

Data Summary

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

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Submitted to EPA in support of request for new emission factors.

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 (July 23, 2001; 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 in 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 90°F 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
for the Mechanical Non-Atomized Application
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.

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 2001 UEF table (www.acmanet.org/ga/uef_table_23jul01.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:

10. 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						
<i>Regression Statistics</i>						
Multiple R	0.73228					
R Square	0.53624					
Adjusted R Square	0.51769					
Standard Error	8.91397					
Observations	27					
ANOVA						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	1	2296.890	2296.890	28.907	1.411E-05	
Residual	25	1986.470	79.459			
Total	26	4283.359				
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
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

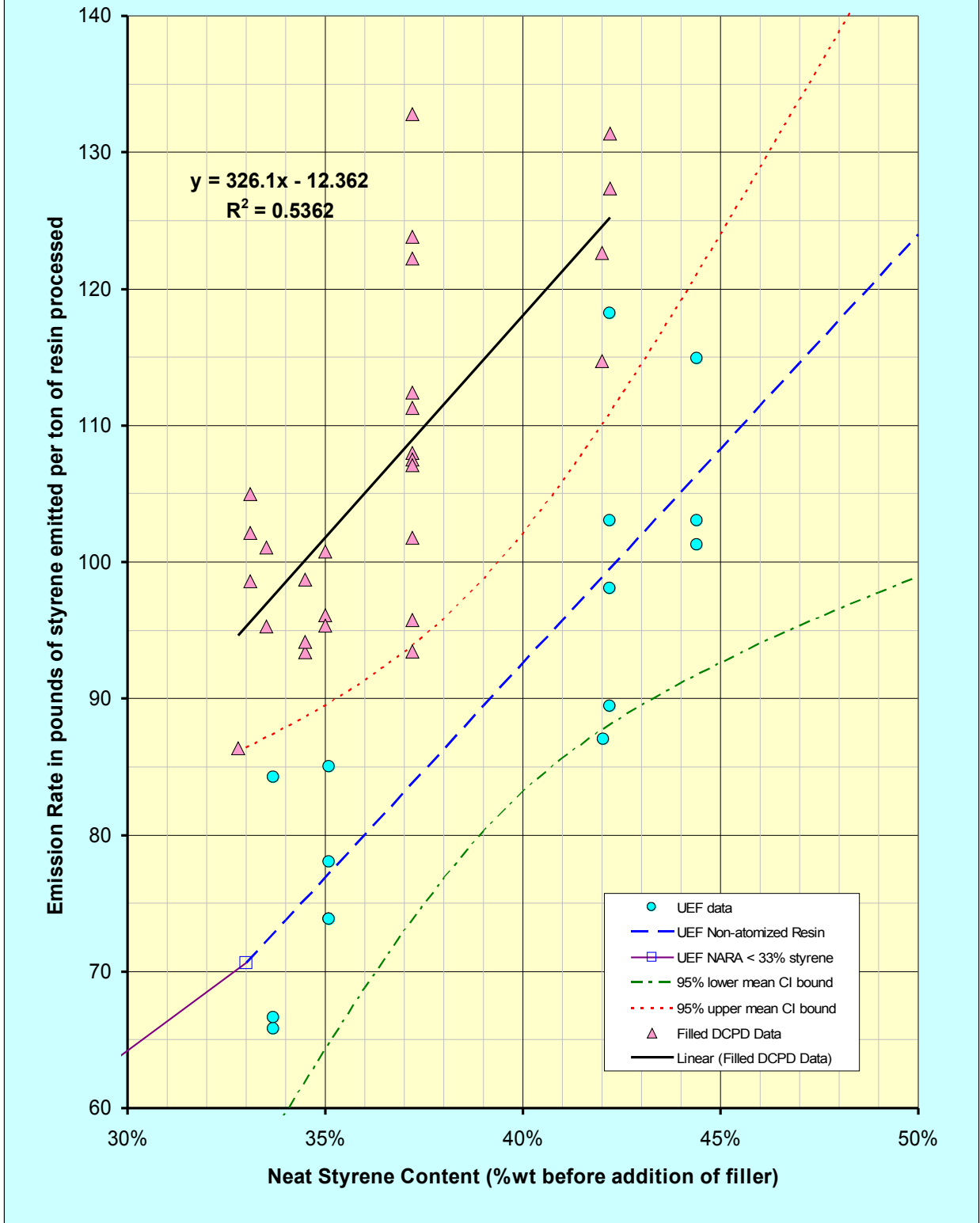


Figure B.

Table D - Emission Rate in Pounds of Styrene Emitted per Ton of Resin or Gelcoat Processed

Styrene content in resin/gel-coat, % (1)	<33 (2)	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	>50 (2)
Mechanical Non-Atomized Filled DCPD Resins (10)	288.6 x %styrene	95	99	102	105	108	112	115	118	121	125	128	131	134	138	141	144	147	151	(326.1 x %styrene) - 12.362

Source Test and CMTI Lab Data Index for the Mechanical Non-Atomized Application of Filled DCDP Resin						
Test Site (EPA oversight)	Data Pt No.	Test Date	PDF files			Observed by EPA
			Test Protocol	Test Report	Test Appendix	
MAAX Marion, IA (Linn Co & IA DNR)	1	3/29/2006	041_P	041_R	041_A	Yes
	2	3/28/2006				
	3	3/27/2006				
	4	4/29/2004	040_P	040_P	040_P	Yes
	5	4/28/2004				
MAAX Martinsburg, WV (WV DEP)	6	4/4/2007	see 030	032_R	032_R	Yes
	7	10/4/2006	030_P	030_R	030_R	Yes
	8	12/15/2005	031_P	031_P	031_P	Yes
	9	12/14/2005				
	10	4/7/2005	n/a	033_R	in report	No
Lasco Bathware Lancaster, TX (TCEQ & Region 6)	11	6/15/2005	see 050	050_P	050_P	Yes
	12	6/14/2005				
	13	12/16/2004	051_P	051_P	051_P	Yes
	14	12/15/2004				
Lasco Bathware Moapa, NV (Clark Co. & Region 9)	15	1/12/2000	020_P	020_P	020_P	Yes
	16	1/11/2000				
ACMA Resin Screening CMTI Lab at Purdue	17 to 27	April to June 2007	100_P	100_R	100_A	No

Source Test Results for the Mechanical Non-Atomized Application of Heavily Filled DCDP Resin at Bathware Facilities					
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	17	23	37.2%	16.43%	122	146%
	18	24	37.2%	14.39%	107	128%
DCPD Resin filled at 50% by 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%