

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, % ⁽¹⁾	<33 ⁽²⁾	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	>50 ⁽²⁾
Manual	$0.126 \times \% \text{styrene} \times 2000$	83	89	94	100	106	112	117	123	129	134	140	146	152	157	163	169	174	180	$((0.286 \times \% \text{styrene}) - 0.0529) \times 2000$
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	$0.169 \times \% \text{styrene} \times 2000$	111	126	140	154	168	183	197	211	225	240	254	268	283	297	311	325	340	354	$((0.714 \times \% \text{styrene}) - 0.18) \times 2000$
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⁾	$0.130 \times \% \text{styrene} \times 2000$	86	97	108	119	130	141	152	163	174	185	196	207	218	229	240	251	262	273	$0.77 \times ((0.714 \times \% \text{styrene}) - 0.18) \times 2000$
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	$0.107 \times \% \text{styrene} \times 2000$	71	74	77	80	83	86	89	93	96	99	102	105	108	111	115	118	121	124	$((0.157 \times \% \text{styrene}) - 0.0155) \times 2000$
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))																			
Filament application	$0.184 \times \% \text{styrene} \times 2000$	122	127	133	138	144	149	155	160	166	171	177	182	188	193	199	204	210	215	$((0.2746 \times \% \text{styrene}) - 0.0298) \times 2000$
Filament application with VSR ⁽³⁾	$0.120 \times \% \text{styrene} \times 2000$	79	83	86	90	93	97	100	104	108	111	115	118	122	125	129	133	136	140	$0.65 \times ((0.2746 \times \% \text{styrene}) - 0.0298) \times 2000$
Gelcoat Application	$0.445 \times \% \text{styrene} \times 2000$	294	315	336	356	377	398	418	439	460	481	501	522	543	564	584	605	626	646	$((1.03646 \times \% \text{styrene}) - 0.195) \times 2000$
Gelcoat Controlled Spray Application ⁽⁴⁾	$0.325 \times \% \text{styrene} \times 2000$	215	230	245	260	275	290	305	321	336	351	366	381	396	411	427	442	457	472	$0.73 \times ((1.03646 \times \% \text{styrene}) - 0.195) \times 2000$
Gelcoat Non-Atomized Application ⁽⁶⁾	SEE Note 9 below	196	205	214	223	232	241	250	259	268	278	287	296	305	314	323	332	341	350	$((0.4506 \times \% \text{styrene}) - 0.0505) \times 2000$
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 (0.50 for Manual <or> 0.55 for Mechanical)																			

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

MMA content in gelcoat, % ⁽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	$0.75 \times \% \text{MMA} \times 2000$

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 $((0.4506 \times \% \text{styrene}) - 0.0505) \times 2000$ for gelcoats with styrene contents between 19% and 32% by wt; use the equation $0.185 \times \% \text{styrene} \times 2000$ for gelcoats with less than 19% styrene content by wt.