UEF Emission Factors
For Open Molding and Other Composite Processes

FIFTH EDITION

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UEF Emission Factors
For Open Molding and Other Composite Processes

FIFTH EDITION

Prepared by
American Composites Manufacturers Association

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UEF Emission Factors
For Open Molding and Other Composite Processes

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Secretariat
American Composites Manufacturers Association

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This forward is included as background information only. It is not part of the official American National Standard ACMA/UEF-5-19.

From 1996 through 1998, the American Composites Manufacturers Association (ACMA), formerly named the Composites Fabricators Association (CFA), conducted styrene emissions testing. The ACMA testing program consisted of three test phases, which investigated the effects of process parameters on the styrene emissions from the open molding of composites. The test protocol used in the ACMA testing is described in the November 18, 1998 ACMA report entitled *Styrene Emissions Test Protocol & Facility Certification Procedures, Revision 2.1*. The results of the ACMA Phase I testing are detailed in the September 1996 CFA report entitled *Phase I - Baseline Study; Hand Lay-up, Gel Coating, Spray Lay-up including Optimization Study*. The results of the ACMA Phase II and III testing are detailed in the report *Technical Discussion of the Unified Emission Factors for Open Molding of Composites*.

On February 28, 1998, Engineering Environmental Consulting Services (EECS) released a report entitled *CFA Emission Models for the Reinforced Plastics Industries* that details a set of equations developed from the ACMA test data. These equations predicted the styrene emission rates from typical lamination processes employed by the reinforced plastics industry. The report was subsequently posted on the EPA CHIEF website as a possible replacement for the obsolete AP-42 factors for reinforced plastics.

In 1997, the National Marine Manufacturers Association (NMMA) also conducted styrene emission testing using the CFA test protocol. The results of this testing are described in the August 1997 NMMA report entitled *Baseline Characterization of Emissions from Fiberglass Boat Manufacturing*. The NMMA report was also posted on the EPA CHIEF website as part of the AP-42 replacement process.

In November 1998, the CFA and NMMA agreed to merge the data from their respective test programs. The merged data sets were used to develop a new set of equations and factors that unify the methodology employed by boat builders and non-boat builders for estimating the VOC and HAP emissions from the open molding of composite parts. These new emission factors have been named the “Unified Emission Factors” (UEF). The Unified Emission Factor Table is the base data for this Standard.

From 2006 through 2008, emission tests were conducted on machines used to prepare sheet molding compound (SMC), which is used to form composite parts via closed molding in compression and injection presses. In 2008, studies were conducted by
Molded Fiber Glass Companies and Environmental Compliance and Risk Management (ECRM) Inc. to develop a predictive equation for emissions from SMC machines. The 2009 report *VOC Emissions from Production of Reinforced Composite Sheet Molding Compound* documents those study results and is the basis for the predictive equation in this Standard.

Styrene emission testing for SMC Compression Molding was conducted beginning August 11, 2008, ending September 4, 2008 by Engineering Environmental Consulting Services. The test report *SMC Compression Molding Test Results* was issued November 30, 2008.

Styrene emission testing for BMC and LCM Compression Molding was conducted beginning September 4, 2008, ending September 12, 2008 by Engineering Environmental Consulting Services. The test report *BMC/LCM Compression Molding Test Results* was issued October 12, 2009.

The test procedures and test methods for this testing were previously described in a test protocol report entitled *Test Protocol to Determine the Process Emissions from Compression Molding using a TTE Enclosure to Measure the VOC Emissions from Charge Preparation and Material Handling* that was submitted to Ohio EPA for comments on July 21, 2008.

This testing and the cited reports serve as the technical basis for the addition of styrene emission factors for compression molding of SMC, BMC, and LCM contained in this Standard.

VOC emissions factors for cast polymer manufacturing, including cultured marble and solid surface products, are published in the EPA AP-42 *Compilation of Air Pollutant Emission Factors*. The data for these factors was generated several decades ago and is unrelated to modern polymer casting equipment. Testing conducted in 2017 by ACMA under contract to the International Cast Polymer Association, and described in the report *Monomer Emissions from the Manufacture of Cultured Marble and Solid Surface Products*, is the basis for the polymer casting emission factors provided in Section 9 of this Standard.

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This Standard was developed under procedures accredited as meeting the criteria for American National Standards. The list of canvassers that reviewed this proposed standard was balanced to assure that individuals from competent and concerned interests had an opportunity to participate. The standard is available for public input from industry, academia, regulatory agencies and the public-at-large. ACMA does not “approve,” “rate,” or “endorse” any item or proprietary device described in this Standard. Participation by federal /state agency representative(s) or persons associated with industry is not to be interpreted as government or industry endorsement of this Standard.

Requests for interpretations or suggestions for revision should be sent to ANSI Secretariat, American Composites Manufacturers Association, 2000 N. 15th Street, Suite 250, Arlington, Virginia 22201.
1.0 Scope and Purpose

1.1 Scope

This Standard provides methods for estimating emissions from certain composites manufacturing operations.

1.2 Purpose

The emission estimates prepared using this Standard can be used for emission inventories, permit applications, compliance reports, TRI reports, business planning and other purposes for which accurate emission estimates are needed.

2.0 Referenced Standards and Publications

2.0.1 40 CFR Part 63, Subpart WWWW

2.0.2 Table 1 Part 63, Subpart WWWW

2.0.3 AP-42, Fifth Edition
3.0 Terms and Definitions

3.0.1 Definitions

Some of the definitions in this Standard may be different from the definitions provided in the EPA Subpart WWWW—NESHAP. Any such differences are believed to be immaterial to the use of the UEF standard. If it would impact NESHAP compliance in a given case, however, the definition in the NESHAP should be used.

3.1 Terms Applicable to Open Molding

3.1.1 Atomized Spray

Any kind of spray application that is not non-atomized spray, but typically includes Conventional Air Atomizing, High Pressure Airless, Air-Assisted Airless, and High Volume Low Pressure applicators.

3.1.2 Controlled Spray

A specific set of three work practices that can be used to reduce material usage, worker exposures, and emissions. The three work practices included in a Controlled Spray program are spray gun set-up and pressure calibration, training in proper spray techniques, and mold-perimeter containment flanges. A full program description and training materials for Controlled Spray can be obtained by contacting ACMA at (703) 525-0511.

3.1.3 Covered Cure

The use of vacuum bagging or other technology where a plastic sheet is used to cover the mold after resin is applied. Covered cure techniques are typically used where higher physical properties of the product are required. Vacuum infusion and other processes where the mold is covered before resin is applied are not considered to be open molding processes.

3.1.4 Filament Application

An open molding process for fabricating composites in which reinforcements are fed through a resin bath and wound onto a rotating mandrel. The materials on the mandrel may be rolled out or worked by using nonmechanical tools prior to curing. Resin application to the reinforcement on the mandrel by means other than the resin bath, such as spray guns, pressure-fed rollers, flow coaters, or brushes is not considered filament application.
3.1.5  **Gel Coat Application**

A process where a clear or pigmented formulated resin is applied to the mold by mechanical applicators. The gel coat will become the visible side of the composite part. If the gel coat resin is applied using a manual application method, the resin is no longer considered a gel coat for emission calculations purposes and emissions should be calculated using the manual application factors.

3.1.6  **Gel Coat Lesser Atomized Application (LAGA)**

Application of gel coat using a device that, when operated according to the manufacturer’s directions, results in an emission rate no greater than the lesser atomized emission factors provided in EF Table 1 of this Standard.

3.1.7  **Manual Application**

Any non-mechanical application (without pumps or pressurized material flow), and includes bucket-and-brush and bucket-and-roller.

3.1.8  **Mechanical Application**

The use of pumps to deliver a pressurized stream of resin or gel coat to a mold through some kind of application device. Spray and non-spray are the two types of mechanical application.

3.1.9  **Mechanical Atomized Application**

The application of resin or gel coat with spray equipment that separates the liquid into a fine mist. This fine mist may be created by forcing the liquid under high pressure through an elliptical orifice, bombarding a liquid stream with directed air jets, or a combination of these techniques.

3.1.10  **Mechanical Atomized Control Spray**

The use of an atomized spray gun in combination with a Controlled Spray program.

3.1.11  **Mechanical Non-atomized Application**

The use of application tools other than brushes to apply resin and gel coat where the application tool has documentation provided by its manufacturer or user that this design of the application tool has been emissions tested, and the test results showed that use of this application tool results in emissions that are no greater than the emissions predicted by the applicable non-atomized application factors in EF Table 1 of this Standard. In addition, the device must be operated according to the manufacturer’s directions, including instructions to prevent the operation of the device at excessive spray pressures. Examples of non-atomized application include flow coaters, pressure fed rollers, and fluid impingement spray guns.
3.1.12 Monomer
A component of resins that is both a diluent for the high molecular weight polymer contained in the resin, and the agent that chemically reacts during cure to crosslink the polymers to convert the liquid resin into a solid product. Common monomers are styrene, methyl methacrylate and methylstyrene.

3.1.13 Methylstyrene
Alpha-methylstyrene and any of the isomers or blends of isomers of vinyl toluene, used as monomers in some resins because of lower volatility. Using low-volatility resins can help composites manufacturers increase production while staying under permitted emission limits.

3.1.14 Open Molding
The manual resin application, mechanical resin application, filament application, and gel coat application. Resin transfer molding and other processes including pultrusion and compression molding where resin is delivered in a closed or covered mold are not open molding processes.

3.1.15 Roll-Out
The process used to compact and remove entrapped air from a laminate after the resin and reinforcement has been applied to a mold.

3.1.16 Subpart WWWW—NESHAP
The EPA NESHAP National Emission Standard for Hazardous Air Pollutants at 40 CFR 63 Subpart WWWW is the MACT (Maximum Achievable Control Technology) standard for reinforced plastic composites production. See additional comment at Sections 3.0.1 and 4.0.1.

3.1.17 Spray
Any material flow moving through the air to be deposited on a mold. Spray can be atomized or non-atomized.

3.1.18 Styrene Content
The styrene content of a resin or gel coat is the styrene content as applied, including any styrene added by the user. For non-gel coat resins the styrene content is calculated before any fillers or other non-styrene materials are added.

3.1.19 Vapor Suppressant
An additive, typically a wax that migrates to the surface of the resin during curing and forms a barrier to seal in the styrene and reduce styrene emissions.
3.1.20 Vapor-Suppressed Resin (VSR)
A resin containing a vapor suppressant added for the purpose of reducing styrene emissions during curing.

3.1.21 Vapor-Suppressed Resin Reduction Factor
A measure of the efficiency of a suppressant with a resin. It is determined by testing each resin/suppressant formulation according to the test method found in The US EPA MACT rule, Appendix A to Subpart WWWW—Test M.

3.2 Terms Applicable to Compression Molding Material

3.2.1 Sheet Molding Compound (SMC)
The feedstock used to produce reinforced plastic composite parts in injection and compression presses. SMC consists of resin paste and fiber reinforcement, sandwiched between two nylon-containing carrier films.

3.2.2 Bulk Molding Compound (BMC)
The feedstock used to produce reinforced plastic composite parts in injection and compression presses. BMC is a premixed blend of resin, reinforcements, initiators and fillers.

3.2.3 Liquid Composite Molding (LCM)
The combination of a fiber reinforcement and a resin paste in a closed mold to produce reinforced plastic composite parts. Liquid resin is applied to the reinforcement before molding. The resin may be applied from a container or conveyance so that it covers typically 10-40% of the area of the reinforcement (poured), or it may be applied and then spread to increase the coverage to in excess of 50% of the area of the reinforcement (spread).

3.3 Terms Applicable to Production of Sheet Molding Compound

3.3.1 Doctor Boxes
The upper and lower reservoirs into which resin paste mixed upstream is introduced and spread in a thin film across nylon carrier film.

3.3.2 Lower Wet Length (Ll)
The distance in feet, measured along the path of lower film travel, between the downstream end of the lower doctor box and the point at which the upper and lower carrier films come together.
3.3.3 **SMC Machine**

Refers to the production line for SMC. In typical configurations, resin paste is pumped to upper and lower reservoirs (*doctor boxes*), from which it is distributed in a thin layer across upper and lower carrier films, which are impervious to styrene. Chopped fibers (usually glass) are spread across the lower carrier film, and the two films are brought together and fed through a series of compression rollers, after which the final product is either rolled or folded (festooned) for storage.

3.3.4 **Total Wet Area \( (A_t) \)**

Is calculated as defined in Section 4.

3.3.5 **Upper and Lower Open Doctor Box Areas \( (A_{du} \text{ and } A_{dl}) \)**

The areas of each doctor box that are uncovered, measured in square feet.

3.3.6 **Upper Wet Length \( (L_u) \)**

The distance in feet, measured along the path of upper film travel and including vertical sections, between the downstream end of the upper doctor box and the point at which the upper and lower carrier films come together.

3.3.7 **Wet Width \( (W) \)**

The width in feet of the layer of resin paste deposited under the doctor box as carrier film moves below it.

3.4 **Terms Applicable to Cast Polymer Operations**

3.4.1 **Cast Polymer**

The production of products using manual application of highly filled pastes comprised of resin, monomer, filler, colorant and other additives. Common terms for cast polymer include cultured marble, solid surface, cultured stone, and polymer concrete.

3.4.2 **Auto Casting Machine**

A closed extruder in which resin is mixed with fillers and other ingredients to form a paste that is fed into molds on the associated casting line.

3.4.3 **Gel Coat Application as part of Cast Polymer Operations**

Factors derived from the EF Table 1 of this Standard and apply to the various forms of gel coat application listed.
4.0 Instructions and Examples for the Emission Factor Table

4.0.1 Table 1

Table 1 of the Subpart WWWW—NESHAP (Equations to Calculate Organic HAP Emission Factors for Specific Open Molding and Centrifugal Casting Operations) was adopted from the UEF Standard in effect at the time the NESHAP was promulgated. The EF Table 1 of this Standard has since been modified while the NESHAP Table 1 has not; where they are different, NESHAP Table 1 should be used to demonstrate compliance with the EPA standard, while the EF Table 1 of this Standard provides the most accurate emission estimate for other purposes such as emission inventories and Toxics Release Inventory (TRI) reporting. See Note 1 to Table 1 of the Subpart WWWW—NESHAP.

4.1 Finding the Proper Open Molding Emission Factor using EF Table 1

4.1.1 Information Required to use EF Table 1 of this Standard

Before using EF Table 1 of this Standard, the following information must be obtained:

4.1.1.1 Styrene, methyl methacrylate or methylstylene content of the resin/gel coat material

The monomer content of the resin/gel coat materials can be obtained from the associated Safety Data Sheet (SDS) information, the Q/A certification sheet sent with most bulk resin shipments, or by calling the resin supplier or manufacturer. Occasionally, the SDS will specify a broad range for the styrene content, such as 20 to 50% styrene by weight. This is a short-cut used by the resin supplier to avoid listing more specific information for each resin formulation. The average value for such a broad range (average 35% for the example above) should not be used. Instead, the resin supplier should be asked to provide more precise estimates of the actual monomer contents for each material.

4.1.1.1 Precision

Occasionally, the SDS will provide a broad range for the monomer content, such as “20 to 50% styrene by weight”. This is a short-cut used by the resin supplier to avoid listing more specific information for each resin formulation. Using the average value for such a broad range can lead to significant errors in estimating emissions as well as compliance problems. Instead, the resin supplier should be asked to provide more precise information on the actual monomer contents for each material.
4.1.1.2 Application process used to apply the material

The correct application process must be identified from the following major types; Manual, Mechanical Atomized, Mechanical Non-Atomized, Filament, or Gel Coat Spraying.

4.1.1.3 Vapor suppressant data - the VSR reduction factor (if used)

Determine if vapor-suppressant is added to the resin formulation. If so, the VSR reduction factor for that specific resin/suppressant mixture must be obtained from the resin supplier, or must be determined at the plant according to procedures detailed in the Vapor-suppressant Effectiveness Test, found in Appendix A to the Subpart WWW—NESHAP—Test Method for Determining Vapor-suppressant Effectiveness Special pollution prevention techniques (if used).

Determine if Controlled Spraying and/or Covered-Cure are used with any of the application processes.

4.1.2 With this information, refer to EF Table 1

4.1.2.1 Find the correct application process in the left-most column of EF Table 1 of this Standard.

4.1.2.2 Find the correct styrene content across the top row of EF Table 1 of this Standard.

4.1.2.3 Locate the cell at the intersection of the selected row and column. This cell contains the correct emission factor that corresponds to the application process and styrene content resin or gel coat selected. If the styrene content is below 33 percent, use the equation in the 2nd left-most column to compute emission factors. If the styrene content is above 50 percent, use the equation on the far right column to compute emission factors. For both equations the styrene content value should be expressed as a decimal fraction, i.e. where the equation calls for “52%” use “0.52”.

4.1.2.4 (For vapor-suppressed resins) If a vapor-suppressed resin is used, first determine the factor as if the resin was non-suppressed. Then the VSR reduction factor for the specific resin/suppressant mixture and the corresponding non-vapor-suppressed emission factor are inserted into the equation in EF Table 1 of this Standard.

4.1.2.5 (For non-suppressed resins that use the covered-cure technique) The appropriate covered-cure factor depends on whether the covering is placed after the wet laminate is rolled out or whether the covering is applied directly to the wet laminate without any rolling taking place. The covered cure factor is multiplied by the corresponding non-vapor-suppressed resin application process emission factor as shown in EF Table 1 of this Standard. Vapor suppressants are not used in conjunction with covered-cure because the impervious cover takes the place of the film formed by the suppressant.
4.2 Calculation of the Methylstyrene Factor

This methylstyrene factor will be equal to 55% of the equivalent UEF non-atomized resin application factor. The following is an example calculation that shows how the methylstyrene factor will be determined:

UEF styrene emission factor for 5% styrene content = 10.7% of styrene weight.

Methylstyrene emission factor for 5% methylstyrene content resin = 55% x 10.7% = 5.89% of methylstyrene weight.

5.0 Estimation of VOC Emissions from Production of SMC

SMC machine emissions of volatile organic compounds (VOC) can be estimated from the following equation:

\[ E = 0.1457 \times A_t - 0.1454 \]

where:

\( E \) = VOC emission rate, lb./hr., when paste is on the line

\( A_t \) = Total wet area of SMC machine = \( A_{dl} + A_{du} + W(L_l + L_u) \), ft\(^2\)

\( A_{dl} \) = open area of the lower doctor box, ft\(^2\)

\( A_{du} \) = open area of the upper doctor box, ft\(^2\)

\( W \) = wet width of SMC, ft.

\( L_l \) = Lower wet length, ft.

\( L_u \) = Upper wet length, ft.

6.0 Estimation of VOC Emissions from Compression Molding of SMC

The emission factor for SMC is expressed as a percentage of the available styrene monomer contained in the uncured SMC material that is processed in the compression mold. The emission factor for SMC part compression molding is:

1.5% of the styrene monomer content (weight) in the SMC material

Therefore monomer emissions from compression molding of SMC:

\[ E_{smc} = 0.015 \times \text{weight of styrene monomer in SMC molded} \]
7.0 Estimation of VOC Emissions from Compression Molding of BMC

The emission factor for BMC is expressed as a percentage of the available styrene monomer contained in the uncured BMC material that is processed in the compression mold. The emission factor for BMC part compression molding is:

1.15% of the styrene monomer content (weight) in the processed BMC material

Therefore monomer emissions from compression molding of BMC:

\[ E_{\text{BMC}} = 0.0115 \times \text{weight of styrene monomer in BMC molded} \]

8.0 Estimation of VOC Emissions from Compression Molding of LCM

The emission factor for LCM part compression molding consists of two separate equations. The first equation is for the spread of LCM paste, the second equation is for poured LCM paste.

1. LCM spread paste factor (% of paste weight) = 0.0072 x % styrene + 0.0008
2. LCM poured paste factor (% of paste weight) = 0.0022 x % styrene + 0.0008

Therefore:

1. Monomer emissions from spread LCM molding: \( E_s = EF_s \times \text{weight of paste molded} \)
2. Monomer emissions from poured LCM molding: \( E_p = EF_p \times \text{weight of paste molded} \)

NOTE: The “% styrene” input value in these equations must be in decimal form instead of percentage (0.20 instead of 20%). These equations generate the factor as a decimal fraction of the processed paste weight.
9.0 Emissions Factors for the Cast Polymer Open Molding Manufacturing Process

9.1 Instructions for Estimating Emissions

9.1.1 The VOC emission factor for manufacture by auto caster of cast polymer and solid surface products is 0.13% (0.0013) of the total weight of material molded (resin + filler + additives). Note that this factor will overestimate emissions from auto caster production of deep (thick) parts – see the study report for possible alternative emission factors.

9.1.2 Emissions from cultured marble, solid surface, and similar casting operations using an auto casting machine can be calculated using the formula:

\[ \text{Monomer emissions (pounds)} = \text{weight of applied paste (pounds)} \times 0.0013 \]

9.1.3 The formula provided in Section 9.1.2 applies to casting of slab-like products like countertops and other products with similar ratio of exposed product surface area to weight of paste applied. Because emissions are primarily a function of surface area of paste exposed to the air, emissions from casting of more three-dimensional products like parking curbs or utility vaults may be lower.

9.1.4 For non-automated production (manual mixing and pouring) of these products, see AP-42 - Table 4.4-2 Emissions Factors for Uncontrolled Polyester Resin Production Processes and are described as Marble Casting 30800766 – Polymer Casting (Cultured Marble or Marble Casting).
### 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 Gel Coat Processed**

<table>
<thead>
<tr>
<th>Styrene content in resin/gel coat, %</th>
<th>Manual 0.126 x % styrene x 2000</th>
<th>Manual emission factor (listed above) x (1 - 0.50 x specific VSR reduction factor for each resin/suppressant formulation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual w/Vapor Suppressed Resin VSR (1)</td>
<td>0.169 x % styrene x 2000</td>
<td>Mechanical Atomized emission factor (listed above) x (1 - 0.45 x specific VSR reduction factor for each resin/suppressant formulation)</td>
</tr>
<tr>
<td>Mechanical Atomized with VSR (2)</td>
<td>0.130 x % styrene x 2000</td>
<td>Mechanical Atomized Controlled Spray emission factor (listed above) x (1 - 0.45 x specific VSR reduction factor for each resin/suppressant formulation)</td>
</tr>
<tr>
<td>Mechanical Atomized Controlled Spray (4)</td>
<td>0.325 x % styrene x 2000</td>
<td>Mechanical Non-Atomized emission factor (listed above) x (1 - 0.45 x specific VSR reduction factor for each resin/suppressant formulation)</td>
</tr>
<tr>
<td>Mechanical Non-Atomized (5)</td>
<td>0.144 x % styrene x 2000</td>
<td>Mechanical Non-Atomized application of resins that contain Methyl Styrene monomer emission Factor (listed above) x .55</td>
</tr>
<tr>
<td>Mechanical Non-Atomized Filled DCPD resin (6)</td>
<td>0.325 x % styrene x 2000</td>
<td>Mechanical Non-Atomized Filled DCPD resin (6)</td>
</tr>
<tr>
<td>Filament application (7)</td>
<td>0.120 x % styrene x 2000</td>
<td>Gel coat Application</td>
</tr>
<tr>
<td>Gel coat Application (8)</td>
<td>0.445 x % styrene x 2000</td>
<td>Gel coat Controlled Spray Application</td>
</tr>
<tr>
<td>Gel coat Non-Atomized Application (9)</td>
<td>0.325 x % styrene x 2000</td>
<td>Gel coat Non-Atomized Application (9)</td>
</tr>
<tr>
<td>Lesser Atomized Gel coat Application (12) for &lt;30 : 0.323 x % styrene x 2000</td>
<td>0.75 x % MMA x 2000</td>
<td></td>
</tr>
<tr>
<td>Covered-Cure after Roll-Out</td>
<td>Non-VSR process emission factor (listed above) x (0.80 for Manual &lt; VSR 0.85 for Mechanical)</td>
<td></td>
</tr>
<tr>
<td>Covered-Cure without Roll-Out</td>
<td>Non-VSR process emission factor (listed above) x (0.50 for Manual &lt; VSR 0.55 for Mechanical)</td>
<td></td>
</tr>
</tbody>
</table>

**Emission Rate in Pounds of Methyl Methacrylate Emitted per Ton of Gel Coat Processed**

<table>
<thead>
<tr>
<th>MMA content in gel coat, %</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
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<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>≥20</th>
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<tbody>
<tr>
<td>Gel coat application (10)</td>
<td>15</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>105</td>
<td>120</td>
<td>135</td>
<td>150</td>
<td>165</td>
<td>180</td>
<td>195</td>
<td>210</td>
<td>225</td>
<td>240</td>
<td>255</td>
<td>270</td>
<td>285</td>
<td></td>
</tr>
</tbody>
</table>

**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, glasses, 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 extrapolated factor equations, these are not based on test data but are believed to the conservative estimates. The value for "% styrene" in the formulas should be input as a fraction. For example, use the input value 0.30% styrene content by weight.
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, glasses, etc.
7. Based on the gel coat data from NMMA Emission Study.
8. SEE the July 17, 2001 EECS report Emission Factors for Non-Atomized Application on Gel Coats used in the Open Molding of Composites for a detailed description of the non-atomized gel coat testing.
9. Use the equation (0.4506 x % styrene) - 0.0505 x 2000 for gel coats with styrene contents between 19% and 32% by wt; use the equation 0.185 x % styrene x 2000 for gel coats 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 methylstyrene factor.
11. Use this factor for the non-atomized application of DCPD or DCPD-blend resin, when filled to 30% or more by weight.

### Table from 30% TO 32% styrene content:

<table>
<thead>
<tr>
<th>MMA content in gel coat, %</th>
<th>30</th>
<th>31</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gel coat content (11)</td>
<td>194</td>
<td>206</td>
<td>217</td>
</tr>
</tbody>
</table>