

## Appendix E.

# Unified Emission Factors for Open Molding of Composites

July 23, 2001

### Emission Rate in Pounds of Styrene Emitted per Ton of Resin or Gelcoat Processed

Styrene content in resin/gelcoat, % <sup>(1)</sup>	<33 <sup>(2)</sup>	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	>50 <sup>(2)</sup>
<b>Manual</b>	0.126 x %styrene x 2000	83	89	94	100	106	112	117	123	129	134	140	146	152	157	163	169	174	180	((0.286 x %styrene) - 0.0529) x 2000
<b>Manual w/ Vapor Suppressed Resin VSR <sup>(3)</sup></b>	<b>Manual emission factor</b> [listed above] x (1 - (0.50 x specific VSR reduction factor for each resin/suppressant formulation))																			
<b>Mechanical Atomized</b>	0.169 x %styrene x 2000	111	126	140	154	168	183	197	211	225	240	254	268	283	297	311	325	340	354	((0.714 x %styrene) - 0.18) x 2000
<b>Mechanical Atomized with VSR <sup>(3)</sup></b>	<b>Mechanical Atomized emission factor</b> [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
<b>Mechanical Atomized Controlled Spray <sup>(4)</sup></b>	0.130 x %styrene x 2000	86	97	108	119	130	141	152	163	174	185	196	207	218	229	240	251	262	273	0.77 x ((0.714 x %styrene) - 0.18) x 2000
<b>Mechanical Controlled Spray with VSR</b>	<b>Mechanical Atomized Controlled Spray emission factor</b> [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
<b>Mechanical Non-Atomized</b>	0.107 x %styrene x 2000	71	74	77	80	83	86	89	93	96	99	102	105	108	111	115	118	121	124	((0.157 x %styrene) - 0.0165) x 2000
<b>Mechanical Non-Atomized with VSR <sup>(3)</sup></b>	<b>Mechanical Non-Atomized emission factor</b> [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
<b>Filament application</b>	0.184 x %styrene x 2000	122	127	133	138	144	149	155	160	166	171	177	182	188	193	199	204	210	215	((0.2746 x %styrene) - 0.0298) x 2000
<b>Filament application with VSR <sup>(3)</sup></b>	0.120 x %styrene x 2000	79	83	86	90	93	97	100	104	108	111	115	118	122	125	129	133	136	140	0.65 x ((0.2746 x %styrene) - 0.0298) x 2000
<b>Gelcoat Application</b>	0.445 x %styrene x 2000	294	315	336	356	377	398	418	439	460	481	501	522	543	564	584	605	626	646	((1.03646 x %styrene) - 0.195) x 2000
<b>Gelcoat Controlled Spray Application <sup>(4)</sup></b>	0.325 x %styrene x 2000	215	230	245	260	275	290	305	321	336	351	366	381	396	411	427	442	457	472	0.73 x ((1.03646 x %styrene) - 0.195) x 2000
<b>Gelcoat Non-Atomized Application <sup>(8)</sup></b>	SEE Note 9 below	196	205	214	223	232	241	250	259	268	278	287	296	305	314	323	332	341	350	((0.4506 x %styrene) - 0.0505) x 2000
<b>Covered-Cure after Roll-Out</b>	<b>Non-VSR process emission factor</b> [listed above] x (0.80 for Manual <or> 0.85 for Mechanical)																			
<b>Covered-Cure without Roll-Out</b>	<b>Non-VSR process emission factor</b> [listed above] x (0.50 for Manual <or> 0.55 for Mechanical)																			

### Emission Rate in Pounds of Methyl Methacrylate Emitted per Ton of Gelcoat Processed

MMA content in gelcoat, % <sup>(6)</sup>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	≥20
<b>Gel coat application <sup>(7)</sup></b>	15	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	0.75 x %MMA x 2000

**Notes**

- 1 Including styrene monomer content as supplied, plus any extra styrene monomer added by the molder, but before addition of other additives such as powders, fillers, glass,...etc.
- 2 Formulas for materials with styrene content < 33% are based on the emission rate at 33% (constant emission factor expressed as percent of available styrene), and for styrene content > 50% on the emission rate based on the extrapolated factor equations; these are not based on test data but are believed to be conservative estimates. The value for "% styrene" in the formulas should be input as a fraction. For example, use the input value 0.30 for a resin with 30% styrene content by wt.
- 3 The VSR reduction factor is determined by testing each resin/suppressant formulation according to the procedures detailed in the **CFA Vapor Suppressant Effectiveness Test**.
- 4 SEE the **CFA Controlled Spray Handbook** for a detailed description of the controlled spray procedures.
- 5 The effect of vapor suppressants on emissions from filament winding operations is based on the **Dow Filament Winding Emissions Study**.
- 6 Including MMA monomer content as supplied, plus any extra MMA monomer added by the molder, but before addition of other additives such as powders, fillers, glass,...etc.
- 7 Based on gelcoat data from **NMMA Emission Study**.
- 8 SEE the July 17, 2001 EECS report **Emission Factors for Non-Atomized Application of Gel Coats used in the Open Molding of Composites** for a detailed description of the non-atomized gelcoat testing.
- 9 Use the equation **((0.4506 x %styrene) - 0.0505) x 2000** for gelcoats with styrene contents between 19% and 32% by wt.; use the equation **0.185 x %styrene x 2000** for gelcoats with less than 19% styrene content by wt.