |
|---|---|---|---|---|---|---|
| Intercept | **-12.362** | 22.198 | -0.557 | 0.583 | -58.081 | 33.356 |
| X Variable 1 | **326.104** | 60.654 | 5.376 | 0.000 | 201.186 | 451.023 |

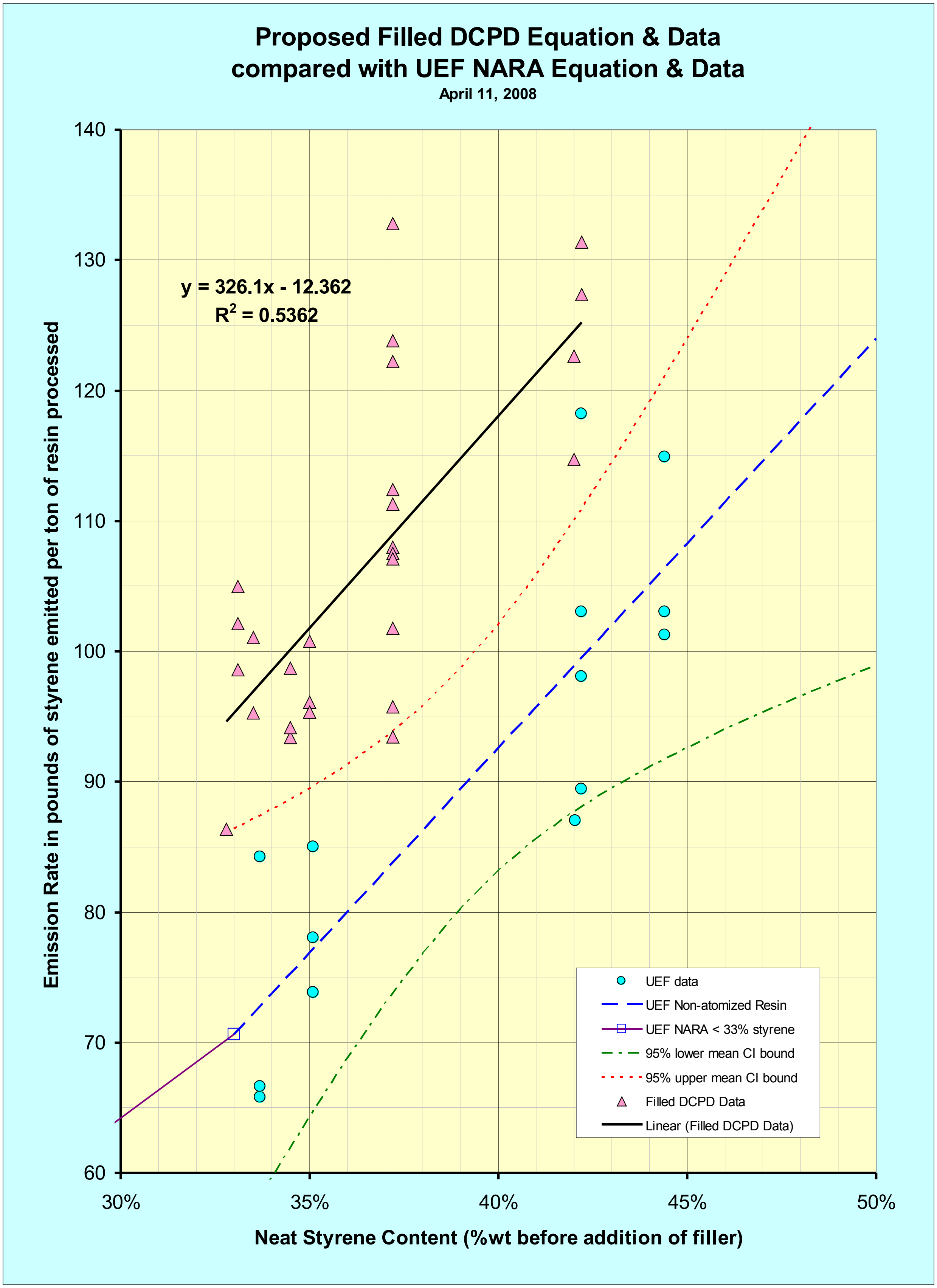
Proposed Filled DCPD Equation & Data
compared with UEF NARA Equation & Data
April 11, 2008
y = 326.1x - 12.362
R2 = 0.5362
Emission Rate in pounds of styrene emitted per ton of resin processed
Neat Styrene Content (%wt before addition of filler)
140
130
120
110
100
90
80
70
60
30%
35%
40%
45%
50%
UEF data
UEF Non-atomized Resin
UEF NARA < 33% styrene
95% lower mean CI bound
95% upper mean CI bound
Filled DCPD Data
Linear (Filled DCPD Data)

***Figure B*.**