Appendix E: Unified Emission Factors for Open Molding of Composites dated October 13, 2009

EF Table 1: Unified Emission Factors for Open Molding of Composites

Revised and Approved: 10/13/2009

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

Styrene content in resin/gelcoat, % [1]	<33 [2]	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	>50 [2]
Manual	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
Manual w/ Vapor Suppressed Resin VSR [3]	Manual emission factor [listed above] x (1 - (0.50 x specific VSR reduction factor for each resin/suppressant formulation))																			
Mechanical Atomized	0.169 x %styrene x 2000	111	126	140	154	168	183	197	211	225	240	254	268	283	297	311	326	340	354	((0.714 x %styrene) - 0.18) x 2000
Mechanical Atomized with VSR [3]	Mechanical Atomized emission factor [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
Mechanical Atomized Controlled Spray [4]	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
Mechanical Controlled Spray with VSR	Mechanical Atomized Controlled Spray emission factor [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
Mechanical Non-Atomized	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
Mechanical Non-Atomized with VSR [3]	Mechanical Non-Atomized emission factor [listed above] x (1 - (0.45 x specific VSR reduction factor for each resin/suppressant formulation))																			
Mechanical Non-Atomized application of resins that contain Methyl Styrene monomer [10]	Mechanical Non-Atomized Styrene monomer emission Factor (listed above) x .55																			
Mechanical Non-Atomized Filled DCPD resins (11)	0.144 x % styrene x 2000	95	98	101	104	108	111	114	117	120	124	127	130	133	136	140	143	146	149	((0.1603 x % styrene)-0.0055) x 2000
Filament application	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
Filament application with VSR [3]	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
Gelcoat Application	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
Gelcoat Controlled Spray Application [4]	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
Gelcoat Non-Atomized Application [8]	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
Lesser Atomized Gelcoat Application [12]	for < 30 : 0.323 x % styrene x 2000	229	241	252	264	276	287	299	311	322	334	346	357	369	381	392	404	416	428	((0.5842 x % styrene)-0.07825) x 2000
Covered-Cure after Roll-Out	Non-VSR process emission factor [listed above] x (0.80 for Manual <or> 0.85 for Mechanical)																			
Covered-Cure without Roll-Out	Non-VSR process emission factor [listed above] x (0.60 for Manual <or> 0.55 for Mechanical)																			

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

MMA content in gelcoat, % [6]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	≥20
Gel coat application [7]	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.

10 Refer to Section 3.0, Instructions and Examples for the Emission Factor table, 3.2 Calculation of the methyl styrene factor

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

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Table from 30% TO 32% styrene content :	30	31	32
	194	206	217