# 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, % [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 | 325 | 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)) | | | | | | | | | | | | | | | | | | | |
| **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 |
| **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 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.