AP42 Section:	4.4
Related:	8
Title:	Reviewer comments of FRP Model, CFA, and NMMA models 1998

Composites Fabricators Association

Committed to Strength Through A Unified Industry

August 25, 1998

Mr. Ron Ryan
EPA-OAQPS
Emissions Monitoring and Analysis Division
Research Commons
79 T.W. Alexander Drive
Building 4201
Research Triangle Park, North Carolina 27711

Dear Ron:

The Composites Fabricators Association recognizes and supports the US EPA's goal to provide conservative and accurate estimation of emissions from sources of air pollution.

We are pleased that EPA has provided us an opportunity to review and comment on the FRP Model which has been developed for the EPA Office of Research and Development.

We have done a comprehensive evaluation of this model, and have enclosed our comments.

We would request that you pay special attention to the "Comparison to the CFA Model" portion of our comments. We realize that EPA is interested in achieving an accurate estimate of emissions from composites facilities. We agree with this goal. In that regard, we would point out that CFA Model compares very favorably, with regard to deriving a conservative estimation of source emissions.

Again we would stress the importance of the "enforceability" aspects of any emissions model which is offered to the states and to industry sources. Since an emissions model will often serve as a basis for a permit limit, the emissions model will most often be presumed as the basis for the permit compliance determination. If model parameters are not "practically enforceable", then major aspects of the permit will not be federally enforceable.

Finally, we would call your attention to the fact that this FRP Model can derive "impossible" endpoints. This would indicate to us that there are practical limitations to the use of this model to derive meaningful emissions estimates from facilities.

We wish to thank you again for the opportunity to comment on this emissions model.

We look forward to additional opportunities to discuss these matters with your office.

Sincerely,

Stephen McNally
Director of Government Affairs

Enc.

CFA Comments Regarding the NRMRL (EPA) "FRP Model version 1.0"

General Inability to Verify the Model:

According to the EPA text provided with the model (under the task bar button labeled "About EPA FRP Model"):

> *"EPA's APPCD, in cooperation with Research Triangle Institute (RTI), has developed a mathematical model to provide better styrene emission estimates for selected open molding fiber-reinforced plastics (FRP)manufacturing processes. The model highlights 10 relevant parameters impacting styrene emissions in FRP processes and helps identify future areas of FRP pollution prevention (P2) research. Seven different emission studies were evaluated and used as model inputs."*

The EPA text does not identify these referenced seven emission studies, so the CFA cannot verify the basis of the model algorithms.

Comparison to CFA Model:

The following table compares the single-factor CFA Model with the FRP Model at the baseline conditions. This is appropriate because the CFA Model has no assigned "baseline" values.

Emission Rate (as % ***available styrene***)
single-factor CFA Model / FRP Model at baseline conditions
MONOMER CONTENT

PROCESS	34 %	38 %	42 %	46 %
Gel coating	46.2 / 52.0	52.4 / 54.8	57.1 / 57.5	61.3 / 60.3
Resin spray up				
NVS	18.5 / 15.3	23.9 / 18.9	28.6 / 22.8	32.2 / 27.1
VS	11.5 / 9.8	15.0 / 12.1	17.6 / 14.6	20.0 / 17.4
Hand lay up				
NVS	12.9 / 11.3	14.7 / 12.3	16.0 / 13.3	17.2 / 14.3
VS	8.2 / 5.7	7.9 / 6.1	7.6 / 6.6	7.2 / 7.1
Flowcoater	9.4 / 10.4	12.3 / 11.3	14.6 / 12.2	16.5 / 13.1
Pressure-fed roller	9.4 / 11.6	12.3 / 12.6	14.6 / 13.6	16.5 / 14.6

Gel coating - the two models are about the same. The CFA Model is ~~more~~ less conservative (~~higher~~ lower estimates) than the FRP Model below 42% content, and ~~less~~ more conservative above. Not much difference until below 34% content.

Resin spray up - the CFA Model is significantly more conservative (higher estimates) than the FRP Model at all monomer content levels.

Hand lay up - the CFA Model is significantly more conservative (higher estimates) than the FRP Model for non-vapor-suppressed resin at higher monomer content levels, and draws close to the FRP Model at 34% content. For vapor-suppressed resin, CFA Model is significantly more conservative (higher estimates) at lower monomer content levels.

(No, it isn't)

Flowcoater and Pressure-fed roller - the CFA Model does not distinguish between the two processes. The FRP Model is more conservative (higher estimates) than the CFA Model in both cases. The difference between the two models is insignificant at 34% content, but increases for higher monomer levels. Overall, the two models are about the same. ?

Overall Implementation and Use:

Very slick "Windows-style" presentation - The model program installed without any problems and ran the first time. The model screens follow the standard Windows 95™ format, and are simple and easy to understand. The input of data by mouse and keyboard is also very easy. Overall, the presentation of the model is very slick and professional-looking.

Emission Calculations are Allowed Outside the Acceptable Range:

If, as the model suggests, results outside the acceptable input ranges may not be reliable, one might reasonably ask why are such results even allowed? The model was self-described by the EPA as a tool to provide better emission estimates and directions for future P2 research. It is difficult to understand what is gained by developing an unreliable tool. A more reasonable approach would be to limit such a tool to reliable inputs. Presumably, one possible reason for allowing out-of-range calculations would be the regulatory application of this model to establish emission rates for permits or emissions reporting, where a source may well operate outside the typical parameter ranges. However, such a use could easily, and often lead to a serious abuse of the model.

The Model is Not Practical:

In the real world, it is difficult to conceive how a source could reliably and consistently measure spray gun distance. This is also true of part thickness and over spray ratio. The model does not offer methodologies regarding where or how the air temperature and air velocity should be measured. Sources would apparently be free to measure at the surface of the part, above the surface, at some set distance from the part, or averaged throughout the work area. This would allow for extraordinary variations in the estimated emissions from fundamentally similar plants. If the parameters cannot be measured, the model cannot be reliably used in the real world.

Not enforceable:

If the model isn't practical, then it simply isn't enforceable. If this model were to be offered as guidance to the states, then the limitations on the practical enforceability of the model parameters must be clearly stated in the model text, or in the EPA guidance to the states, to avoid potential misapplication by state or local agencies.

Overly complex and sophisticated algorithms:

The only algorithms provided in the EPA text were for resin spray lay up, and they took the following forms:

PARAMETER	EQUATION FORM
Styrene content	second-order polynomial $AX^2 + BX + C$ (C= O)
Styrene suppressant	linear equation $AX + B$ if suppressant is used
Distance spray gun to mold	linear equation $AX + B$
Ratio of dry material off mold to material sprayed	second-order polynomial $AX^2 + BX + C$
Thickness	step-wise linear equations $AX + B$, with step at 40 mils
Gel time	linear equation $AX + B$
Application rate	linear equation $AX + B$ if less than 4 lb/min
Air temperature	linear equation $AX + B$
Air velocity over mold	step-wise linear equations AX -t- B, with step at 38 fpm

No specific comments can be offered because the underlying data and assumption were not provided by the EPA. However, based upon the industry's knowledge, so far, of the available data, we are skeptical that such complex and sophisticated equations could have been developed with any reasonable confidence.

Impossible results are possible with acceptable model inputs:

This model can result in physically impossible emission rates while using acceptable input values. A simple exercise in repeated application of the model gave the following factor range *for the acceptable input range*:

PARAMETER	FACTOR RANGE
Styrene content	0.64 - 1.68
Styrene suppressant	0.64 for unfilled resin
Distance spray gun to mold	0.94 - 1.51
Ratio of dry material off mold to material sprayed	0.91- 1.16
Thickness	1.04 -0.84
Gel time	0.98 - 1.07
Application rate	1.30 - 1.00 above4
Air temperature	0.83 - 1.22
Air velocity over mold	0.94 - 1.04

The model assumed that these factors were independent, so the factors were simply multiplied together. This could lead to an extremely unrealistic emission rate that would still be judged acceptable under the model conditions. For example, a 50% monomer, non-suppressed, 40" gun distance, 10% overspray, 50 mil thick, 1 lb/hr, 50 minute gel time, 95°F, 200 fpm condition would yield a modification factor of 5.46 that is then applied to the baseline emission rate of 18.9%. These factors result in an absurdly high 103.1% emission rate, which is **physically impossible**.

On the other hand, a 30% monomer, vapor-suppressed, 12" gun distance, 1% overspray, 150 mil thick, 4 lb./hr, 5 minute gel time, 60°F, 20 fpm condition would yield a modification factor of 0.23 that is then applied to the baseline emission rate of 18.9%. This factor results in a very low 4.3% emission rate, which is equally unlikely.

Conclusions:

The CFA is not confident that the NRMRL (EPA) "FRP Model version 1.0" for estimating styrene emissions from composites facilities is either appropriate, or consistently accurate.

Respectfully submitted,

Stephen McNally
Director of Government Affairs

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Composites Fabricators Association

Committed to Strength Through A Unified Industry

September 22, 1998

Mr. Ron Ryan
EPA-OAQPS
Emissions Monitoring and Analysis Division
Research Commons
79 T.W. Alexander Drive
Building 4201
Research Triangle Park, North Carolina 27711

Dear Ron:

The Composites Fabricators Association continues to be very interested in the development of the new AP-42 emissions factors for reinforced plastic composites. We were sorry to find that the September 17 phone conference had been canceled. We hope that another meeting can be scheduled in the near future. We would be pleased to assist you in developing agenda topics for this meeting, if you believe that this would be helpful.

In the meantime, however, we would like to receive some additional information regarding the ORD Model. We have reviewed the information which is currently available regarding this model, but we feel that the additional information is needed if we are going to be able to fully evaluate it.

Data Sources:
The information regarding the derivation of the ORD Model suggests that information and data from seven separate sources were evaluated and included in the data set which set the model. We would like to know "What are the seven sources of this data?" We would like to see the data lists from these seven sources so that we can evaluate the underlying data supporting the model. We would also like to see any information regarding the Quality Assurance of the testing done at each of the seven sources so we can qualify the data.

Philosophy Behind the Curves:
We have evaluated the impacts of the various secondary parameters in the model. Some of these parameters are seen to have substantial impacts on the calculated emissions. We believe that the curves were set utilizing second order equations? We would like to have whatever information is available which explains the philosophy behind deciding to set these curves as second order equations.

Intended Purpose of the Model
We are under the impression that this model, commissioned by EPA Office of Research and Development, had been a long time in development. The resulting model is an interesting tool, and it takes an interesting approach to the prediction of emissions from a specific materials processing scenario. We are interested in knowing what was the intended purpose and what was the intended use of the model when the project was initially commissioned by ORD.

1655 North Fort Myer Dr., Suite 510 Arlington, Virginia 22209-2022 USA
Tel: 703/525-0511 COMPOSITES '98 San Antonio, TX • Oct. 21-24, 1998 Fax: 703/525-0743
E-mail: cfa-info@cfa-hq.org • Internet: http://www.cfa.org

We would appreciate it, if you have access to this information, that you could forward it to us at your earliest convenience, as it will greatly assist us in developing our evaluation of the ORD model.

The above information is information which the CFA had been careful to include in the paper ? describing the derivation of the CFA model. We feel that this information is a very important tool for anyone who would seek to provide critical review of an emissions model another meeting.

We are looking forward to working together with the Emissions Modeling and Analysis Division in the development of a new AP-42 emissions model. We look forward to meeting with you on this issue in the near future.

Sincerely,

Stephen McNally

Stephen McNally
Director of Government Affairs

Cc: John Schweitzer
Rob Haberlein
Carlos Nunez

National
Marine
Manufacturers
Association

1819 L ST., N.W. • SUITE 700 • WASHINGTON, D.C. 20036 • (202) 861-1180 • FAX (202) 861-1181

September 9, 1998

Mr. Ron Ryan
USEPA-Emissions, Monitoring and Analysis Division
MD-13
Research Triangle Park, North Carolina 27711

Re: Review of EPA FRP Model for Emission Factors

Dear Ron,

The National Marine Manufacturers Association (NMMA) appreciates the opportunity to provide the U.S. Environmental Protection Agency (EPA) with comments on the emission factor model developed by its Office of Research and Development (ORD) in collaboration with Research Triangle Institute (RTI). The FRP Model (version 1.0, 1998) attempts to provide a multi-variable model for estimating emissions of styrene from fiberglass manufacturing operations.

Although we applaud these worthy efforts, we find that the model does not adequately reflect all data available. In particular, the NMMA believes that the best available data for the boat manufacturing industry were generated in its study conducted in 1997. The data specific to this industry generated under operational conditions in a boat manufacturing plant are the most representative for this industry. NMMA believes that our data should be used for boat manufacturing plants, as more representative of our industry practices and emissions than a model that attempts to characterize any and all fiberglass manufacturing operations.

Further, NMMA finds that the model, as developed is not valid for estimating emission factors. We believe that it is a tool to assess the relative effects of various parameters on an emission factor. However, it is not a true multi-variable model, taking into account the interactions of these parameters on the emission factors. This is vividly seen in the limitations of the model where parameters can be selected which result in estimated emission factors greater than 100 percent of the available styrene in the resin. Finally, NMMA does not believe that sufficient data exist to generate a reliable multi-variable model at this time.

NMMA has detailed comments on the model and its development in the enclosure. As you are aware, NMMA has been involved in discussions with Region IV in an effort to educate them as to the problems associated with using a multi-factor model for determining emissions. It is NMMA's hope that these comments will highlight the obvious problems with this model and spur a concerted effort to provide the boat building industry with updated emissions factors based on representative data. We would be happy to discuss these comments with you . Please feel free to call me at 202-721-1604.

Sincerely,

John McKnight

John McKnight, Director
Environmental and Safety Compliance

cc: Doug Neeley, Region IV
Leonardo Ceron, Region IV

INTRODUCTION

The Office of Research and Development (ORD) of the U.S. Environmental Protection Agency (EPA) released in 1998 version 1.0 of a model for estimating emissions of styrene from open molding of fiberglass-reinforced plastic (FRP) parts. The FRP Model was developed by the EPA/NRMRL/APPCD in collaboration with Research Triangle Institute (RTI) in Research Triangle Park, North Carolina. These notes provide comments on the model, the paper accompanying the model, and the results achieved using the model.

We applaud the efforts of the EPA in attempting to develop a model for such a broad source category as the FRP manufacturing industry. There has been significant effort by the EPA and industry to generate reliable and meaningful data, representative of various subsets of the industry in the past several years. Using them in a coherent way to develop a general tool for estimating emissions from any FRP process is a worthy endeavor. We are convinced, however, that the data available, although significant, cannot be used to generate a true multi-variable model that yields accurate representations of emissions according to numerous parameters. (For example, selection of parameters at boundary conditions of the model yields unrealistic results of emission factors.) Further, we think that developing a generic model of this type may undesirably dilute the quality of the end result when it is used in lieu of actual data that exist for a specific source category such as boat manufacturing.

The model as developed provides useful insight into some factors that affect emissions. Although not a true multi-variable model, we believe the FRP model is generally useful in assessing the relative influence of a single parameter on emissions. The model, however, is inappropriate for assessing the synergistic effects of more than one parameter. The model was developed using data collected from general testing, not from testing done to assess the effect of a single parameter, holding all other parameters constant. So the results obtained from testing represents the effects of several parameters. The model evaluates the influence of each parameter (which may be valid) and then combines the individual effects into a single correction or adjustment factor (which is not a valid, precise measure of emission factor). Although the model has apparently been constructed to yield "correct answers" in some cases (in the context of emission factors and measurement accuracy); it does not necessarily follow that the model is correct and universally applicable. There are cases where the model does not provide correct answers. The model also fails to address materials that contain more than a single volatile reactive constituent, for example the presence of methyl methacrylate (MMA) in marine gel coats.

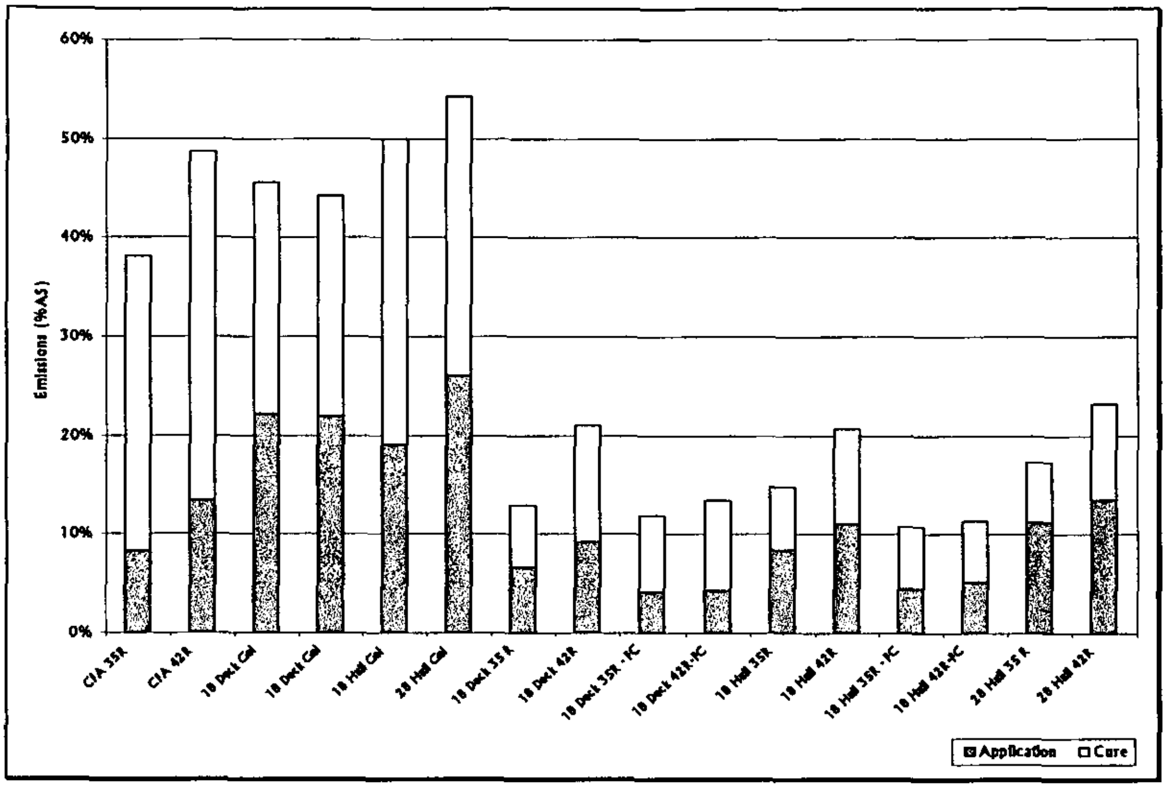
Finally, the model is written to run on personal computers running under a Windows95® operating system, or better. This is a serious limitation for many users. For many boat manufacturing operations, the personal computers in use are not the latest Pentium®-based machines. Also, many of these machines operate on older operating systems, such as Windows 3.1 or even Windows 3.11 for Workgroups. The model cannot even be installed on these machines, making it impossible to use. As a practical matter, the model should be available in formats used throughout the industry if it is to be available to general user in the industry.

NMMA DATA

The testing conducted by the National Marine Manufacturers Association (NMMA) in March and April 1997 and reported in August 1997 provides the best available data for FRP manufacturing for the marine industry. We have not prepared a computer emission model from these data, but instead provide our data in a number of formats to allow our members the ability to use the results to reflect their operations appropriately. Some operations may elect to use the most generic approach, that is, one of the discrete emission factors published in our summary report. Others may use all the data to generate an emission factor for their operation through interpretation of the data on styrene content in the resin, distance from the mold during application, and application technique.

We have continued to evaluate our results and hereby present a further refinement of the results. In the following figure we present the emission factors for each test, segmented by the two phases of operation: resin application and curing. We believe that this presentation is useful in assessing factors affecting emissions, and in comparing the NMMA data and estimates of emission factors obtained using the FRP model.

FIGURE 1: NMMA EMISSION FACTORS BY CONTRIBUTION OF SPRAY AND CURE



MODEL APPROACH

The FRP model proposed by the EPA is an empirical model, based solely on the available data, which interpolates the data using various equation formats. The model extrapolates beyond the bounds of the available data using these same equations. (The bounds of each variable are not clearly defined in the model. They can be determined, but the model does not provide the user a clear sense of the bounds of the base data.) There is no clear rationale for selecting various formats of the equations to describe the relationship between the independent variables and emissions.

The model, as currently drafted, is far more complex than warranted by the amount of data available. Not all the model parameters are truly independent variables; others have little effect on emissions. The data for other parameters is insufficient to warrant the degrees of weighting given in the model.

PARAMETERS

The technical basis of the list of parameters (or variables) evaluated for use in the model is unclear (Table 1). A research effort such as the development of a model would typically use the technical description of the problem as the starting point in defining the independent model parameters and expected ranges. We do not see evidence that this type of technical foundation has been established.

TABLE 1: VARIABLES IN THE FRP MODEL

Variable	Type	Observed Effect
Styrene content (%)	Independent	Significant
Distance from spray gun to mold (in)	Independent	Larger
Dried material off mold (%)	*Dependent*	*Not a large effect on emission factor*
Laminate (gel coat) thickness (mil)	Independent	Larger
Cup gel time (min)	Independent	No significant effect observed
Application rate (lb/hr)	Independent	No significant effect observed
Air temperature (°F)	Independent	No significant effect observed
Air velocity (ft/min)	Independent	No significant effect observed

Even a model based solely on empirical data would use multi-variable data reduction in developing a model relating independent variables with the dependent variables or, in this case, the emission factor. Unfortunately, the use of multi-variable analysis necessitates a tremendous amount of carefully collected data. Although a great deal of information has been developed regarding emissions from FRP manufacturing operations, the data serve more to indicate trends rather than to support the development of a complex model relating numerous factors. Model reduction could be applied to eliminate those parameters not really having observed influences on the emission factor. Again, the assessment of the theory of emission generation could provide insight into those factors affecting emissions and the observed results could indicate those factors having less significant influence.

Styrene Content

Styrene content has long been recognized as having a significant influence on the emission factor for open molding using unsaturated polyester resins. Historically, the relationship has been assumed to be linear, as suggested in the existing guidance documentation (AP-42). The FRP model assumes a non-linear quadratic relationship. The data on emissions do not appear to be sufficient to warrant use of the higher level model, especially given the absence of data for resins containing less than 31-32 percent styrene. While a non-linear relationship may fit the data, there is insufficient data to indicate that the relationship should be quadratic or that it should represent styrene contents in resin much less than a reasonable range, much less representing a zero styrene content resin. To characterize the relationship in these regions, additional data on emissions from use of resins containing less than 30 percent styrene should be collected.

Realistically, the styrene content in unsaturated polyester resins will have a natural floor, a content below which the resin cannot be effectively formulated. It is that range of realistic formulations that should guide the development of the model. Also, it is perfectly sound to use a relationship between resin styrene content and emission factor that either is linear or does not traverse the origin. In this case, the selection of model format should be based on fit of available data (all available data) to the candidate formats, taking into consideration the realistic limitation of the actual resins used. Our results indicate that for certain shapes and application techniques, there is good linearity in the emission factor as a function of styrene content over the range of conditions found in the boat manufacturing industry. The slopes of emission factor as a function of resin styrene content for the three mold shapes evaluated indicate this linearity (Table 2). Although the 18-ft deck mold showed slight differences from the other two molds evaluated, this difference can be attributed to the combination of spray and hand application necessary on this complex shape.

TABLE 2: LINEARITY OF RESIN STYRENE CONTENT EFFECT ON EMISSION FACTOR

Case	Slope of Emission Factor v. Resin Styrene Content
18-ft Deck	1.14
18-ft Hull	0.83
28-ft Hull	0.84

Distance from Application Equipment to Mold

An observation from the NMMA testing was a perceived relationship between emission factor and distance between the operator and the mold. Our brief 8-page paper (provided to the EPA in late 1997) summarizing the results of the study presented a figure illustrating the emission factors for spray chopper application of glass and 35.1-percent styrene content resin. The distances observed from the testing were about 18 inches for the 18-ft deck, 36 inches for the 18-ft hull, and 60 inches for the 28-ft hull. We anticipated some relationship between emission factors and distance between operator and mold; this is consistent with mass transfer theory. For greater distance between operator and mold, the residence time for resin while in droplet form (i.e., at maximum surface area) will be greater, providing increased opportunity for evaporation before reaction. We evaluated our emission data, generating emission factors for two periods: application and cure. The application period included those times when the spray equipment was actually operated. Cure periods included roll-out of the glass and resin, as well as the conventional resin curing cycle. This assessment showed a linear relationship between distance and emission levels for the limited cases and distances tested (Figure 2); a nearly identical trend was seen for application of both resins, however. We also considered the emissions during cure; these emissions were seen to be relatively constant for the tests conducted (Figure 3). Only the tests for 42-percent styrene resin applied to the 18-ft deck yielded results slight greater than those for hulls. This could be attributed to differences in part shape, although we did not see this same sort of difference with the 35-percent styrene resin.

FIGURE 2: EFFECT OF APPLICATION DISTANCE ON EMISSION FACTOR - SPRAY

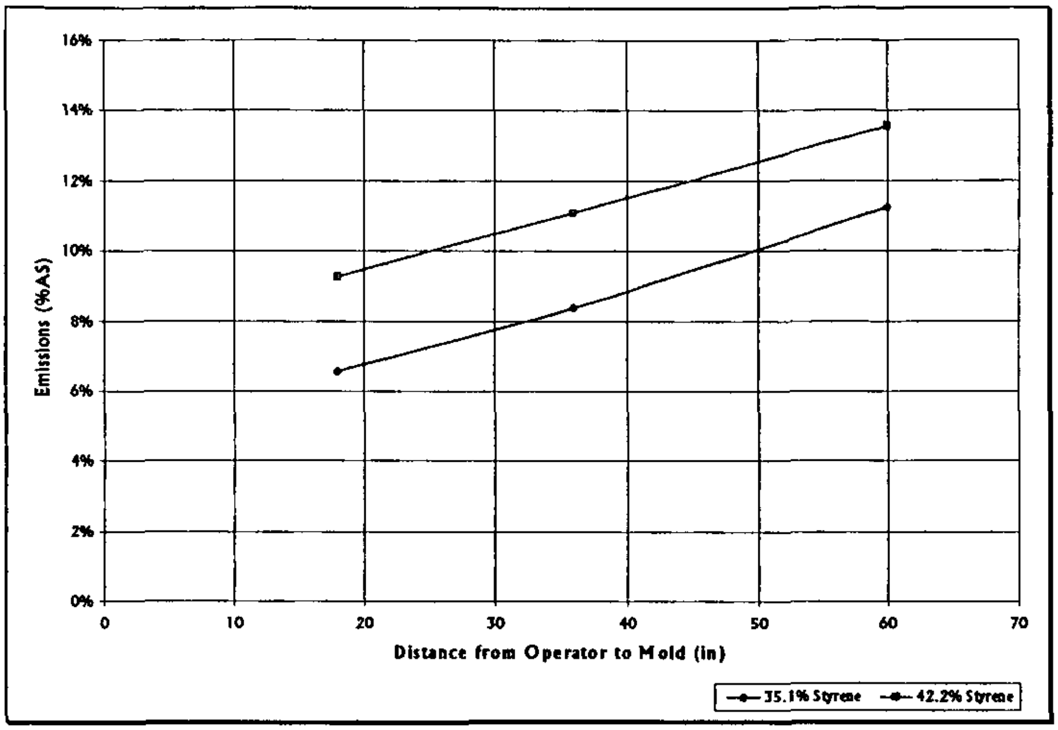
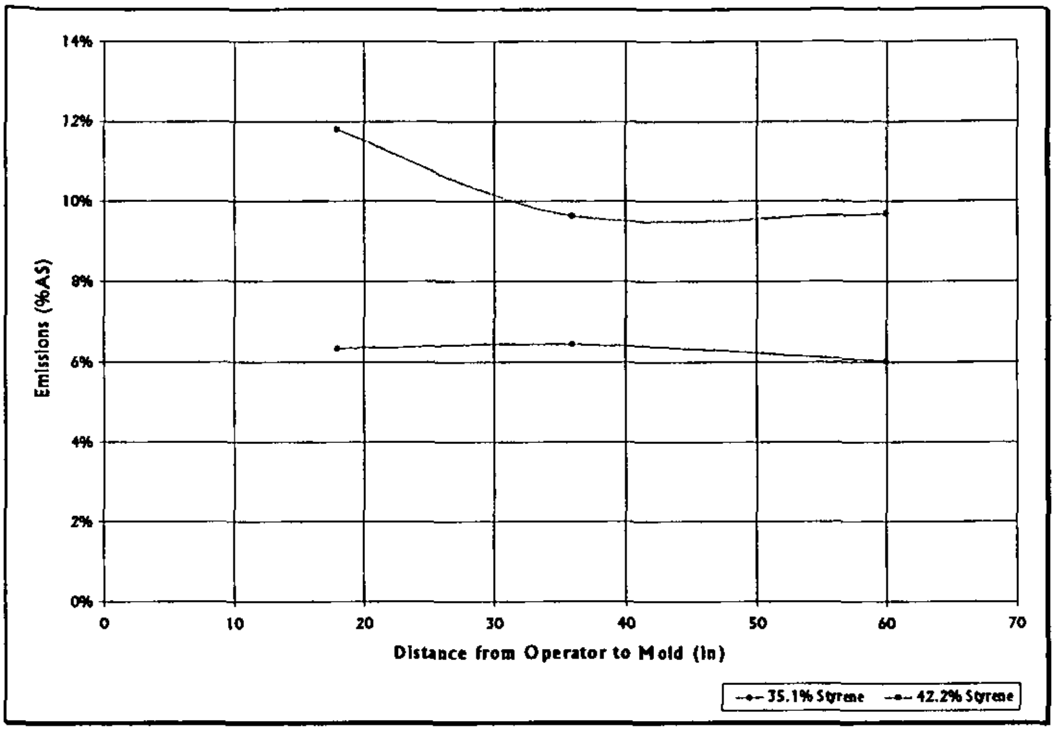

16%
14%
12%
10%
8%
6%
4%
2%
0%
Emissions (%AS)
0
10
20
30
40
50
60
70
Distance from Operator to Mold (in)
35.1% Styrene
42.2% Styrene

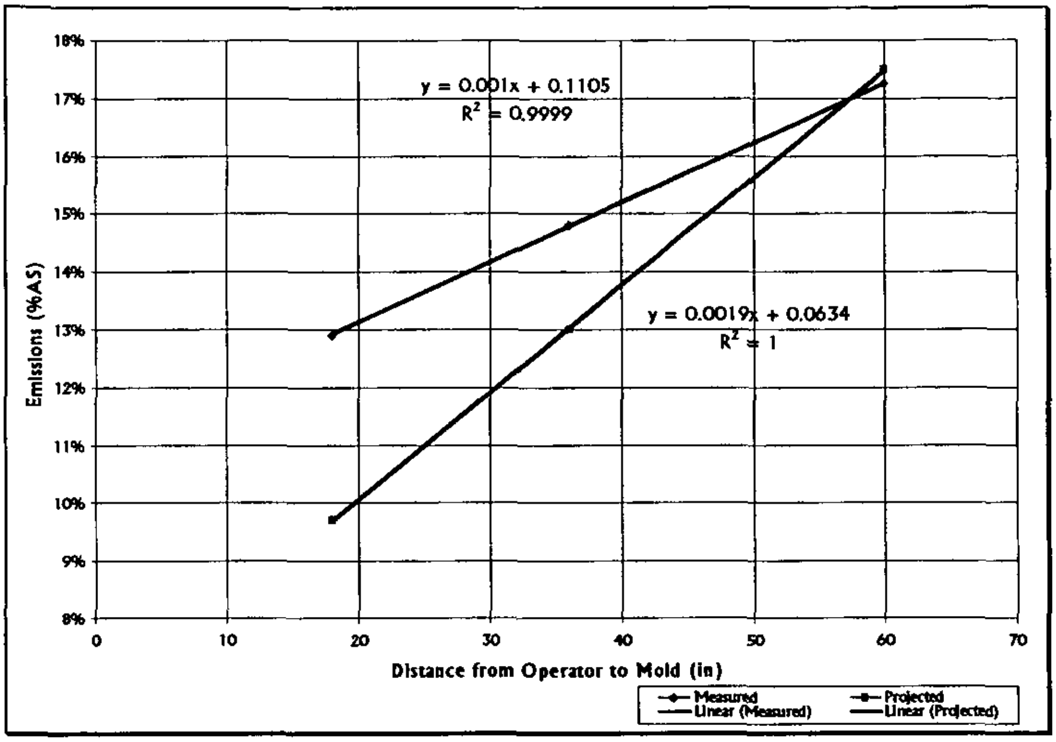
FIGURE 3: EFFECT OF APPLICATION DISTANCE ON EMISSION FACTOR - CURE



We compared the results obtained from our testing to the results of the FRP model using our inputs (Figure 4). The results shown compare the emission factors for applying 35 percent styrene resin from three distances. We believe that the 60-in application distance observed during lamination of the 28-ft hull is at the greater end of the expected distances. The FRP model does indicate the appropriate direction of change in emission factor with distance, that is decreasing emission factor with decreasing distance between operator and mold surface. However, we believe that the FRP model will under-predict the actual emission factor at closer distances. This difference from actual emissions may be attributed to the impression of the distances used as the model inputs, which is an inherent problem with the multi-variable approach.

While we can see some obvious trends in the data, the use of these scant data in developing an exact correlation does not seem justified. Nor do we believe that most operations using open molding techniques can actually use this parameter as a precise measurement. Rather, we feel that the base data (such as our graphical presentation) can be used in making judgments about the selection of appropriate emission factors.

FIGURE 4: COMPARISON OF ACTUAL (NMMA) AND PROJECTED (FRP MODEL) EFFECT OF APPLICATION DISTANCE ON EMISSIONS



Dried Material off Mold

The amount of dried material off the mold (as a percentage of total dried material applied) is really a dependent variable, related more to article size, application equipment, and application technique. It is true that the amount of material off the mold (call it over-spray) can affect total emissions but the influence on emission factor is not well described, especially for production circumstances. Over-spray is costly and is really less of an issue with larger parts like boat hulls. This variable was not measured during the NMMA testing, but it is safe to say that the amount of material not applied to the mold surface was less than 0.5 percent. This is really an insignificant factor and should therefore not be included in this model. Certainly, the amount of material in over-spray must be included in the total amount of material used when calculating total emissions.

The effect of over-sprayed material on emission factor would be minimal, compared with the emissions measured from applied resins. The over-sprayed material is likely much less than that applied to the mold, meaning a much thinner laminate. This might lead to greater emissions, except that the thickness is undoubtedly too small to cure quickly. Also, the material would not be rolled out, a process that will increase actual emissions.

We did review the data used in developing the correction for over-spray presented in an earlier draft of the FRP model. From the draft material, the correction is based on only two data points, insufficient to provide reliable results for all possible scenarios. Certainly for a factor that as presented can have equal weight to the final result as laminate thickness and distance to mold, and greater importance than styrene content in the neat resin, the underlying data is inadequate for a reliable model. Until better information is generated, this factor should not be included in the model.

Laminate (Gel Coat) Thickness

Observing the data available on FRP manufacturing makes it clear that there can be a significant influence on emission factors from laminate thickness. Thinner laminates yield greater emissions per unit mass of resin (or gel coat) applied than thicker laminates. This can be explained simply by the actual polymerization process wherein the free styrene cross-links with the polyester resin as the resin cures. In thinner laminates, more styrene can be released from the surface of the laminate; in thicker laminates, the free styrene in the laminate matrix (and not on the surface) is available within the thicker laminate and cross-links with other free styrene and polyester. Evaporation is mot possible and migration to the surface is unlikely before the styrene is reacted.

In boat manufacturing the laminates are much thicker than had been previously tested. The NMMA study used representative boat molds and representative laminate schedules. The skin coats used during the NMMA study were 90 mil thick and the full build-up layers were approximately 340 mil thick (on average). In some cases, such as the keel of the larger boat hull, the laminate thickness was greater than 400 mils thick. The test plan for the NMMA study projected that the laminate thickness would affect the results. Less styrene would be available as emissions for each pound of resin applied. Also, the material was applied in a time schedule that built up the laminate schedule without waiting for complete cure between incremental layers. Again, this was to mirror actual production practices. The emission tail (i.e., those emissions during cure after resin has been applied) was cut off, reducing the total emissions per pound of material applied.

In evaluating the FRP model, it is evident that the NMMA data were not incorporated in the development of this modification factor. Laminate thickness greater than 70 mils is considered outside the range of the model inputs. We were unable to assess the correlation developed for laminate thickness because the data were not presented. This is surprising, given the apparent importance of this parameter as suggested by the aggregate modification factor. Further, the model modification factor for laminate thickness greater than 40 mils (resin spray operations) is 1.14-0.002x, where x is the laminate thickness in mils. Under this scenario, a laminate thickness of 250 mils (reasonable from our study) would have emissions 64 percent of the baseline. This seems to be too great a correction when actual data are available for this relationship. This model assumes a linear relationship, which appears invalid at the thickness tested during the NMMA study.

Our data indicate that there is an increase in emission factor of 9-11 percent from the 90 mil skin coat to the 250 mil bulk coat. We can rely upon this as a quantitative measure only to the extent that it represents the data from this series of tests. For practical purposes, these results can be considered equal. The emission tail of the skin coat had not completely cured; so emissions attributed to the bulk application could actually represent skin coat.

These results do raise a question about the relationship between laminate thickness and emission factor. It can be inferred from these results, that the emission factor will decrease with increasing laminate thickness to a point, dictated by the geometry of the part, application equipment, and resin/catalyst system. The NMMA study does show that the thinner laminates, such as those applied to the CFA mold and those applied during gel coating, contribute to greater emission factors than those laminate schedules that are thicker (representing structural production parts). For the boat manufacturing industry, the structural parts making up the vast majority of resin consumption have thicker laminate schedules where thickness has not further effect on emission factor. Those effects are already seen in the data generated during our study.

Although we have produced data for boat manufacturers, it is clear from the data that there is some effect of laminate thickness on the emission factor. Additional data could be generated to define this relationship more conclusively and to define that point at which the effect is no longer noted. However, the utility of incorporating this factor may be less than the benefit of recognizing the effect. Multiple laminate thicknesses may be used manufacturing the same boat. In this case, numerous calculations would be necessary to describe the emissions from the manufacture of a single boat design. This procedure would be nearly impossible to track for each boat manufactured and more resource intensive than warranted for the data.

Cup Gel Time

This variable is included as a parameter in the model but is not discussed in the paper. The model uses a correlation for spraying resin and gel coat that is most nearly 1 (unity). This indicates little effect on the emission factor. We recommend that this parameter not be included in the model as adding complexity that is unwarranted based on the model equations. Typically in a production environment, a variety of gel times will be used to compensate for various climatological factors and for the specific equipment used that day. Also, the cup gel time might be varied over the course of a day to account for changes in these climatological factors.

The model uses a completely different equation for the modification factor for hand lay-up, pressure-fed rollers, and flow coaters. Again, the data are not presented, making an assessment of the relationship impossible.

The NMMA study included testing of flow choppers for two parts: 18-ft deck and 18-ft hull. Cup gel time was not varied from those gel times used during spray chopper experiments. There was no compelling reason to expect any different trend with respect to cup gel time for the flow choppers, however, because the effect of cup gel time would be seen on emissions from the cure portion of the application cycle. Emissions from the cure portion should not vary significantly from hand lay-up, to spray chopper, to flow chopper application, because the mechanisms for emissions from the mold surface would be the same, regardless of how the resin and glass had been applied.

Application Rate

Application rate was not evaluated as part of the NMMA study. The resin application evaluation was conducted at basically a 6.5-lb/hr resin application rate. So, our data do not permit testing of this factor. And, the model actually indicates no effect at resin application rates greater than 4 lb/hr. The application rate might have some influence on the emission factor but it is expected to be an insignificant factor compared with other factors (e.g., resin styrene content, distance between operator and mold, and laminate thickness). The influence of this parameter is probably incorporated in the distance algorithm, because the closer distance to the mold would preclude greater application rates. Therefore, we recommend elimination of the parameter as unnecessary.

Air Temperature

We do not believe that air temperature is a parameter affecting emissions. Mass transfer theory would indicate that this parameter would have minimal impact on the rate of mass transfer. The temperature of the material applied and the temperature of the resin in the mold would have a bearing on the emission generation and mass transfer characteristics, including vapor pressure and mass transfer coefficients. Even so, the temperature can represent two competing factors. Increasing temperature increases vapor pressure (the driving force for mass transfer), but also increases the reaction rate (which removes the styrene as polymer). This balance of competing factors is not known and has not been defined through a defined testing program. We believe air temperature (presumably ambient air temperature) would only have an influence as it relates to the temperature of the materials being applied.

The paper states that there will be a modification factor change of about 1 percent for every 1°F above or below the 75°F baseline temperature. Our assessment of the model indicates that the effect is slightly less than this value for gel coat application (an increase of approximately 0.6 percent of available styrene), and much less for resin application using spray and flow chopper application (an increase of only 0.1-0.2 percent of available styrene). The validity and strength of this relationship cannot be assessed because the data are not presented in either this version of the model or the previous version released to NMMA last year. Unless compelling data are presented that clearly demonstrate the relationship, this influence should be considered minor and deleted from consideration.

Air Velocity

Data collected from the various test programs are inconclusive. The model uses a disconnected function, two straight lines. The data indicating reduced emissions at air velocities less than 30-35 ft/min were for testing at pultrusion operations and for Dynatron-Bondo resins (filled resins). Other data from this range of air velocities (RTI bench-scale studies using Ashland resins) show little or no change from typical emission factors. Data from the NMMA studies essentially held the air velocity constant; however, comparing the data with other reported emission factors for FRP operations indicate that there is little influence at nominal air velocities that might be expected at production facilities where workplace air must be changed with a degree of regularity mandated by OSHA.

Theoretical projections from mass transfer theory indicate an increase in emissions with an increase in the air velocity across the material surface. However at some point, the effect of air velocity over the surface ceases to result in increased or reduced emissions. Empirical data indicate little influence on emission factor by this parameter. Further, it would be extremely difficult and impractical to measure air velocity at each point of a complex part, which is implied to be necessary to apply the model to obtain "accurate" results. Accordingly, we recommend eliminating this variable from the model as (1) having an insignificant effect and (2) being impractical to implement.

LIMITATIONS OF THE MODEL

We evaluated the effects of using the parameters at their extreme values. We found that we could yield emission factors of greater than 100 percent of available styrene (%AS). Clearly this cannot be possible. This is a limitation of the model that should have been tested before release, or at least those bounds should have been assessed before release and proper warnings made. This clearly indicates the potential for users to "game" the model (i.e., to obtain the desired results through clever selection of inputs), which surely is not one of the EPA's objectives.

TABLE 3: ASSESSMENT OF MODEL LIMITATIONS

Parameter	Spray Resin	Gel Coat	Gel Coat
Styrene content (%)	50	50	50
Distance from spray gun to mold (in)	40	40	40
Dried material off mold (%)	10	10	10
Laminate (or gel coat) thickness (mil)	50	10	20
Cup gel time (min)	50	50	50
Application rate (lb/hr)	1	1	1
Air temperature (°F)	95	95	95
Air velocity (ft/min)	200	200	200
Baseline factor (%AS)	18.9	54.8	54.8
Calculated factor (%AS)	103.1	145.5	114.3

PAPER

The paper would be better served as an assessment of trends noted in the data collected from testing at various FRP manufacturing sites instead of a tool for estimating emission factors. The paper provides a description of the current state of the science of emission measurements for styrene emissions from FRP industries. It describes the approach used in developing the model and provides practical examples. The descriptions above indicate technical issues with individual aspects of the model. The paper itself is lacking in some of its explanations.

The paper, however, is slightly confusing with the use of the term "emissions." Because the paper describes a model used to estimate factors for use in inventory development, the term "emissions" would be assumed to mean emission factor, emissions per unit of material used. (In the case of FRP manufacture, this factor has traditionally taken the format of styrene emitted as a percentage of available styrene, or free styrene in the monomer.) The term "emissions" in the paper, however, is also used to mean total emissions. Although those discussions are interesting, and perhaps even germane to inventory assessments, they appear inappropriate for the initial description, presentation, and explanation of the model.

The model itself brings together "all" of the data available from FRP manufacturing operations in the hopes of representing the widest portion of the industry. The results do not appear to have been used across all of the assessments, though. For example, the data generated by the National Marine Manufacturers Association (NMMA) indicated a relationship between emissions and distance from the mold. These data were reported used in the development of the modification factor in the FRP Model for distance from the mold, although this study is not listed in Table 3 of the paper showing the studies used in developing inputs for the model.

As an explanation on the development of the model, the absence of the data used in developing the relationships is significant. Also, not all variables used in the model are described.

CONCLUSION

We appreciate the efforts of the EPA in striving to present a model that can be used to estimate emission factors. Unfortunately, this approach to the model is not adequate to the task. It is useful in indicating trends of relative effects of individual parameters, but not for combining those effects in estimating the emission factor.

Any future model efforts should keep in mind that only those factors with significant influence on emission factor should be included. Models should be as simple as possible so that obfuscation does not become the result of the model. Simplification is particularly needed for the widespread use by the industry segment.

We would be happy to work with you in developing a list of potential parameters and helping reduce the number of parameters to a reasonable, workable number.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

AUG 6 1998

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Response to your Request for Comments on Website Documents Regarding Emission Estimation for Fiber-Reinforced Plastics (FRP) Processes

FROM: Madeleine Strum, Environmental Engineer
Coatings and Consumer Products Group, ESD (MD-13)

TO: Ron Ryan, Environmental Engineer
Emission Factors & Inventory Group, EMAD (MD-14)

This memorandum is in response to your March 18, 1998 request for comments on the reports entitled: CFA Emission Models for the Reinforced Plastics Industries, and Baseline Characterization of Emissions from Fiberglass Boat Manufacturing. You posted these under the heading "Potentially Useful for Emissions Estimation" as part of your efforts to revise the AP-42 section for fiber-reinforced plastics (FRP) operations. You requested comments on the materials "...while we begin drafting a replacement AP-42 section based largely on the two reports." The following five items contain my comments.

(1) An AP-42 section based on the two reports would ignore known and measurable parameters that affect emissions.

The available data shows that emissions from the FRP process are influenced by known and measurable parameters (such as thickness and gel time) that are not taken into account in the model proposed by the Composite Fabricators Association (CFA) nor in the Boat Manufacturing report. An emission factor that ignores known and measurable parameters that affect emissions can potentially result in an underestimation or over of emissions for facilities with certain values of these parameters. The CFA had several multi-variable models that took into account other parameters, but their proposed model condensed these parameters into a one-variable model. This condensation reduces the accuracy of the model, because it does not reflect the effects of these other parameters. For example, at a styrene content of 42 percent by weight, the emissions from the CFA's baseline study of spray up varied from 22.4 to 38.0 percent of available styrene depending on the thickness (which varied from 40 thousandths of an inch to 80 thousandths of an inch), gel time (which varied from 15 to 30 minutes), resin flow (which varied from 2 to 4 pounds per minute) and air flow accross the part (which varied from 50 to 100 feet per minute). At 35 percent by weight styrene, hand lay up emissions varied from 9.8 percent to 17.7 percent of

evalute affect

why?

available styrene. The effects of these parameters are likely to be greater at specific facilities in which the values of the parameters are outside the tested range. For a spray or hand lay up process with a 1-hour gel time, for example, the CFA model would potentially greatly underestimate the emissions.

One possibility to correct the above-stated problem is for AP-42 to use the EPA's Office of Research and Development (ORD) model, which utilizes the available test data to account for the effects of various parameters on emissions. The ORD put forth a substantial effort to develop an accurate model based on available data that would account for all parameters known to effect FRP fabrication emissions. It should be considered for use as an emission estimation tool for the FRP processes. – Is it used for MACT

Another possibility would be for AP-42 to present ranges at the various HAP contents, and to explain the ranges as ways to take into account those parameters that were measured, but not quantified by the model in terms of their effects on emissions. Also, an explanation of how these parameters affect emissions should also be included. The range of the parameters used during the testing should be a part of the explanation, and it should be encouraged that facilities whose parameters lie outside the range tested should attempt to take into account the effect of the parameters on emissions. how?

(2) An unbalanced, arbitrary set of data were chosen to perform the linear regresssion.

Another issue regarding the condensation of the parameters are the data the CFA used to perform the linear regression. The data used for the four variable and one variable regression are different. The CFA added more data in the one variable regression than they had in the four-variable model. For example, they added 44.4 styrene content runs in the resin spray up linear regression which were associated with a thicker laminate. These data were also associated with the testing of a different mold. This additional unbalanced data (i.e., there were no "pairs" of highs and lows of the parameters which were condensed) could have skewed the linear fit a certain way. In addition, there was no explanation of why the 44.4 runs were added and no other spray up data were added. It would appear that since known effects of other parameters on emissions were to be condensed that only balanced values (i.e., both highs and lows) of those parameters should be used in the condensation. – eval.

is there others

(3) The CFA emission model's quantification of controlled spraying could produce highly inaccurate emission estimations because the controlled spraying program is based on subjective and nonmeasurable techniques and the emission reductions are uncertain.

The CFA model includes the subjective and ambiguous term, "controlled spraying" and provides a 23-percent emission reduction for any facility claiming to participate in this program. While I agree that improvements in spray technique can result in lower emissions, I do not think but yet we can assign a specific baseline

that the controlled spraying program can be assigned a specific emission reduction quantity from the "baseline" testing. First, the model does not contain objective parameters that can be used to estimate emissions. In addition, the 23 percent across both resin and gel coat does not agree with other available data utilizing a controlled spray technique. For example, when Research Triangle Institute (RTI) used such a technique for gel coating, they achieved less than half of that reduction (for resin they achieved more than that reduction). Individual test comparisons show significant differences in the effects of controlled spraying.

Furthermore, not all facilities have the ability to achieve the controlled spraying emission reductions achieved in the CFA tests because of differences in mold shape and size. For example, an operator conducting the controlled spray program, who is physically limited in how close he/she can get to the mold, the program may not achieve the "control factor" of 0.77 suggested by the CFA.

The problems identified with the controlled spraying emission estimates may be resolved by the ORD model. The ORD model has incorporated spray technique in the model by containing objective parameters that can be linked to spray technique. The ORD model replaces this term with objective and measurable parameters: "distance from spray gun to mold" and "amount of dry material off the mold, divided by total material sprayed." Further, the ORD model recognizes that emissions increase continuously as "distance from the gun to the mold" and "dry material off the mold" increase. This can be compared with the discontinuity in the CFA model, in which "controlled spraying" produces a "step" reduction in emissions (i.e., no variations in the amount of "control" are accounted for). - ORD will produce a step based on one-time judgment degree of control

Another resolution is to acknowledge controlled spraying as an emission reduction technique in the text of AP-42, but not assign an emission reduction factor to it.

(4) The CFA proposed model has several inaccuracies when compared to available test data.

The CFA model assumes a linear relationship between styrene emissions per mass of resin used and styrene content. A problem with this is the linear extrapolation for styrene contents outside of the measured range. This linear extrapolation results in a large under-prediction of emissions from low monomer resins and gel coats. For example, the model predicts negative emissions for resin spray up when the resin monomer content is below 25 percent by weight and for gel coat when the gel coat monomer content is 18 percent. There are presently resins containing as low as 28.2-percent monomer in the EPA MACT database. There are existing emission data at low styrene gel coats (25 percent by weight styrene) for which the CFA model underestimates emissions by 64 percent. (See Table 1 in the memorandum from Carlos Nunez to you dated July 17, 1998).

The ORD model contains a more accurate relationship between styrene content and emissions, and accurately predicts emissions at the known "boundary" condition of zero styrene content.

In addition to the inaccuracies in the model when the model is extrapolated outside the measured range of data, there is also a serious inaccuracy within the measured range pertaining to the treatment of vapor suppressants. The proposed CFA model includes a fixed reduction factor for styrene suppressants, regardless of whether the resin is unfilled or filled. However, both RTI and CFA testing have shown that the emission reductions from styrene suppressants are significantly smaller with filled resins (i.e., suppressant effectiveness approaches zero, as filler content approaches 60 percent). In addition, while working on the MACT project, I have heard that not all suppressants are equally effective in all resin formulations. As a result, the CFA and EPA are working on a laboratory-based test method that would assist us in estimating the effectiveness of different resin/suppressant formulations. The results of the test method should assist emission estimation as well as assist with compliance with the MACT standard. However, a more immediate fix to this situation is to use the ORD model, which contains a more accurate estimation of emissions for the case in suppressant is used with filled resins.

status

we should be consistent

Another inaccuracy involves emissions estimation from flow coater and pressure fed roller resin application. The CFA model contains a fixed "control factor" (0.51) for the use of non-atomizing application, but available data shows that the styrene content of the resin has an effect on the amount of reduction achieved by non-atomizing application. For example, the data obtained in the boat study showed a significantly larger emission reduction for the higher styrene resin than the lower styrene resin.

agree on effect

(5) I am concerned that the data contained within the National Marine Manufacturers Association (NMMA) report (Baseline Characterization of Emissions from Fiberglass Boat Manufacturing) are not representative of the FRP operations that occur across the Nation's boat manufacturing facilities, and I question separating FRP boat operations from non boat FRP operations.

[illegible]

I am in agreement that the boat manufacturing emissions test program at U.S. Marine was well done, and the results are accurate for the specific conditions that occurred during the testing. However, I am concerned that the results of the NMMA test report may be inappropriately used for other boat manufacturing situations which are not similar to the conditions at U.S. Marine. In particular, the resin spray up testing at U.S. Marine was performed by a spray gun operator who is the corporate trainer for U.S. Marine Corporation. In addition, the molds at U.S. Marine were on a rotating frame, which not all boat facilities have. It was observed that there was very little over spray (material off the mold) during the testing on boat molds at U.S. Marine. In situations where more material is deposited off the mold (such as with a less experienced spray gun operator, and the use of molds that do not rotate), emissions would be higher.

Air velocities over the mold during NMMA testing at U.S. Marine were well below 40 feet per minute. These low velocities may not be typical for boat manufacturing, especially in situations where personnel fans are used. These low velocities may produce lower emissions than would occur with higher velocities over the mold. Temperatures at the testing facility were

what is ORD's prediction?

significantly lower than the temperatures where most of the boat facilities are located (Southeastern United States) and may also result in producing lower emissions than may be seen at a different facility. – ORD effect?

Furthermore, I question distinguishing between boat and non boat FRP processes for emission estimation purposes. The processes and raw materials at boat and non boat reinforced plastic facilities are similar. Because diversity within non boat reinforced plastics is as great or even greater than the difference between the boat and non boat reinforced plastics manufacturing, it would make sense to have the same estimation technique for boat and non boat parts. The ORD model accomplishes this in that it is not part specific.

In conclusion, I appreciate the opportunity to provide comments on the above reports with regard to their use in developing an updated AP-42 section for polyester resin operations. As you know, I have new emissions data for continuous lamination operations and pultrusion operations, which will be helpful as you review the emission factors for these operations. If you have any questions on the above comments or the emissions data please contact me.

Status of Emission Estimation Tools for Fiber-Reinforced Plastics

CURRENTLY AVAILABLE

CFA developed both a 4-variable and a 1-variable model. The 1-variable model and a report documenting the development of both the 4 and 1-variable models has been made available via the FYI page of CHIEF since March 1998.

NMMA produced a report documenting the results of parametric testing on boat production. No model or analysis done to suggest what to do for situations "in-between". The test report has been made available via the FYI page of CHIEF since January 1998.

ORD has produced a 9-variable model. Documentation is a draft paper submitted to a peer-reviewed journal, not yet published. Region 4 has made the software available to their State agencies. EFIG has sent copies of the draft paper to the two trade associations, and refers callers to the RTI web page for the software.

Region 4 sent a letter dated 9-16-98 to their State agencies recommending use of the ORD model.

ESD has used their own variation of a 1-variable model for determining the MACT floor. A point system has been proposed for determining compliance with MACT(?)

ESD and the Office of Compliance jointly issued a letter dated 12-30-97 to the CFA ststing that "controlled spraying" cannot be used as an option to meet the MACT level of emissions.

ONGOING WORK

CFA has performed some additional lab testing on multi-control cases, and claims to have about 10 tests from actual plants that corroborate their model. They have mentioned revising their model to incorporate some of this data, and possibly the NMMA data.

Neither NMMA nor ORD has performed any work beyond what is shown as Currently Available, above.

COMMENTS ON THE MODELS

The additional variables in the ORD model potentially provide a way to integrate the NMMA boat-building data into a single model with all of the other data. This would answer the question of what emission factor to use when you are building boats at conditions between test data points. The ORD model also allows for varying levels of "controlled spraying", rather than just an "on or off" choice, and attempts to objectively quantify or define "controlled spraying" via two of the variables. However, to use the model someone must determine which values to use for each of the variables. "Baseline" values are included in the model.

The CFA model would be easy for facilities to use in that it requires only one variable, the

%styrene in the resin, to be specified. However, it does not account for differences in amount of overspray, and so it does not predict the NMMA emissions test results very well. The CFA model also includes a %reduction for "controlled spraying", but there is no criteria provided for what constitutes "controlled spraying".

I. ISSUES SURROUNDING ALL EMISSIONS ESTIMATION MODELS

Issue #1: Number & Type of Independent Variables / Process Parameters

Issue: There is a large difference in the number and type of independent variables (process parameters) used in CFA, NMMA, and EPA/ORD models. Table 1 below indicates the independent variables present in each model by process.

Table 1: Independent Variables Used in CFA, NMMA, and EPA/ORD models

Manual Resin Application (Hand Lay-up/Bucket & Tool Application) [a]										
Model	HAP Content	Laminate Thickness	Cup Gel Time	Material Flow Rate	Ambient Air Temp.	Air Flow Across Mold	Distance From Spray Gun	Material Over spray	Controlled Spraying	Mold Size & Shape
CFA	X			N/A			N/A	N/A	N/A	
NMMA				N/A			N/A	N/A	N/A	
EPA/ORD	X	X	X	N/A	X	X	N/A	N/A	N/A	
[illegible]										
CFA	X								X	
NMMA	X									X
EPA/ORD	X	X	X	X	X	X	X	X		
[illegible]										
CFA	X			N/A			N/A	N/A	N/A	
NMMA	X			N/A			N/A	N/A	N/A	X
EPA/ORD	X	X	X	N/A	X	X	N/A	N/A	N/A	
[illegible]										
CFA	X						N/A	N/A	N/A	
NMMA							N/A	N/A	N/A	
EPA/ORD							N/A	N/A	N/A	
[illegible]										
CFA	X								X	
NMMA	X									X
EPA/ORD	X	X	X	X	X	X	X	X		

[a] NMMA did not propose an emissions model for manual resin application (hand lay-up) or filament winding.

[b] EPA/ORD did not propose an emissions model for filament winding.

Issue #1: Number & Type of Independent Variables / Process Parameters (Continued)

The use of different independent variables in the models is primarily a result of differing views on the required degree of accuracy for emission estimates, the importance of certain process parameter with respect to emissions, the practicality of measuring certain process parameters in a production environment, and the enforceability of the final emission estimation. The stakeholder views are summarized in the table below for the following:

1.) Does the process parameter significantly affect HAP emissions from one or more open molding processes?

2.) Is the process parameter measurable in a production environment for use in an enforceable emissions estimation model?

3.) Should the process parameter be included as an independent variable in an enforceable emissions estimation model?

Table 2: Stakeholder Views Concerning Process Parameters / Model Variables a

HAP Content	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Laminate Thickness	No	No	Yes	Yes	No	No	Yes	Yes
Cup Gel Time		No	Yes	Yes	No	No	Yes	Yes
Material Flow Rate		No	Yes	Yes	No	No	Yes	Yes
Ambient Temperature	No	No	Yes	Yes	No	No	Yes	Yes
Air Flow Across Mold or Mandrel	No	No	Yes	Yes	No	No	Yes	Yes
Distance from Spray Gun to Mold	No	No	Yes	Yes	No	No	Yes	Yes
Amount of Over spray	No	No	Yes	Yes	No	No	Yes	Yes
Conducts CFA Controlled Spraying	Yes		No	No	Yes		No	No
Mold Size & Shape		Yes	No	No	No	Yes	No	No

aBlank spaces indicate no definitive view was expressed. Certain model parameters overlap in their effect on emissions and represent different ways of characterizing the same phenomenon. For example, controlled spraying, distance from spray gun to mold, amount of over spray, and mold size & shape, all related to the effects of spraying technique and mold size & shape on HAP emissions.

bEPA/ORD views were all assumed to be yes if the independent model variable was included in the EPA/ORD model.

[c]For the production parameters of material flow rate, ambient temperature, air flow, distance from spray gun to mold, and amount of over spray, EPA/ESD considers these parameters to be possible to measure but not necessarily practical to measure.

[d]EPA/ESD considers that certain of these parameters may not be practical to include in all model formats, but perhaps could be included in another way such as picking worse case values for these parameters.

Issue #1: Number & Type of Independent Variables / Process Parameters (Continued)

In addition to the differing views above, there is also disagreement on the validity of assuming that the effect of each process parameter is independent from the another. Specifically, both the CFA and EPA/ORD models assume that each independent variables in their multi-variable (or multi-factor) models is independent and does not affect the other independent variables effect or contribution to emissions. In reality, though, each independent variable in the CFA and EPA/ORD models is not independent and will interact with and affect the other model variables to some degree. This interaction will result in reduced accuracy of the given model, with the degree of inaccuracy produced dependent on the total number of model variables, the strength of the interaction and the model input parameters selected. As such, the effect of interaction between model variables (process parameters) will affect the number and type of independent variables selected for an emissions model.

The possibilities for variable interaction and the subsequent effect on the emissions estimate in the nine-variable EPA/ORD model are very obvious and can occur for any combination of variable inputs. For the CFA "one-variable" model, the effect can appear due to the presence of a fixed reduction factor for implementing a controlled spray program for atomized mechanical resin application or gel coating. In other words, the CFA model assumes that the effect of the control spray variable is independent of any of the other process parameters that effect HAP emissions for atomized mechanical resin application or gel coating. Similarly, the CFA model assigns a fixed reduction factor for the use of vapor suppressants for atomized mechanical resin application and filament winding. Thus, the CFA model assumes that the effect of the vapor suppressant variable is independent of any of the other process parameters that affect HAP emissions from mechanical resin application or filament winding. The CFA model also assigns a fixed reduction factor for non-atomized mechanical resin application. Finally, the CFA fixed reduction factors for controlled spraying and non-atomized mechanical resin application can be used in conjunction with the fixed reduction factor for vapor suppressants.

The CFA has commented that the EPA/ORD model assumption of variable independence "could lead to an extremely unrealistic emission rate that would still be judged acceptable under model conditions." Both the CFA and NMMA provided examples where the EPA/ORD model provided physically impossible emission results (>100% of available styrene) for inputs judged acceptable by the EPA/ORD model. (Acceptable in that the model inputs did not generate a warning message from the model program indicating that the model inputs were outside normal values).

The converse of this issue is that reducing the number of independent variables in an emissions estimation equation can also reduce the accuracy of that model since the emissions from the resulting model will not change with varying process parameters unless those process parameters are included as independent variables in the emissions estimation equation.

Both EPA/ESD and EPA/ORD noted that the CFA model ignores process parameters that ~~significantly affect~~ HAP emissions (such as laminate thickness, gel time and temperature) and the resulting inaccuracy of the model can result in a significant underestimation or overestimation of HAP emissions depending on the process parameters used by a particular facility.

Issue #1: Number & Type of Independent Variables/Process Parameters (Continued)

Questions: For each open molding process, which process parameters significantly affect HAP emissions?

For each open molding process, which process parameters must be included in an emissions estimation model to produce the required level of accuracy?

there is no requ. level

For each open molding process, does the assumption of variable independence in the CFA and EPA/ORD models adversely affect the accuracy of those models?

For each open molding process, which process parameters must be excluded in an emissions estimation model to produce the required level of accuracy?

For each open molding process, which process parameters can reasonably be measured in a production (as opposed to laboratory) environment?

For each open molding process, if an emissions model serves as the basis for a permit limitation and as a basis for compliance with the same permit, which process parameters can be included in this emissions model such that the permit in question is federally enforceable?

How does prior EPA rulings on the enforceability of the CFA controlled spraying program affect this issue?

Is this EPA ruling also pertinent to the process parameters used by the EPA/ORD model to evaluate the affects of spraying technique on emissions?

Note: The enforceability of the CFA Controlled Spraying Program was addressed in a December 30, 1997 letter from Bruce Jordan (EPA/OAQPS/ESD) and John B. Rasnic (EPA/OOC/METD) to Steve McNally (CFA).

Issue #2: Applicable Ranges of Independent Variables / Acceptable Model Inputs

Issue: Once the independent variables of a model have been selected, the range of acceptable model inputs for each independent variable must be decided. For example, if a model input is the HAP content of the resin or gel coat, what are acceptable inputs for that model parameter? 20% to 50% HAP? 0% to 60% HAP? An alternative way to approach or express this issue is over what range of model inputs for each independent variable must be model be of the required accuracy.

The acceptable range of model inputs is very important, because models are generally designed to be the most accurate for the most probable set of model inputs, with lesser degrees of accuracy for less probable model inputs. In short, the emissions model must be able to handle the range of model inputs that will be present in actual use and still maintain a certain minimum level of accuracy.

Issue #2: Applicable Ranges of Independent Variables / Acceptable Model Inputs (Continued)

This issue has been widely discussed (debated) for the process parameter of resin ~~(or gel coat)~~ HAP content, particularly with respect to the lower bound of the parameter. Both EPA/ESD and EPA/ORD have indicated their view that the CFA model seriously under predicts ~~HAP emissions~~ at lower resin and gel coat HAP contents that are currently available and does not take into account that new resins and gel coats with even low HAP contents are currently being developed. Both of these organizations have indicated in order for an emissions model to be acceptable, it must accurately predict HAP emissions at currently available low HAP resins and gel coats and must allow for the development and use of even lower HAP resins and gel coats. Both EPA/ESD and EPA/ORD have indicated that the EPA/ORD model successfully meets those requirements. (The EPA/ORD model assumes that 0.0% HAP is the lower bound for resin and gel coat HAP content).

The CFA and NMMA have indicated that it is not possible for resins and gel coats to function adequately below a certain HAP content because a certain amount of HAP is required to successfully complete the chemical reaction that results in a cured resin or gel coat. In other words, unlike a surface coating, some of the HAP contained in the resin is used as a reactive diluent to form chemical bonds and a certain minimum HAP content is necessary for the required number of these chemical bonds to be formed. As such, creating an emissions model that attempts to predict HAP emissions below a certain HAP content is attempting to create a model that will address resins or gel coats that are not currently in existence and may not be possible to develop given the realities of resin chemistry. The CFA has also indicated in the past that attempts to create models at very low resin and gel coat HAP contents results in interpolating significantly beyond the available emissions data, and these attempts are therefore questionable.

Questions:

Assuming a process parameter is an acceptable independent variable in an emission model as discussed in issue #1, what are the acceptable ranges of model inputs?

Issue #3: Requirements for and Development of an Emissions Estimation Model

Once the number and type of independent emission variables (and the acceptable range of model inputs) have been determined for each open molding process, the next step is to derive an emissions estimation model that will accurately estimate HAP emissions from that process for all acceptable model inputs. There are several considerations that must be addressed in the development of this emissions estimation model.

The first consideration is the selection of a data set or data sets from emission studies that are representative of the process being modeled and the end-use of the model. In other words, the process parameters used during the emission study the data was obtained from should be process parameters that are representative of the industry for the process in question. If this is not the case, the emissions estimation model will not produce emission results representative of the process and industry (or industry segment) in question.

Issue #3: Requirements for and Development of an Emissions Estimation Model (Continued)

The next consideration is the use of balanced data sets to derive the emissions estimation model. Once a data set that is representative of the industry is selected, is the data set balanced (or can it be balanced) in such a fashion that the emission model is not unnecessarily biased toward any particular combination of process parameters? In certain cases (for certain processes) it may not be possible to obtain balanced data sets.

The next consideration is whether or not the accuracy of the derived model is acceptable for all possible combinations of model inputs (within the range of acceptable model inputs).

There has been extensive commentary by all stakeholders on the three considerations discussed above. Each stakeholder has criticized one or more of the currently developed emission models (or approaches) for failure to use representative data sets, the lack of balanced data sets, or the lack of an acceptable level of accuracy for what the stakeholder considered to be acceptable model inputs.

Questions:

EPA/ORD Model

Does the EPA/ORD model produce acceptable levels of accuracy for all possible inputs?

Is the EPA/ORD model based on representative data sets for the processes modeled?

Is the EPA/ORD model derived using "balanced" data sets that do not bias emission results unnecessarily toward any particular combination of process parameters?

CFA Model

Does the CFA Model produce acceptable levels of accuracy for all possible inputs?

Is the EPA/ORD model based on representative data sets for the processes modeled?

Is the EPA/ORD model derived using "balanced" data sets that do not bias emission results unnecessarily toward any particular combination of process parameters?

NMMA Approach

Does the NMMA approach produce acceptable levels of accuracy for all possible inputs?

Is the NMMA approach based on representative data sets for the processes modeled?

Is the NMMA approach derived using "balanced" data sets that do not bias emission results unnecessarily toward any particular combination of process parameters?

Issue #4: Units of EF Equations (% Available Styrene, %Available MMA, % of Resin Weight)

Issue: The CFA model presents emission factor information for all open molding processes on the basis of styrene emissions per amount of resin consumed (% of resin weight consumed). For example, an emission factor of 5.0% in units of % of resin weight would represent 5 grams of styrene emitted per 100 grams of resin consumed. The EPA/ORD model presents emission factor information on the basis of emissions per amount of available styrene (% of available styrene). An example of this set of units is an emissions factor of 5.0% would represent 5 grams of HAP emitted per 100 grams of available HAP. The NMMA model presents EF information in terms of % of available styrene or % of available MMA, depending on the HAP in question.

In the past, HAP emissions for reinforced plastics fabrication have been expressed in % of available styrene and the EPA/ORD and NMMA models follow this historical pattern. The CFA has indicated that the best statistical fit of emissions data occurs when emissions are expressed on a emissions per amount of resin consumed basis and therefore more accurate emission estimation models can be created when emissions models are derived using emissions expressed on this basis. (The resulting models express the emission factor information in % of resin consumed.)

<u>Questions:</u>

Should emission models be derived from emission data expressed as % of resin weight or % of available styrene?

Should emission models provide emission factors that are expressed in % of resin weight or % of available styrene? (or % of available MMA?)

Issue #5: Development of EF's for Vapor Suppressants

Issue: There are several issues with respect to the development of EF's for resins and gel coats with vapor suppressants. The current EF's in AP-42 for manual and mechanical resin application were derived from laboratory tests and facility source tests, respectively. In recent years, there have been a number of studies that have tested vapor suppressed resins applied using manual and mechanical resin application. These studies have indicated widely varying degrees of effectiveness for vapor suppressants depending on the set of process parameters present and the amount of filler present in the resin system. (One large study indicated that the effectiveness of vapor suppressants is virtually zero when filler loadings approach 50% - 60%).

Using the data from these studies both the CFA and EPA/ORD have developed models that estimate emissions from vapor suppressed resins applied using manual or mechanical resin application. The CFA model uses an equation and a fixed control factor to estimate vapor suppressant effectiveness for manual resin application and mechanical resin application, respectively. The CFA model does not take into account the effect of filler on vapor suppressants. The EPA/ORD model uses equations to estimate the effectiveness of vapor suppressants for manual and mechanical resin application and these equations do incorporate the amount of filler contained in the resin. Neither of the models take into account the effect of resin chemistry on the effectiveness of vapor suppressants.

In recognition of the data that demonstrates that resin chemistry ~~and filler loading~~ can have a significant effect of the emissions from vapor suppressed resins, EPA/ESD is working with the CFA and several resin manufacturers to develop a vapor suppress~~ed resin~~ (VSR) effectiveness test that can be conducted in a laboratory setting. In order to obtain compliance credit for the use of a vapor suppressed resin, the tentative (still under development) MACT standard for the Plastic Composites source category will require that a facility conduct a vapor suppressant effectiveness test for each vapor suppressant/resin/filler combination used by the facility. This test value will be used in conjunction with an equation that takes into account the emission profile of the process used to apply the vapor suppressed resin (i.e. the emission profile of either manual or mechanical resin application.) The emissions profile of the fabrication process is important because the vapor suppressant is assumed to reduce emissions only during curing (and not application) and the percent of total emissions emitted during curing is different for manual and mechanical resin application.

These developments lead to several different areas that need to be addressed. Once the VSR effectiveness test method has been approved and the MACT standard for the plastic composites source category is in place, failure to use its results to predict emissions may also constitute failure to use "best available information" to estimate emissions. Failure to use the results of the VSR effectiveness could also result in forcing a facility or regulatory agency to use an emissions estimation model that either over or underestimates the HAP emissions from the application of the vapor suppressed resin in question (a lose-lose situation). It is important to note, though, that the the MACT standard in question is not scheduled for promulgation until November 15, 2000. Facilities will not have to comply with the new standard (or conduct the VSR effectiveness test) until up to three years after promulgation. Thus, there is an approximately four year period of

time where
VSR effectiveness test results will not be available for use. Since the current EF's can probably no longer be assumed to represent "best available data" in light of the recent emission studies, it would

Issue #5: Development of EF's for Vapor Suppressants (Continued)

appear that an intermediate or alternative model is necessary to estimate emissions from application of vapor suppressed resins.

Questions:
For vapor suppressed manual and mechanical resin application, should an alternative emission model be presented in AP-42 that does not utilize results from the VSR effectiveness test?

Should this alternative emission model take into account the effects of resin chemistry and/or filler?

For vapor suppressed manual and mechanical resin application, should an intermediate emission model be presented in AP-42 that does not utilize results from the VSR effectiveness test?

Should this intermediate emission model take into account the effects of resin chemistry and/or filler?

For vapor suppressed manual and mechanical resin application, should the emission model be presented in AP-42 that utilizes results from the VSR effectiveness test?

Should treatment of vapor suppressed resins by EPA be consistent between the different sections of the EPA in order to avoid confusing EPA regional offices, state and local regulatory agencies, and the members of the regulated community or are the mission requirements and goals of different sections of the EPA distinct enough to justify differing treatment of vapor suppressed resins?

Filament Winding (See also Issue #10)
The next issues concerns the use of vapor suppressants with filament winding. The current EF's in AP-42 for vapor suppressed filament winding were derived from a "technology transfer estimation" and not actual emissions data. There is now emissions data available for vapor suppressed filament winding from an emissions study conducted by DOW Chemical. Using this data, the CFA has created a model that estimates emissions from vapor suppressed filament winding for different resin monomer contents. This model is subject to the same problems as the models for vapor suppressed manual and mechanical resin application in that it does not address the vary effectiveness of vapor suppressants due to differences in resin chemistry and the possible presence of filler.

It is possible to conduct the VSR effectiveness test on a filled or unfilled vapor suppressed resin used for filament winding. However, unlike manual and mechanical resin application, there is no clear delineation between the application and curing stages of filament winding. The resin is applied to the reinforcement in the resin bath at the same time that previously wound resin and reinforcement is curing on the mandrel. Thus, both resin application and curing can occur at the same time during the fabrication of a part with filament winding. Therefore, it is difficult to relate the results of the VSR effectiveness test to an emissions profile in same manner as manual and mechanical resin application.

Issue #5: Development of EF's for Vapor Suppressants (Continued)

Questions:
Should a model for vapor suppressed filament winding be present for those facilities that have not conducted a vapor suppressed resin effectiveness test?

What limitations or explanations (if any) should accompany the presentation of this model?

How can the results of the vapor suppressant effectiveness test be incorporated in a model to estimate emissions from vapor suppressed filament winding?

Centrifugal Casting (See also Issue #11)
The next issue concerns the use of vapor suppressants with centrifugal casting. The tentative MACT standard for the Plastic Composites source category groups centrifugal casting with filament winding and considers vapor suppressants a control option for centrifugal casting. There is no data for the use of vapor suppressants with centrifugal casting.

Questions:
Should these EF's for centrifugal casting assume that vapor suppressants work during centrifugal casting in the same fashion as filament winding?

Should the complete lack of data for the effects of vapor suppressants with centrifugal casting result in only the inclusion of EF's for non-vapor suppressed centrifugal casting?

Gel Coat Application
The next issue concerns the use of vapor suppressants with gel coat application. There are currently EF's on AP-42 for the application of vapor suppressed gel coats by manual resin application (hand lay-up) and mechanical resin application (atomized spray lay-up). EPA/ESD has indicated that vapor suppressed gel coats are used in certain instances in boat manufacturing due to the presence of wax in the enamel gel coats used to coat engine covers, interior of closets, etc. EPA/ESD also pointed out that there is no data on the effectiveness of the wax in reducing emissions from these gel coats and recommended removal of the vapor suppressed gel coat emission factors from AP-42. The CFA has indicated that vapor suppressants cannot be used with gel coat application. The EPA/ORD does not consider vapor suppressants as a control option or model variable for gel coating.

Note: The VSR effectiveness test under development is only for use with vapor suppressed resins. It is not designed for vapor suppressed gel coats.

Questions:
Should the revised AP-42 section contain EF's for vapor suppressed gel coats applied using manual or mechanical application?

If EF's for vapor suppressed gel coats are necessary, how should these EF's be derived?

Issue #6: Separate EF Equations/Model for Boat Manufacturers

Issue: The NMMA has stated "... NMMA believes that the best available data for the boat manufacturing industry were generated in its study conducted in 1997. The data specific to this industry generated under operational conditions in a boat manufacturing plant are the most representative for this industry. NMMA believes that our data should be used for boat manufacturing plants, as more representative of industry practices and emissions than a model that attempts to characterize any and all fiberglass manufacturing operations."

The NMMA also indicated that "We have not prepared a computer emission model from these data, but instead provide our data in a number of formats to allow our members the ability to use the results to reflect their operations appropriately. Some operations may elect to use the most generic approach, that is, one of the discrete emission factors published in our summary report. Others may use the data to generate an emission factor through interpretation of the data on the styrene content of the resin, distance from the mold during application, and application technique."

Note: These comments were provided by the NMMA in part to contrast the NMMA data and approach with the EPA/ORD model which had been reviewed by the NMMA.

EPA/ESD indicated a general concern that the NMMA test results, while accurate for the specific conditions at the test site, "may be inappropriately used for other boat manufacturing situations which are not similar to the conditions at U.S. Marine." EPA/ESD provided several specific reasons why the NMMA data may result in the under prediction of HAP emissions. The first was the concern that the amount of over spray (material off the mold) was atypically low due to the fact that the spray operator for the testing was a very experienced spray operator (the corporate trainer for U.S. Marine) and the testing molds were on a rotating frame (hence making resin application more efficient). EPA/ESD also indicated that the air velocities at the U.S. Marine study were well below 40 feet per minute and may not be typical for boat manufacturing facilities, especially where personnel fans are used. EPA/ESD also commented that temperatures at the testing facility were significantly lower than the temperatures where most of the boat manufacturing facilities are located (Southeastern United States).

EPA/ESD also questioned distinguishing between boat and non boat FRP processes for emission estimation purposes, due to the similarity of the processes and raw materials used for both. EPA/ESD also stated that "the diversity within non-boat reinforced plastics is as great or even greater than the difference between the boat and non boat reinforced plastics manufacturing" and as such it would make sense to use the same emission estimation technique for both types of manufacturing (i.e. to have an emissions estimation approach that is not part specific). EPA/ESD also pointed out that non-hull/non deck parts (such as hatch covers, shower stalls, etc) are considered part of boat manufacturing and as such data from the NMMA study may not be representative for these types of parts.

EPA/ORD indicated many of the same concerns as EPA/ESD. EPA/ORD also indicating their belief that the process parameters present at the NMMA testing could not possibly represent the range of process parameters present at boat manufacturing facilities.

Issue #6: Separate EF Equations/Model for Boat Manufacturers (Continued)

Questions: Should boat manufacturing have a separate emissions estimation model from other types of reinforced plastic composites manufacturing?

Should the emission results of the NMMA Study and the facility-specific interpretation approach suggested by the NMMA be used as the HAP emissions estimation approach for boat manufacturing?

Should the emission results of the NMMA Study and the facility-specific interpretation approach suggested by the NMMA be used as the HAP emissions estimation approach for the types of boat molds/parts used in the NMMA study (i.e. decks and hulls) with another approach used for non-hull/non-deck molds/parts?

If the emission results of the NMMA Study and the facility-specific interpretation approach suggested by the NMMA is used as the HAP emissions estimation approach for the types of boat molds/parts used in the NMMA study or even FRP activities related to boat manufacturing, who will decide how to interpret the NMMA study results? The facility? The relevant regulatory agency? What guidance will (should) be provided to the facilities and regulatory agencies on how to interpret and use the NMMA study results

If the NMMA approach is adopted, how will emissions from non-hull/non-deck parts that are constructed entirely or in part with manual resin application be determined?

If the NMMA approach is adopted, how will emissions from gel coating be determined for gel coats that do not contain MMA? (The NMMA study tested one gel coat containing 32.0% styrene and 5.0% MMA).

II. PROCESS-SPECIFIC EMISSION ESTIMATION ISSUES

Issue #7: Separate EF for Resin Application with Flow-Coaters and Pressure-Fed Rollers

Issue: For the case of non-atomized resin application, the CFA, NMMA, and EPA/ORD models differ in their treatment of flow-coaters and pressure-fed rollers. The EPA/ORD model uses different emission factor equations depending on whether the resin is applied using a flow-coater or pressure-fed roller. The CFA model assumes the use of flow-coaters and pressure-fed rollers results in the same level of HAP emissions when all other factors (process parameters) are equal. The NMMA study did not test pressure-fed rollers (only flow-coaters) and the estimation of HAP emissions when resin is applied using pressure-fed rollers is not addressed in their test report.

Note: The tentative MACT standards for the plastic composites and boat manufacturing industries that are currently being developed by EPA assume that pressure-fed rollers and flow-coaters produce an equal level of HAP emissions (and provide an equal emission reduction when used as a control technique for atomized spray lay-up) when all other factors (process parameters) are equal.

Questions: Should pressure-fed rollers and flow-coaters be assigned separate EF equations to reflect the differences in these resin application technologies or are these technologies (or their resulting HAP emissions) similar enough to warrant the use of the same EF equation for both technologies?

Will assigning separate EF equations for these technologies produce more accurate estimates of HAP emissions or will separate EF equations simply add an additional level of complexity to estimating emissions from these industries without producing a significant improvement in accuracy?

Should treatment of these technologies by EPA be consistent between the different sections of the EPA in order to avoid confusing EPA regional offices, state and local regulatory agencies, and the members of the regulated community or are the mission requirements and goals of different sections of the EPA distinct enough to justify differing treatment of these resin application technologies?

Issue #8: Separate EF Equations for Gel Coats Containing Methyl Methacrylate

Issue: The use of gel coats containing the HAP methyl methacrylate (MMA) is increasing as reinforced plastic fabricators attempt to increase the performance of their products. The NMMA study tested a white gel coat containing 32.0% styrene and 5.0% MMA. The results of the NMMA testing indicated that approximately 75% of the available MMA contained in the white gel coat was emitted (compared to approximately 45% of the available styrene). The CFA and EPA/ORD models do not attempt to address the difference in HAP emissions that occurs when gel coats contain MMA in addition to styrene. Therefore, these two models may significantly underestimate the amount of HAP emissions when these types of gel coats are used. The NMMA approach does address this issue with the limitation that the NMMA approach provides an emission factor for these types of gel coats does not change with increasing HAP content.

Issue #8: Separate EF Equations for Gel Coats Containing Methyl Methacrylate (Continued)

Note: The tentative MACT standards for the plastic composites and boat manufacturing industries that are currently being developed by EPA treat gel coats that contain both styrene and MMA in the same manner as gel coats that contain styrene only.

There are several negative consequences attached to this issue. Under Title III of the Clean Air Act, a facility is a major source if has the potential to emit, considering controls, more than 10 tons per year of any single HAP or more than 25 tons per year of any combination of HAP. In order for regulatory agencies and the regulated community to determine if a facility meets the major source definition (considering controls) by emitting more than 10 tpy of MMA or if the facility crosses the 25 tons per year threshold due to emitting MMA in addition to other HAP, a method of estimating emissions of MMA from gel coat application must be available. If such a method is not available, regulatory agencies and facilities may used widely varying and inaccurate methods to determine MMA emissions.

Another negative consequence is that a facility may attempt to reduce HAP emissions by moving to a gel coat that has a lower HAP content (by weight) but fail to reduce HAP emissions due to being unaware of the results of the NMMA testing noted above. For example, if a facility moves from a gel coat that contains 32.0% HAP by weight (32.0% styrene, 0.0% MMA) to a gel coat that contains 30.0% HAP by weight (22.0% styrene, 8.0% MMA), the facility may actually emit more total HAP due to the greater emission potential of MMA discussed above. The negative aspects of the failure to actually reduce the HAP emissions from the gel coating would be compounded by the very likely possibility that the facility incurred various costs to select and test the new gel coat.

Questions: Should gel coats containing both MMA and styrene be assigned a separate EF equation to reflect the fact that gel coats containing MMA emit a greater amount of total HAP for the same initial HAP content than gel coats that contain styrene only?

Should EF equations for gel coating contain terms or be structured in such a fashion as to allow regulatory agencies and the regulated community to estimate both the amount of styrene and MMA emitted by a particular gel coat?

If the answer to either of the above questions is yes, how should these EF equations be derived?

Should treatment of gel coats containing MMA be consistent between the different sections of the EPA in order to avoid confusing EPA regional offices, state and local regulatory agencies, and the members of the regulated community or are the mission requirements and goals of different sections of the EPA distinct enough to justify differing treatment of these gel coats?

Issue #9: Development of an Emission Factor for Vacuum Bagging

Issue: The use of vacuum bagging has been accepted (tentatively) as a control option for manual resin application and mechanical resin application (both atomized and non-atomized) in the MACT standard under development for the plastic composites source category. There are a small number of facilities that use some form of vacuum bagging in the database of facilities EPA is using to develop the plastic composites MACT standard. Vacuum bagging is not typically used for boat manufacturing. The use of vacuum bagging is expected to reduce HAP emissions while a part is curing since the bag is made of a material impermeable to styrene and functions as a barrier to prevent HAP from being emitted during curing. Note that vacuum bagging decreases HAP emissions essentially in the same fashion as vapor suppressants, i.e. by forming a barrier over the part during curing that acts as a barrier to escaping HAP emissions. In the case of vapor suppressants the barrier is the film created on the surface of the part by the vapor suppressant and in the case of vacuum bagging the barrier is the bag that is impermeable to styrene. Vacuum bagging does not affect HAP emissions that occur during application of the resin or during roll out.

The magnitude of the emission reduction will depend on the process (manual or mechanical resin application) since more emissions are emitted during the application stage of atomized mechanical resin application than during the application stages of non-atomized mechanical resin application or manual resin application. The magnitude of the emissions reduction will also depend on whether the resin/reinforcement mixture was rolled out prior to the application of the bag and vacuum and the speed the bag is applied to the mold following application of the resin.

Since vacuum bagging has tentatively been accepted as a control option for manual and mechanical resin application and since there are currently facilities that use vacuum bagging, EF's for vacuum bagging (with and without roll out) are needed for manual and mechanical resin application.

The current section of AP-42 describes vacuum bagging as a closed molding process and indicates an EF of 1-3% of available HAP. However, since vacuum bagging can only reduce HAP emissions that would occur during the curing stage and not the application stage, the current closed molding EF's in AP-42 may greatly underestimate HAP emissions when the vacuum bagging process is employed. For example, the range of HAP emissions data from the CFA phase I study for manual resin application was 9.6% of available styrene to 21.2% of available styrene. Assuming that approximately 1/2 of the HAP emitted during this run was emitted during the roll out and curing stages (and the remaining half during the application stage), the maximum emissions reduction the application of a vacuum bag (with no roll out) could produce is 50%. Applying a 50% emission reduction to the measured HAP emissions range yields an emissions range of 4.8% to 10.6%. These emissions values are approximately <u>two to five times greater than</u> the HAP emissions value that would be predicted by the AP-42 midpoint for closed molding.

This effect is present to an even greater degree for mechanical resin application (atomized spray lay-up). The range of HAP emissions data for mechanical resin application (atomized spray lay-up) from the CFA Phase I study was 16.1% of available styrene to 38.0% of available styrene.

Using
Issue #9: Development of an Emission Factor for Vacuum Bagging (Continued)

the same assumptions as above, this yields a HAP emissions range for vacuum bagging of 8.05% to 19.0%. These emissions values are approximately four to eight times greater than the HAP emissions value that would be predicted by the AP-42 midpoint for closed molding.

Questions:
Are the current EF's for closed molding acceptable for vacuum bagging, or do these EF's greatly underestimate the HAP emissions from a vacuum bagging process due to the mold being open during the application of the resin?

If the current EF's for vacuum bagging are unacceptable, how can EF's be derived for the above mentioned vacuum bagging applications?

Issue #10: Discrepancies in the Filament Winding Data Sets

Issue: Some of the data for vapor suppressed and non-vapor suppressed filament winding are different in the documents "Filament Winding Emission Study, Craigie, L.J., Webster, G.L., February 1997" and "CFA Emission Models for the Reinforced Plastics Industries, Haberlein, R.A., February 1998", even though both documents cite the same study conducted by Dow Chemical. In order to develop accurate EF's for filament winding, the correct data must be ascertained.

The first document above lists data from 18 test runs while the second document lists data from 20 test runs. The first document indicates that the styrene content for the vapor suppressed resin used in run #3 is 33% styrene, while the second document indicates that the styrene content for the vapor suppressed resin used in run #3 is 48%.

Questions: What is the actual styrene content for the vapor suppressed resin used in run #3?

Are the two additional test runs in the second document valid test runs? Duplicates?

Issue #11: Development of an Emission Factors for Centrifugal Casting

Issue: Centrifugal Casting is a fabrication technique commonly used to make products that are surfaces of revolution such as pipes and storage tanks. There are two different sources of HAP emissions data for centrifugal casting and these two sources indicate greatly differing levels of HAP emissions. The reason for this large difference is that there are a number of differences in the way centrifugal casting is conducted that can result in large differences in HAP emissions. These differences include whether or not a facility pumps air through the center of the mold, whether the air is heated, and the degree of closure of the mold.

Issue #11: Development of an Emission Factors for Centrifugal Casting (Continued)

There are currently a small number of facilities that use centrifugal casting in the database of facilities EPA is using to derive the plastic composites MACT standard. None of these facilities reported the use of vapor suppressants with centrifugal casting.

Note: The tentative MACT standard for the plastic composites source category that is currently being developed by EPA groups filament winding and centrifugal casting together in a process/product grouping and does not distinguish between the two processes.

Questions: How should EF's for centrifugal casting be developed or assigned?

Should treatment of centrifugal casting be consistent between the different sections of the EPA in order to avoid confusing EPA regional offices, state and local regulatory agencies, and the members of the regulated community or are the mission requirements and goals of different sections of the EPA distinct enough to justify differing treatment of centrifugal casting?

Composites
Fabricators
Association

Committed to Strength Through A Unified Industry

August 25, 1998

Mr. Ron Ryan
EPA-OAQPS
Emissions Monitoring and Analysis Division
Research Commons
79 T.W. Alexander Drive
Building 4201
Research Triangle Park, North Carolina 27711

Dear Ron:

The Composites Fabricators Association recognizes and supports the US EPA's goal to provide conservative and accurate estimation of emissions from sources of air pollution.

We are pleased that EPA has provided us an opportunity to review and comment on the FRP Model which has been developed for the EPA Office of Research and Development.

We have done a comprehensive evaluation of this model, and have enclosed our comments.

We would request that you pay special attention to the "Comparison to the CFA Model" portion of our comments. We realize that EPA is interested in achieving an accurate estimate of emissions from composites facilities. We agree with this goal. In that regard, we would point out that CFA Model compares very favorably, with regard to deriving a conservative estimation of source emissions.

Again we would stress the importance of the "enforceability" aspects of any emissions model which is offered to the states and to industry sources. Since an emissions model will often serve as a basis for a permit limit, the emissions model will most often be presumed as the basis for the permit compliance determination. If model parameters are not "practically enforceable", then major aspects of the permit will not be federally enforceable.

Finally, we would call your attention to the fact that this FRP Model can derive "impossible" endpoints. This would indicate to us that there are practical limitations to the use of this model to derive meaningful emissions estimates from facilities.

We wish to thank you again for the opportunity to comment on this emissions model.

We look forward to additional opportunities to discuss these matters with your office.

Sincerely,

Stephen McNally
Director of Government Affairs

Enc.

1655 North Fort Myer Dr., Suite 510 Arlington, Virginia 22209-2022 USA
Tel: 703/525-0511 Fax: 703/525-0743
E-mail: cfa-info@cfa-hq.org • Internet: http://www.cfa.org

CFA Comments Regarding the NRMRL (EPA) "FRP Model version 1.0"

General Inability to Verify the Model:

According to the EPA text provided with the model (under the task bar button labeled "About EPA FRP Model"):

> *"EPA's APPCD, in cooperation with Research Triangle Institute (RTI), has developed a mathematical model to provide better styrene emission estimates for selected open molding fiber-reinforced plastics (FRP)manufacturing processes. The model highlights 10 relevant parameters impacting styrene emissions in FRP processes and helps identify future areas of FRP pollution prevention (P2) research. Seven different emission studies were evaluated and used as model inputs."*

The EPA text does not identify these referenced seven emission studies, so the CFA cannot verify the basis of the model algorithms.

Comparison to CFA Model:

The following table compares the single-factor CFA Model with the FRP Model at the baseline conditions. This is appropriate because the CFA Model has no assigned "baseline" values.

	Emission Rate (as % ***available styrene***) single-factor CFA Model / FRP Model at baseline conditions MONOMER CONTENT			
PROCESS	34 %	38 %	42 %	46 %
Gel coating	46.2 / 52.0	52.4 / 54.8	57.1 / 57.5	61.3 / 60.3
Resin spray up				
NVS	18.5 / 15.3	23.9 / 18.9	28.6 / 22.8	32.2 / 27.1
VS	11.5 / 9.8	15.0 / 12.1	17.6 / 14.6	20.0 / 17.4
Hand lay up				
NVS	12.9 / 11.3	14.7 / 12.3	16.0 / 13.3	17.2 / 14.3
VS	8.2 / 5.7	7.9 / 6.1	7.6 / 6.6	7.2 / 7.1
Flowcoater	9.4 / 10.4	12.3 / 11.3	14.6 / 12.2	16.5 / 13.1
Pressure-fed roller	9.4 / 11.6	12.3 / 12.6	14.6 / 13.6	16.5 / 14.6

Gel coating - the two models are about the same. The CFA Model is ~~more~~ less conservative (~~higher~~ lower estimates) than the FRP Model below 42% content, and ~~less~~ more conservative above. Not much difference until below 34% content.

Resin spray up - the CFA Model is significantly more conservative (higher estimates) than the FRP Model at all monomer content levels.

Hand lay up - the CFA Model is significantly more conservative (higher estimates) than the FRP Model for non-vapor-suppressed resin at higher monomer content levels, and draws close to the FRP Model at 34% content. For vapor-suppressed resin, CFA Model is significantly more conservative (higher estimates) at lower monomer content levels.

Flowcoater and Pressure-fed roller - the CFA Model does not distinguish between the two processes. The FRP Model is more conservative (higher estimates) than the CFA Model in both cases. The difference between the two models is insignificant at 34% content, but increases for higher monomer levels. Overall, the two models are about the same.

Overall Implementation and Use:

Very slick "Windows-style" presentation - The model program installed without any problems and ran the first time. The model screens follow the standard Windows 95™ format, and are simple and easy to understand. The input of data by mouse and keyboard is also very easy. Overall, the presentation of the model is very slick and professional-looking.

Emission Calculations are Allowed Outside the Acceptable Range:

If, as the model suggests, results outside the acceptable input ranges may not be reliable, one might reasonably ask why are such results even allowed? The model was self-described by the EPA as a tool to provide better emission estimates and directions for future P2 research. It is difficult to understand what is gained by developing an unreliable tool. A more reasonable approach would be to limit such a tool to reliable inputs. Presumably, one possible reason for allowing out-of-range calculations would be the regulatory application of this model to establish emission rates for permits or emissions reporting, where a source may well operate outside the typical parameter ranges. However, such a use could easily, and often lead to a serious abuse of the model.

The Model is Not Practical:

In the real world, it is difficult to conceive how a source could reliably and consistently measure spray gun distance. This is also true of part thickness and over spray ratio. The model does not offer methodologies regarding where or how the air temperature and air velocity should be measured. Sources would apparently be free to measure at the surface of the part, above the surface, at some set distance from the part, or averaged throughout the work area. This would allow for extraordinary variations in the estimated emissions from fundamentally similar plants. If the parameters cannot be measured, the model cannot be reliably used in the real world.

Not enforceable:

If the model isn't practical, then it simply isn't enforceable. If this model were to be offered as guidance to the states, then the limitations on the practical enforceability of the model parameters must be clearly stated in the model text, or in the EPA guidance to the states, to avoid potential misapplication by state or local agencies.

Overly complex and sophisticated algorithms:

The only algorithms provided in the EPA text were for resin spray lay up, and they took the following forms:

PARAMETER	EQUATION FORM
Styrene content	second-order polynomial $AX^2 + B X + C$ (C= O)
Styrene suppressant	linear equation $A X + B$ if suppressant is used
Distance spray gun to mold	linear equation $A X + B$
Ratio of dry material off mold to material sprayed	second-order polynomial $AX^2 + B X + C$
Thickness	step-wise linear equations $A X + B$, with step at 40 mils
Gel time	linear equation $A X + B$
Application rate	linear equation $AX + B$ if less than 4 lb/min
Air temperature	linear equation $A X + B$
Air velocity over mold	step-wise linear equations AX -t- B, with step at 38 fpm

No specific comments can be offered because the underlying data and assumption were not provided by the EPA. However, based upon the industry's knowledge, so far, of the available data, we are skeptical that such complex and sophisticated equations could have been developed with any reasonable confidence.

Impossible results are possible with acceptable model inputs:

This model can result in physically impossible emission rates while using acceptable input values. A simple exercise in repeated application of the model gave the following factor range *for the acceptable input range*:

PARAMETER	FACTOR RANGE
Styrene content	0.64 - 1.68
Styrene suppressant	0.64 for unfilled resin
Distance spray gun to mold	0.94 - 1.51
Ratio of dry material off mold to material sprayed	0.91- 1.16
Thickness	1.04 -0.84
Gel time	0.98 - 1.07
Application rate	1.30 - 1.00 above4
Air temperature	0.83 - 1.22
Air velocity over mold	0.94 - 1.04

The model assumed that these factors were independent, so the factors were simply multiplied together. This could lead to an extremely unrealistic emission rate that would still be judged acceptable under the model conditions. For example, a 50% monomer, non-suppressed, 40" gun distance, 10% overspray, 50 mil thick, 1 lb/hr, 50 minute gel time, 95°F, 200 fpm condition would yield a modification factor of 5.46 that is then applied to the baseline emission rate of 18.9%. These factors result in an absurdly high 103.1% emission rate, which is **physically impossible**.

On the other hand, a 30% monomer, vapor-suppressed, 12" gun distance, 1% overspray, 150 mil thick, 4 lb./hr, 5 minute gel time, 60°F, 20 fpm condition would yield a modification factor of 0.23 that is then applied to the baseline emission rate of 18.9%. This factor results in a very low 4.3% emission rate, which is equally unlikely.

Conclusions:

The CFA is not confident that the NRMRL (EPA) "FRP Model version 1.0" for estimating styrene emissions from composites facilities is either appropriate, or consistently accurate.

Respectfully submitted,

Stephen McNally
Director of Government Affairs

Styrene Emissions Modeling Forum

Composites Fabricators Association
1998 Annual Convention

San Antonio, Texas
October 23, 1998

The ORD*/RTI Styrene Emission Factor Model, Version 1.0

Mark Bahner
and C. Andrew Clayton,
Research Triangle Institute (RTI)

Carlos Nuñez and Geddes Ramsey
U.S. Environmental Protection Agency
National Risk Management Research Laboratory
Air Pollution Prevention and Control Division

*** ORD = EPA Office of Research and Development***

knowledgments

- Rob Haberlein, Engineering Environmental
- Composites Fabricators Association (CFA)
- National Marine Manufacturers Association (NMMA)

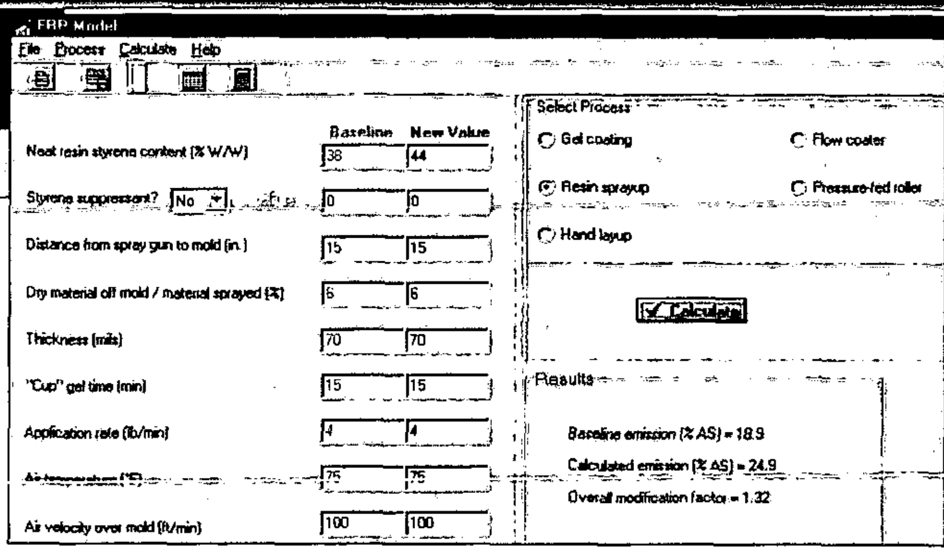
ckground

- ORD/RTI model predicts emission factors from "open mold" processes.
- Model is mainly empirical.
- Input data from many studies: ORD/RTI, CFA, NMMA, and others.
- Model Form
  - Emission Factor = Baseline (Mod. Factors)$_{1-9}$

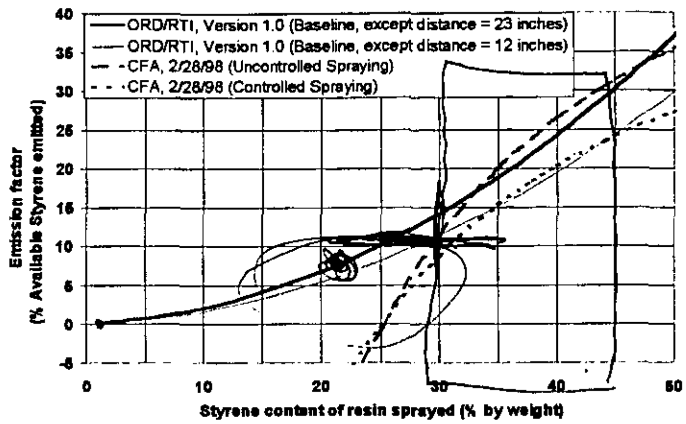
odification Factors

- *Styrene content of neat resin (%, by weight)*
- *Styrene suppressant (Yes / No)*
- *Distance from gun to mold (inches)*
- *Dried material off mold (as percentage of total material sprayed)*
- *Thickness (each laminating session, mils)*
- *"Cup" gel time (minutes)*
- *Application rate (pounds per minute)*
- *Air temperature (°F)*
- *Air velocity over mold (feet per minute)*

D/RTI model interface (Version 1.0)

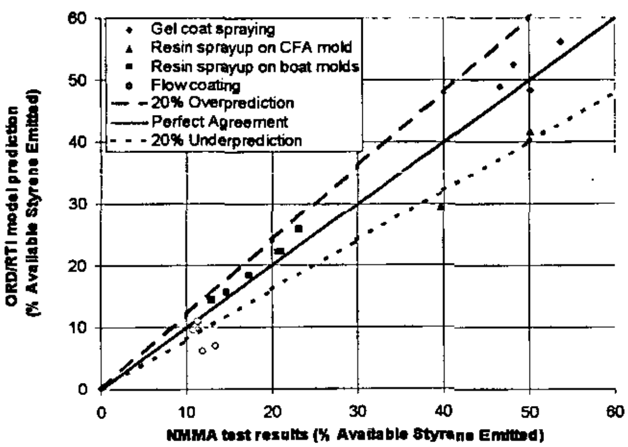


parison of ORD/RTI model with CFA model



Comparison of model predictions for sprayup with non-vapor-suppressed resin

)RD/RTI model version 1.0 versus test results: oat-size molds



Comparison of NMMA test results with ORD/RTI model version 1.0 predictions

ummary of ORD/RTI Model

- Based on input data from many studies.
- Nine "modification factors".
- User-friendly interface (with default values).
- Can be downloaded from internet: http://www.rti.org/units/ese/p2/frp_soft.html
  - E-mail address: bahner@rti.org

MEMORANDUM

TO: Mr. Ron Ryan
U.S. Environmental Protection Agency

FROM: Robert Jemison
Pacific Environmental Services, Inc.

DATE: September 12, 1998

SUBJECT: Development of Emission Factors for Open Molding Processes

I. INTRODUCTION

Purpose of Memo
-Summarize & Discuss Issues

Importance of Accurate Emission Factors
-Title V, Synthetic Minor Permits, Permit Compliance
-Community Right to Know
-Misallocation of Financial & Human Resources

II. OPEN MOLDING EMISSION STUDIES

Recent Open Molding Emission Studies
-Manual Resin Application (Hand Lay-Up)
Summary Graph (In % of Resin & % of Available Styrene)
-Mechanical Resin Application (Atomized Application)
Summary Graph (In % of Resin & % of Available Styrene)
-Mechanical Resin Application (Non-Atomized Application)
Summary Graph (In % of Resin & % of Available Styrene)
-Filament Winding
Summary Graph (In % of Resin & % of Available Styrene)
-Gel Coat Application
Summary Graph (In % of Resin & % of Available Styrene)

Table X: Summary of Recently Completed Emission Studies by Process

Table X: Summary of How Process Parameters Affect Emissons by Process

III. RECENTLY DEVELOPED EMISSION MODELS

<u>General Discussion (Basic Features of Model)</u>

CFA Emission Model (Manual, Mechanical, Filament Winding, Gel Coating)
NMMA Emission Model (Mechanical, Gel Coating)
RTI/ORD Emission Model (Manual, Mechanical, Gel Coating)

Table X: Table Summarizing Equations or Factors for Each Model by Process

Table(s) X, Graphs: Comparison of Emission Models Using "Realistic" Inputs

IV. ISSUES SURROUNDING ALL EMISSIONS ESTIMATION MODELS

Issue #1: Number & Type of Independent Variables (Process Parameters) Used In Model
- Enforceability & Measurability & Model Complexity & Effect on Accuracy

Issue #2: Applicable Ranges of Independent Variables / Acceptable Model Inputs
-CFA: Styrene Content
-NMMA: Styrene Content & Mold Type
-RTI/ORD: All 8 Parameters

Issue #3: Type of Equation (Linear, Power, Polynomial)
-CFA: Linear (Y=mx+b)
-NMMA: Linear (Y=mx+b)

Issue #4: Units of Dependent Variable (% AS or % of Resin Wt)
-CFA: % of Resin Wt.
-RTI/ORD & NMMA: % AS

Issue #5: Representativeness of Data Sets Used to Derive Models
-Pultrusion Study for Air Flow of RTI/ORD Model

Issue #6: The Use of Balanced Data Sets
-None of the CFA Models Use Balanced Data Sets

Issue #7: Interaction Between Model Variables
-Problem the more variables are present

Issue #8: Accuracy of Models for Applicable Ranges of Independent Variables/ Model Inputs
-Illustrate typical inputs and inputs that reveal weaknesses

Issue #9: EF for Vapor Suppressants
-Model after MACT standard by using Results of VSR test
-Intemediate model while test is being developed
-Filled vs. Unfilled, CFA model does not account for difference
-Interaction w/ VS's and resin type, models do not account for
-VSR for gel coats, CFA says no, ORD/ RTI says no, NMMA does not say, EPA/CCPG VSR test will not be used for gel coats, recommends taking factors out of AP-42, although some gel coats used in boat manufacturing use VS.

Issue #10: Separate Model for Boat Manufacturers
-Mold types may be more representative, although CCPG would disagree
-Other parts made for boats that are not decks & hulls such as hatch covers
-How to account for Hand Lay-up which the NMMA did not test
-Only one gel coat tested
-Experienced Spray Operator
-Low Air Flow Rates

V. PROCESS-SPECIFIC EMISSION ESTIMATION ISSUES

Issue #11: Separate EF for resin application with Flow-Coaters and Pressure-Fed Rollers
-EF close, all esssentially non-atomized distribution of resin
-CFA:No, RTI/ORD:Yes, NMMA: Did not test PFR

Issue #12: Separate EF for Gel Coats Containing Methyl Methacrylate
-NMMA testing reveals greater HAP emissions
-CFA acknowledges problem in publications
-No Models address problem in equations

Issue #13: Development of an Emission Factor for Vacuum Bagging
-Control technique for open molding for standard, not considered by any model

Issue #14: Discrepancies in the Filament Winding Data Sets
-Additional Duplicates and Data Transcripton Error

Issue #15: Development of an Emission Factor for Centrifugal Casting
-Tenatively considered part of open molding under standard (grouped with Filament Winding)
-Emissions information varies greatly due to differences in process

"ONE VARIABLE" A B C DE F cH I JK L M N O P Q

Unified Emission Model

Nov 20, 1998

	APPLICATION METHOD	Styrene Monomer Content (% wt)	Base Emission Factor (% styrene)		Vapor Suppressant Factor (%)		Controlled Spraying Factor (%)	Add-on Control Factor (%)	% of Add-on Control (%)	CFA Emission Factors (lb/ton) of resin		CFA Emission Factors (% resin)	CFA Emission Factors (% styrene)
8	Manual Resin	40.0%	15.4%		n/a		n/a	95%	0%	123	SAME	6.2%	15.4%
10	New Manual Resin w/VSR	40.0%	7.7%		n/a		n/a	95%	0%	62	SAME	3.1%	7.7%
12	Mechanical Spray Resin	40.0%	26.4%	n	100%	n	100%	95%	0%	211	SAME	10.6%	26.4%
14	New Non-Atomized Resin	40.0%	11.6%	n	100%		n/a	95%	0%	93	was 108; 5.4%	4.6%	11.6%
16	Gelcoat Spray	40.0%	54.9%		n/a	n	100%	95%	0%	439	SAME	21.9%	54.9%
18	Filament Resin	40.0%	20.0%	n	100%		n/a	95%	0%	160	SAME	8.0%	20.0%

Added

Added

NOTES

1. Type Y for yes or N for no, where indicated
CFA does not recommend these models for computing factors outside the range from 33% to 50% styrene.
Factors below 33% styrene monomer content ~~assume a fixed lower bound factor at 33%, expressed as % styrene.~~ are set equal to factors for 33%
Factors above 50% ~~assume a fixed upper-bound factor at 50%, expressed as % styrene.~~ " " " " " 50%

required input values

n/a not applicable

.714(8) - .18

.157(5) - .0165 / 5

V.S. - red CF gets greater at lower monomer

* - need NOTES

Steve: 2nd sheet? - multi-variable? X
Notes for other fields? ?X
CS.
Check Excel First

DS: Limit 33-50%
split Manual w/VSR ←
NORMA??
split non-atomized resin out ←
Added to styrene EF column

One Variable:Q8: +C8*((1-M8)+M8*(1-L8))
One Variable:Q10: +C10*((1-M10)+M10*(1-L10))
One Variable:Q12: +C12*E12*I12*((1-M12)+M12*(1-L12))
One Variable:Q14: +C14*E14*((1-M14)+M14*(1-L14))
One Variable:Q16: +C16*I16*((1-M16)+M16*(1-L16))
One Variable:Q18: +C18*E18*((1-M18)+M18*(1-L18))

simplify

$\approx C8 * (\cancel{1 - M8} + \cancel{M8} - M8 * L8)$

$1 - M8 * L8$

BASE EF (% STYRENE)

wt % styrene

1 g of ~~100~~ 2000 lbs resin

= ~~20~~ lb / 2000 lbs

= 20 lb/ton

```
One Variable:C8: @IF(B8<0.33,(0.286*0.33-0.0529)/0.33,@IF(B8>0.5,(0.286*0.5-0.0529)/0.5,(0.286*B8-0.0529)/B8))
One Variable:C10: @IF(B10<0.33,(0.04476*0.33+0.01289)/0.33,@IF(B10>0.5,(0.04476*0.5+0.01289)/0.5,(0.04476*B10+0.01289)/B10))
One Variable:C12: @IF(B12<0.33,(0.714*0.33-0.18)/0.33,@IF(B12>0.5,(0.714*0.5-0.18)/0.5,(0.714*B12-0.18)/B12))
One Variable:C14: @IF(B14<0.33,(0.157*0.33-0.0165)/0.33,@IF(B14>0.5,(0.157*0.5-0.0165)/0.5,(0.157*B14-0.0165)/B14))
One Variable:C16: @IF(B16<0.33,(1.036*0.33-0.195)/0.33,@IF(B16>0.5,(1.036*0.5-0.195)/0.5,(1.036*B16-0.195)/B16))
One Variable:C18: @IF(B18<0.33,(0.2746*0.33-0.0298)/0.33,@IF(B18>0.5,(0.2746*0.5-0.0298)/0.5,(0.2746*B18-0.0298)/B18))
```

← SAME ~~NEW~~ EQN (C10)

– was 57% of above (C14)

VS Factor

```
One Variable:F12: @IF(E12="Y",0.62,1)
One Variable:F14: @IF(E14="Y",0.62,1)
One Variable:F18: @IF(E18="Y",0.65,1)
```

← New! (F14)

CS

```
One Variable:I12: @IF(H12="Y",0.77,1)
One Variable:I16: @IF(H16="Y",0.73,1)
```

EF lb/ton

```
One Variable:O8: +P8*2000
One Variable:O10: +P10*2000
One Variable:O12: +P12*2000
One Variable:O14: +P14*2000
One Variable:O16: +P16*2000
One Variable:O18: +P18*2000
```

EF % resin (P18)

EF % resin

```
One Variable:P8: +Q8*B8
One Variable:P10: +Q10*B10
One Variable:P12: +Q12*B12
One Variable:P14: +Q14*B14
One Variable:P16: +Q16*B16
One Variable:P18: +Q18*B18
```

EF % styrene (Q18)

basis = 100 lbs resin B lbs styr.

100 x B = lbs sty.

(EF % sty) → % resin

$$\frac{lb}{100\ lbs\ sty} \times \frac{B/100\ lbs\ sty}{100\ lbs\ resin}$$

Unified Emission Model

Nov 20, 1998

APPLICATION METHOD	Styrene Monomer Content (% wt)	Base Emission Factor (% styrene)	Vapor Suppressant Factor (%)	Controlled Spraying Factor (%)	Add-on Control Factor (%)	% of Add-on Control (%)	CFA Emission Factors (lb/ton)	(% resin)	(% styrene)
Manual Resin	40.0%	15.4%	n/a	n/a	95%	0%	123	6.2%	15.4%
Manual Resin w/VSR	40.0%	7.7%	n/a	n/a	95%	0%	62	3.1%	7.7%
Mechanical Resin	40.0%	26.4%	n 100%	n 100%	95%	0%	211	10.6%	26.4%
Non-Atomized Resin	40.0%	11.6%	n 100%	n/a	95%	0%	93	4.6%	11.6%
Gelcoat Spray	40.0%	54.9%	n/a	n 100%	95%	0%	439	21.9%	54.9%
Filament Resin	40.0%	20.0%	n 100%	n/a	95%	0%	160	8.0%	20.0%

NOTES

7 Type Y for yes or N for no, where indicated
CFA does not recommend these models for computing factors outside the range from 33% to 50% styrene.
Factors below 33% assume a fixed lower bound factor at 33%, expressed as % styrene.
Factors above 50% assume a fixed upper bound factor at 50%, expressed as % styrene.

required input values

n/a not applicable

CFA Emission Model for the Reinforced Plastics Industries - 1 Variable

February 28, 1998

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	APPLICATION METHOD	~~Current Monomer Content (%)~~	~~New~~ Monomer Content (%)	Monomer Factor (%)		Vapor Suppressant Factor (%)		Controlled Spraying Factor (%)	or	Non-Atom Equipment Factor (%)	Add-on Control Factor (%)	% of Add-on Control (%)	Current Emission Factor (lb/ton)	New Emission Factor (lb/ton)	New Emission Factor (% resin)
10	Manual Resin	44.0%	38.0%	76.5%	n	y = [illegible] ~~100%~~		n/a		n/a	95%	0%	146	112	5.6%
13	Mechanical Resin	44.0%	38.0%	68.1%	y	62%	n	77 100%	n	57 100%	95%	0%	268	113	5.7%
16	Gelcoat Spray	44.0%	38.0%	76.2%		n/a	n	73 100%		n/a	95%	0%	522	397	19.9%
19	Filament Resin	44.0%	38.0%	81.9%	n	y = [illegible] ~~100%~~		n/a		n/a	95%	0%	182	149	7.5%

```
A:D10: (0.286*C10-0.0529)/(0.286*B10-0.0529)
A:D13: (0.714*C13-0.18)/(0.714*B13-0.18)
A:D16: (1.036*C16-0.195)/(1.036*B16-0.195)
A:D19: (0.2746*C19-0.0298)/(0.2746*B19-0.0298)
A:F10: @IF(E10="Y",((0.04476*C$10+0.01289)/(0.286*C$10-0.0529)),1)
A:F13: @IF(E13="Y",0.62,1)
A:F19: @IF(E19="Y",0.65,1)
A:H13: @IF(G13="Y"#AND#I13="N",0.77,1)
A:H16: @IF(G16="Y",0.73,1)
A:J13: @IF(I13="Y"#AND#G13="N",0.51,1)
A:M10: (0.286*B10-0.0529)*2000
A:M13: (0.714*B13-0.18)*2000
A:M16: 2000*(1.036*B16-0.195)
A:M19: (0.2746*B19-0.0298)*2000
```

```
A:N10: +M10*D10*F10*((1-L10)+L10*(1-K10))
A:N13: +M13*D13*F13*H13*J13*((1-L13)+L13*(1-K13))
A:N16: +M16*D16*H16*((1-L16)+L16*(1-K16))
A:N19: +M19*D19*F19*((1-L19)+L19*(1-K19))
A:O10: +N10/2000
A:O13: +N13/2000
A:O16: +N16/2000
A:O19: +N19/2000
```

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

DEC 30 1997

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Mr. Stephen McNally
Director of Government Affairs
Composites Fabricators Association
1655 North Fort Myer Drive, Suite 510
Arlington, Virginia 22209

This is in response to your letter of November 11, 1997 regarding the incorporation of a controlled spray program in the maximum achievable control technology (MACT) standard for reinforced plastic composites manufacturing. After discussion with our staffs, we have concluded that the controlled spray program cannot be used as an option to offset or reduce the MACT floor level of emissions control to be determined by your proposed averaging concept. The remainder of this letter provides the rationale for our conclusion, addresses several points raised in your letter, and presents a proposal for promoting the concept of better spraying practices in the standard.

The controlled spray program was designed by industry to minimize spraying emissions by using better spray practices. It was presented as part of the averaging approach that you and other industry representatives proposed for determining the MACT floor and establishing compliance with the MACT standard. You proposed a 0.77 emission reduction factor be applied to the averaging approach for those facilities choosing to adopt a controlled spray program. This would offset one or more control options in the standard currently under consideration, such as material specifications on the resin, equipment specifications for the application technique, and/or abatement equipment. The reasons we concluded that the controlled spray program cannot be traded with the other options are that the program is considerably more difficult to enforce and cannot be assured to achieve quantifiable and continuous emission reductions.

With regard to enforceability and continuous compliance, the program does not contain objective parameters which would allow a person to distinguish between a facility that is performing (that is, achieving the reductions associated with) controlled spraying and one that is not. For example, establishing the lowest pressure setting that provides an adequate fan pattern is subjective. Further, it is not only pressure setting that affects the fan pattern, but materials, tip size, catalyst ratio, and perhaps even other parameters that would make it difficult for enforcement personnel to objectively determine compliance with the MACT standard. The photographic images suggested in your letter would aid in the demonstration that the pressure setting procedure was carried out; however, they would not guarantee that the lowest pressure setting that provides an adequate fan pattern was found. Issues arise in other parts of the program as well, such as the verification of proper operator technique. A flange could well limit the spray on some molds, but for convex and complicated shapes, it would not guard against spraying past the mold perimeter. Imagine a hemisphere-shaped mold, for example. A flange on the edge of the mold will not guard against the operator spraying over the top or past the right or left side of the mold. Even with parts where the flange will serve as a guard, there is no procedure that assures continuous compliance, i.e., that the operator is always spraying within the flange distances.

Your letter indicated that there was close agreement in the results of the controlled spray testing done by the Composites Fabricators Association (CFA) and the Research Triangle Institute (RTI) under cooperation with the Environmental Protection Agency (EPA). Our analysis of the results indicates that the agreement was not as stated in your letter. For the gel coat operation tested, RTI achieved a 9 percent reduction in emissions in terms of percent available styrene (%AS) for a high air velocity situation and a 17 percent reduction for a low air velocity situation, as compared to the CFA's result of 42 percent reduction in %AS emissions. For the resin operation, RTI achieved a 36 percent emission reduction of %AS emissions as compared to the CFA's result of 20 percent emission reduction in %AS emissions. These results are *not in close agreement*; however, they do indicate that spray technique influences the amount of emissions that result from polyester resin spray operations. This has been a longstanding point of agreement between the EPA and industry representatives.

The EPA recognizes controlled spraying as a best management pollution control practice. The operation of an emission source in a manner consistent with good air pollution practice is required by Subpart A of Part 63 (which applies to all MACT standards). In particular, under Section 63.6(e)(1)(i), "At all times, including periods of startup, shutdown, and malfunction, owners or operators shall operate and maintain any affected source, including associated air pollution control equipment, in a manner consistent with good air pollution control practices for minimizing emissions at least to the levels required by all relevant standards." To encourage sources to use controlled spraying techniques, we are considering inclusion of a requirement for an operator training program that addresses better spraying practices in the MACT standard. This requirement would be consistent with the provision of Section 63.6(e)(1)(i). A facility could demonstrate compliance by keeping records of its training program and records demonstrating that operators applying resin have taken this training. This concept was incorporated in Subpart JJ-National Emission Standards for Wood Furniture Manufacturing Operations. The training program (and other work practices) was required in addition to emission limitations, equipment standards, and material requirements. Your efforts on the controlled spray program would be valuable to facilities that choose to expand upon or develop new operator training programs to meet such a requirement, if established.

In summary, we support encouraging better spray practices with the standard, but we do not plan to allow them to be used to offset the other emission reduction techniques that were used in determining the level of the MACT standard. Due to the lack of enforceability of the program designed by the industry, it *cannot* be used to generate credits which would be traded with the other emission reduction techniques to meet the MACT standard. Our current thinking is to add a requirement for operator training which would encourage better spray practices. We appreciate your efforts to develop a program to promote better spray practices and your ongoing work to make your members aware of the importance of operator technique on reducing emissions.

Sincerely,

Bruce Jordan
Director
Emission Standards Division

John B. Rasnic
Director
Manufacturing, Energy, and
Transportation Division
Office of Compliance

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF AIR QUALITY PLANNING & STANDARDS
EMISSION STANDARDS DIVISION
RESEARCH TRIANGLE PARK, NC 27711

FAX COVER SHEET

Date: 4/24/98

TO: Ron Ryan	VOICE PHONE:
OFFICE:	FAX PHONE: 1-0684
FROM: Madeleine Strum	VOICE PHONE:
OFFICE:	FAX PHONE: 1-5689

NOTES:

Page 1 of 4 (includes cover)

CFA EMISSION FACTORS

(Styrene Emission Rates listed as % of Neat Resin Weight as applied)

Styrene Content % wt	Manual Resin Application: Bucket & Tool, Non-Vapor Suppressed	Bucket & Tool, Vapor-Suppressed	Mechanical Resin Application: Uncontrolled Spray, Non-Vapor Suppressed	Uncontrolled Spray, Vapor-Suppressed	Controlled Spray, Non-Vapor Suppressed	Controlled Spray, Vapor-Suppressed	Non-Atomized Application, Non-Vapor Suppressed	Non-Atomized Application, Vapor-Suppressed	Gelcoat Application: Uncontrolled Spray	Gelcoat Application: Controlled Spray	Filament Winding: Non-Vapor Suppressed
33%	4.1%	2.8%	5.6%	3.4%	4.3%	*	**	*	14.7%	10.7%	6.1%
34%	4.4%	2.8%	6.3%	3.9%	4.8%	*	**	*	15.7%	11.5%	6.4%
35%	4.7%	2.9%	7.0%	4.3%	5.4%	*	**	*	16.8%	12.2%	6.6%
36%	5.0%	2.9%	7.7%	4.8%	5.9%	*	**	*	17.8%	13.0%	6.9%
37%	5.3%	2.9%	8.4%	5.2%	6.5%	*	**	*	18.8%	13.7%	7.2%
38%	5.6%	3.0%	9.1%	5.7%	7.0%	to	**	to	19.9%	14.5%	7.5%
39%	5.9%	3.0%	9.8%	6.1%	7.6%	be	**	be	20.9%	15.3%	7.7%
40%	6.2%	3.1%	10.6%	6.5%	8.1%	determined	**	determined	21.9%	16.0%	8.0%
41%	6.4%	3.1%	11.3%	7.0%	8.7%	by	**	by	23.0%	16.8%	8.3%
42%	6.7%	3.2%	12.0%	7.4%	9.2%	05/15/98	6.1%	05/15/98	24.0%	17.5%	8.6%
43%	7.0%	3.2%	12.7%	7.9%	9.8%	*	6.5%	*	25.0%	18.3%	8.8%
44%	7.3%	3.3%	13.4%	8.3%	10.3%	*	6.8%	*	26.1%	19.0%	9.1%
45%	7.6%	3.3%	14.1%	8.8%	10.9%	*	7.2%	*	27.1%	19.8%	9.4%
46%	7.9%	3.3%	14.8%	9.2%	11.4%	*	7.6%	*	28.2%	20.6%	9.7%
47%	8.2%	3.4%	15.6%	9.6%	12.0%	*	**	*	29.2%	21.3%	9.9%
48%	8.4%	3.4%	16.3%	10.1%	12.5%	*	**	*	30.2%	22.1%	10.2%
49%	8.7%	3.5%	17.0%	10.5%	13.1%	*	**	*	31.3%	22.8%	10.5%
50%	9.0%	3.5%	17.7%	11.0%	13.6%	*	**	*	32.3%	23.6%	10.8%

prepared on 1/15/98 - emission rates based on revised 12/8/97 CFA Matrix Models

** outside the tested range

The New CFA Open Molding Emissions Model

"AP-42 Emissions Calculations"

The CFA Styrene Emissions Test Project has produced the most comprehensive body of information on emissions from open molding. During the course of the project, we identified four types of variables, which affect the measurement process, or the determination of emissions:

1. Variables that influenced the testing accuracy, such as capture efficiency, background emissions, stack airflow fluctuations and skill with the instrumentation calibration. We took extensive steps to control these variables in our study. Because it's unlikely that these factors can be controlled in actual in-plant stack tests, an emissions determination model will produce more accurate results than stack tests performed under less rigorous conditions.
2. Variables that influenced emissions but can't practically be used as part of an overall emissions determination. This includes gel time, laminate thickness, ambient air temperature and material flow rate. These variables were measured in great detail, and are encapsulated within the emissions model in the form of averages. These averages produce accurate results for an overall estimation of emissions.
3. Variables that influence emissions, can be measured, are part of the model, but are not widely useful as "controls." Resin styrene content is an example of a model variable, which is not necessarily a "control factor". In some cases, styrene content may be modified to reduce emissions. In other cases, it can. only be manipulated in a very narrow range and is a limited control.
4. Variables that are used in the model explicitly as controls such as suppressants, controlled spray, and non-atomized application. Unlike styrene content, these are widely employed to reduce emissions, but of course have certain limitations.

The Problem with Stack Measurements

A search of published literature and review of test data reveals that in-plant stack measurements probably have a best case accuracy of ±20%. In certain cases, the results may be (100% actual emissions. Because of this, stack testing is considered a relatively inaccurate method of determining styrene emissions, unless

By Bob Lacovara
Composites Fabricators Association

performed using the most rigorous test methods, and under the most favorable conditions. It is unlikely these conditions can be arranged for most on-site testing. In addition, stack testing is usually a 'snapshot" of a given set of parameters, taken over a relatively short time. These conditions may or may not be representative of overall conditions. Stack testing is expensive, requires specialized skills, a detailed understanding of the industry, and may not produce an accurate overall assessment of emissions.

Mathematically Speaking

A primary result of the CFA Emissions Test Project has been the development of a Styrene Emissions Model for open molding. The model is an arithmetic statement of the influence of the process variables, like application technique and styrene content, on the resulting emissions. For example, emissions from a spray lay-up operation are given by the equation shown in figure 1.

Process Variable Factors

The open molding models are comprised of a number of variables, which contribute to and influence emissions from the molding process. Nine possible variables could be considered in the models, however the CFA emissions model uses four variables. These four variables encompass and encapsulate all the variables in the open molding process in a way that is adaptable to both regulatory considerations, and is accurate over a wide range of operations and conditions. This discussion details model variables that are included

Calculating Your Emissions

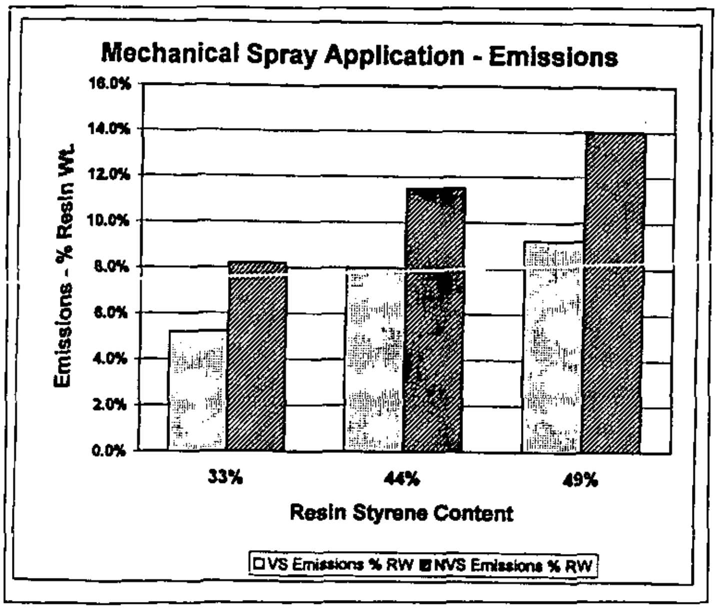
For over a decade the composites industry has used EPA AP-42 emission factors to calculate styrene emissions. In April 1998 the "old" AP-42 open molding emissions factors were withdrawn by the EPA EMAD Division. The revised AP-42 for open molding is the CFA Emissions Model (located on CFA's website, www.cfa-hq.org). This model has been published on the EPA CHIEF website, and has been accepted as the best available information.

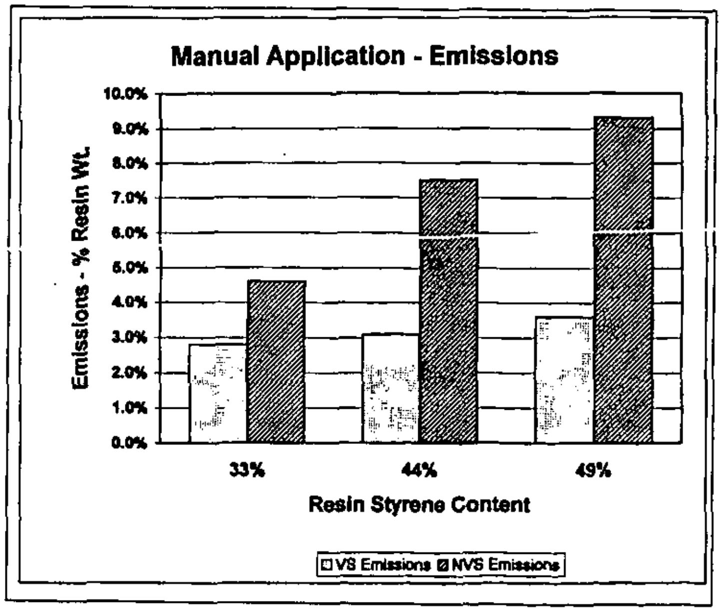
EPA Region IV, in an action inconsistent with the Federal EPA, has released an emissions model based on misappropriated CFA data. This model is seriously flawed, both mathematically, and from the lack of understanding of practical model variables. *It is not recommended that the Region IV model be used by the composites industry or other regulatory agencies.*

The open molding composites industry is encouraged to use the new Federal EPA AP-42 model (CFA Model) for the most accurate results.

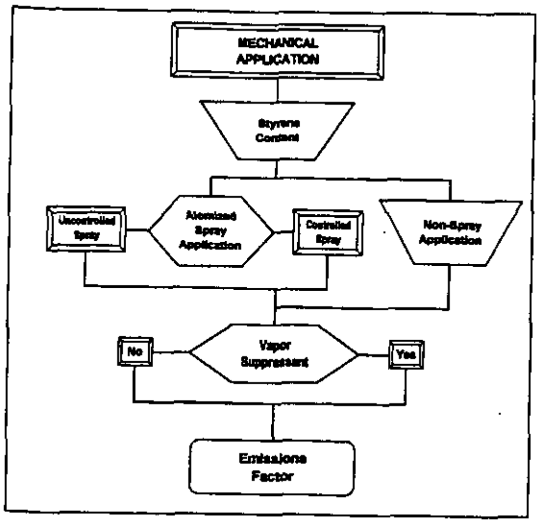
Figure 1.

Emission Rate = Resin Usage x (0.00714 x % styrene - 0.180)
x [Suppressant Factor 1.00 <or> 0.62]
x [Controlled Spray Factor 1.00 <or> 0.77]
<or> [Non-spray Factor 1.00 <or> 0.51]





Emissions Model Variables



Mechanical Resin Application:
Uncontrolled Spraying *- No spray gun pressure calibration, no mold containment flanges, no specific operator training. Please note: Spray application is atomized fluid delivery only.*
Controlled Spraying *- Spray gun pressure gun calibration verified, mold containment flanges in place, and operator training documented as outlined in the CFA Controlled Spraying handbook. All three elements must be in place and documented to quality as Controlled Spray Application.*
Non-Atomized Application *- Includes flow coaters, flow choppers, pressure fed rollers, or other non-spray applications. Please note: flow coaters and flow choppers are considered non-spray application methods*

and excluded in the CFA model.

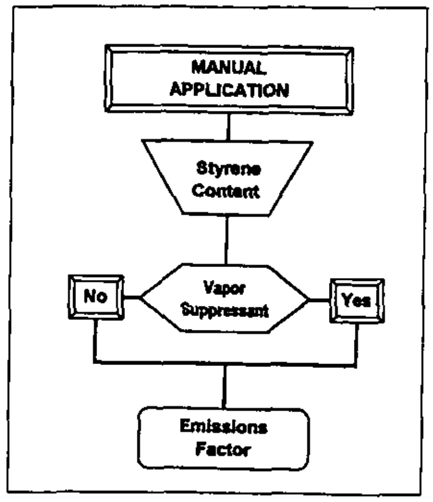
CFA Model Variables

Styrene Content

Open molding emissions are influenced by resin styrene content. However, styrene content is a limited control factor. In many cases, resin styrene content can only be manipulated within a limited range, in order to produce a finished product with properties suitable for the intended purpose. For example, corrosion resistant products may require a high molecular weight resin with very specific chemical and physical properties. High molecular

Positive Aspects	Factor	Negative Aspects
Lower styrene % = lower emissions	**STYRENE CONTENT**	*Styrene is a limited control factor. Range of styrene content is dictated by resin formulation, which is dictated by end use properties. Low styrene resins may be more difficult to use.*
Controlled spraying = lower emissions	**CONTROLLED SPRAYING**	*No negative aspects- can be used in all spray applications.*
Non-spray = lower emissions	**NON-SPRAY APPLICATION**	*Non-spray application may not be suitable for all production requirements or product configurations.*
Vapor suppressants = lower emissions	**VAPOR SUPPRESSANTS**	*Vapor suppressants may cause secondary bonding problems and cannot be used in certain types of products or laminate configurations.*
Thicker laminates = lower emissions	**LAMINATE THICKNESS**	*Laminate thickness and laminate sequence is determined by product and production requirements. Thickness cannot be used as a regulatory control.*
Lower temperature = lower emissions (within a limited temperature range-if same gel time is in place)	**AMBIENT TEMPERATURE**	*Temperature is a limited facility control, particularly in hot weather where ambient temperature is above 70°F. Temperature cannot be used as a regulatory control.*
Shorter gel time = lower emissions	**GEL TIME**	*Gel time is predicated on required working time, laminate thickness, and shop temperature. Gel time cannot be used as a regulatory control.*
Higher flow rates = lower emissions	**MATERIAL FLOW RATE**	*Material flow rates are dictated by operator ability to handle material. Material flow rate cannot be used as a regulatory control.*
Airflow has no effect on emissions	**AIRFLOW**	*Airflow has no effect on Emissions.*

Emissions Model Variables



Manual Resin Application
Manual Resin Application *- Bucket and tool application, with resin being hand mixed in a container and manually applied to the laminate with brush, paint roller, or other tool.*

Mechanical Application Model

The same model in the CFA Excel spreadsheet version is easy to use and requires no calculations on the part of the user.

1	Current Monomer Content	40.0%
2	New Monomer Content	35.0%
3	Vapor Suppressant (Y or N)	N
4	Controlled Spray (Y or N)	Y
5	Non-Atomized Application (Y or N)	N
6	% Add-on Control	0%
	Current Emission Factor (lb/ton)	211
	Current Emission Factor (% resin)	10.6%
	New Emission Factor (lb/ton)	108
	New Emission Factor (% resin)	5.4%

weight resins typically require a higher styrene level than general-purpose resins.

Because of this, the range of acceptable styrene content may vary, according to the specific resin formulation, and the required end-use properties of the finished product. While styrene content is a contributing factor to overall styrene emissions, styrene content limitations are strictly a function of the requirements of specific resin formulations. These formulations are driven by finished product property requirements. The result of this is that low styrene resins can be used in some applications, and are not acceptable for others. Therefore, styrene content is a limited control factor, and not an acceptable regulatory control limitation.

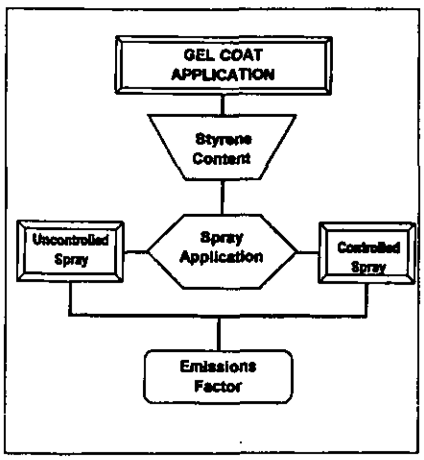
Controlled Spraying

Controlled Spraying is a method to increase transfer efficiency in atomized spray application. Surface area is a major factor in styrene emissions. Atomized spray application contributes to increased surface area in two ways: First, a higher the level of atomization results in greater the surface area from the spray fan pattern. Second, overspray (off-mold spray) contributes to increased surface area. The goal of controlled spraying is to minimize surface area by reducing atomization and overspray.

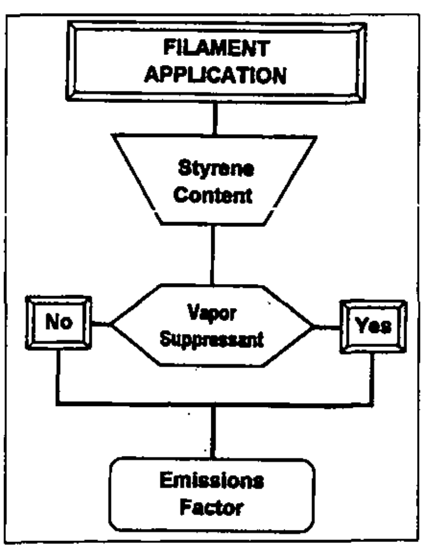
Controlled spraying consists of three elements which

("Emissions Model..." continued on p. 16)

Emissions Model Variables



Gel Coat Application:
Gel Coat Application *- The application of gel coat products using atomized spray with controlled or uncontrolled application method.*



Filament Winding:
Filament Winding *- The wet wrapping of a continuous filament around a mandrel.*

Non-atomizing mechanical application consists of flow applicators (flow choppers), pressure fed rollers or other mechanical fluid delivery systems, which do not atomize the fluid stream.

("Emissions Model..." continued from 16)

function together to increase transfer efficiency:

Spray Gun Pressure Calibration — Provides a procedure to determine the minimum fluid tip pressure for any combination of spray equipment, materials or conditions.

Operator Training — Spraying technique influences transfer efficiency. An operator training program outlines methods for spray gun handling and application techniques focused on reducing overspray and therefore increasing transfer efficiency.

Overspray Containment Flanges — Overspray can be reduced with mold perimeter flanges that limit "off-spray" from the edge of the mold. These flanges can be built into the mold, or consist of removable masking around the perimeter.

Controlled spraying can be used in all cases where atomized spray application takes place. In order to qualify for controlled spraying, all three of the above elements must be in place and documented, as outlined in the CFA Controlled Spraying Handbook.

Non-Atomizing Mechanical Application

Non-atomizing mechanical application consists of flow applicators (flow choppers), pressure fed rollers or other mechanical fluid delivery systems, which do not atomize the fluid stream. While flow applicators and pressure-fed rollers can be used in a wide range of production settings, they are not a universal substitute for atomized spray application. In specific cases, where "chop" must be projected over a distance to reach the mold surface, or with certain deep draw mold geometry, flow applicators may not be feasible. In the case of pressure-fed rollers, the process entails the use of roll stock reinforcements (fiberglass reinforcements), which are saturated with resin by roller application. This process is not a substitute, or control, for the spray-up (chopping) process due to technical production and economic considerations. Gel coat products require atomized spray application and cannot be successfully applied with flow applicators at this time.

Vapor Suppressants

The use of vapor suppressants is an effective styrene emissions reduction technique. However, vapor suppressants cannot be used in all applications due to inherent secondary bonding problems. Suppressants form a film, which inhibits styrene evaporation, on the surface of a curing laminate. This film may decrease adhesion of subsequent laminates, causing the structural integrity of the laminate may be compromised. In critical applications, such as tanks or other load bearing structures, a laminate bond failure can lead to a catastrophic failure of the structure. Vapor suppressants can be successfully used where secondary bonding is not an issue. Vapor suppressants cannot be used with gel coat application.

Variables Which Are Not Emissions Modeling Factors

There are a number of factors, which influence styrene emissions, but are not viable control factors for calculating emissions quantities.

Laminate Thickness

Thicker laminates produce fewer emissions per weight of resin as compared to thinner laminates. However, laminate thickness is a function of the requirement of the finished product, and not subject to regulatory control. In addition, in cases where multiple laminates are applied, the thickness and sequence of the laminate application is a function of the material/production process interaction.

Emissions calculations based on laminate thickness become convoluted with the consideration of exactly what "thickness" implies. For example, a .250" thick laminate could consist of two separate plies .125" thick, or four separate plies .062" thick. The emissions for two or four individual plies will vary. Even within a single molded product, the laminate thickness may vary from area to area. Because of this, even determining "thickness" on a specific product is complicated, to the point of excluding usefulness as a control factor. The CFA emissions factors are based on laminates of .040" and .080", which leads to an environmentally conservative estimate of emissions.

Ambient Temperature

In open molding resin and gel coat curing is influenced by process and ambient environmental temperatures. Temperature, however, is not a useful control or emissions calculation factor, because of a wide range of variability in operating temperature ranges. One confounding aspect of temperature is that although styrene may evaporate at a higher rate as temperature increases, gel time decreases at the same time. A shorter gel time reduces emissions. It is difficult to determine the effect of ambient temperature on laminates of varied thickness because of the effect of laminate mass on gel time. Thicker laminates exhibit higher exotherm, which interacts with ambient temperature to modify the cure profile of the laminate. In a practical sense, the temperature in a molding operation can also vary through out the workday. For example, in certain areas of the country, the shop temperature may be 50°F at the start of the day shift, and increase to 100°F by the end of the day. CFA emissions factors are based on an average temperature of 70°F, which represents an average processing tempera-

("Emissions Model..." continued on p. 19)

The CFA Emissions Model is available in a user friendly spreadsheet form, complete with instructions, definitions, and "what-if" worksheets to allow you to compare process and materials changes.

("Emissions Model..." continued from 17)

ture over the course of a year. In the long term emissions will fall within the average range, therefore variable temperature is not a useful control factor in emissions calculations.

Gel Time

Resin gel time is another emissions influencing factor, which is not useful as an emissions *control* factor. Resin gel time specifications are typically based on a 100 gram mass of resin, which is cured with a specified quantity of initiator. Resin mass has a major influence on gel time. Therefore, the gel time in a 100 gram beaker mass and the same 100 grams in a laminate may vary considerably. During the process gel time is influenced by ambient temperature, initiator level and laminate thickness. All of these factors may vary during the daily course of production, or within an individual molded part. In addition, measuring actual laminate gel time is very subjective, with no standardized test available.

Material Flow Rate

In the case of atomized spray application, spray gun flow rate may influence emissions. Higher flow rates (faster material application) result in lower emissions due to shortening the ìtransfer stage" of resin application. However, flow rate is adjusted according to on the size and configuration of the product being molded. Within a facility, many different spray gun flow rates may be used, and the flow rate may be varied during individual molding operations. CFA emissions factors are based on a range of typical flow rates used across the industry. Material flow rates are not an applicable emissions control factor.

Airflow Over Mold

During the course of extensive emissions testing, it has been determined that airflow rates between 50-100 fpm across the mold surface have no influence on styrene emissions. This represents the typical range of airflow found across the industry. Airflow is neither an influencing factor nor an emissions control factor.

The CFA Emissions Model

The CFA Open Molding Emissions Model is the result of a comprehensive multi-year study, which has quantified styrene emissions in great depth. While the model is based on four emissions variable factors, *it encompasses all of the influencing factors.* These factors are taken into consideration by incorporating a range of testing parameters, which encapsulate a vast majority of conditions, materials and processing techniques found across the open molding industry. Although emissions may vary from a highly specific ìsnapshot" of conditions in a precise moment, overall facility emissions using a typical range of parameters will be very accurate. Because of inaccuracies involved in actual stack testing, the CFA emissions model offers the most accurate quantification of emissions from the open molding process available.

The User Friendly Version

The CFA Emissions Model is available in a user friendly spreadsheet form, complete with instructions, definitions, and "what-if" worksheets to allow you to compare process and materials changes. The model is packaged as a Microsoft Excel 97 spreadsheet template, or is available with an included runtime version of Excel. You may obtain a copy of the "CFA Open Molding Emissions Model" for a $6.00 handling and shipping charge, by contacting CFA Headquarters at (703)-525-0511 or send request to: CFA, 1655 N. Ft. Myer Dr., Arlington, VA 22209. ☆

Bob Lacovara is Director of Technical Affairs for the Composites Fabricators Association

Benchmarking Program **Emissions Calculations**

Subsequent to the last Benchmarking survey there have been changes to the classification of acetone emissions, and revisions to styrene emissions factors based on the latest test data. Although acetone is no longer listed, or required to be reported, as a VOC, it is helpful to understand the use of acetone for the purposes of Benchmarking. The calculation for solvent emissions is the same as in previous years.

As a result of recently completed emissions testing projects, styrene emissions factors have undergone significant changes. The following Styrene Emissions Factors Table is the result of comprehensive tests, which have provided, for the first time, an accurate assessment of styrene emissions. This emissions factor table should be used to calculate emissions both for this Benchmarking Survey and for regulatory reporting.

To: Ron R

541-0684

Calculating Volatile Solvent Emissions *(Acetone or other volatile solvents)*

(Beginning year inventory + Quantity purchased) – (End of year inventory + Waste disposed) = Yearly Emissions

Example:

(B+Q) – (E+W) = Yearly Emissions

(B) Beginning year inventory = 2,000 lbs

(Q) Quantity purchased = 24,000 lbs

(E) End of year inventory = 1,000 lbs

(W) Waste disposed = 3,500 lbs

(2,000 + 24,000) – (1,000 + 3,500) = Lbs Solvent Emissions

26,000 – 4,500 = 21,500 Lbs. Solvent Emissions

Calculating Styrene Emissions

Changes in Emissions Calculations: Styrene emissions must be calculated using the best available data. The result of comprehensive emissions testing is a revision of previous emissions factors. These revised factors will become the new AP-42 emisions standards. Please note that the new factors are expressed in emissions % per resin weight, as compared to the old method, which used factors of emisions per available styrene. These new factors do not reflect an actual change in pounds of styrene emitted, but apply the new and more accurate calculations to current and previous emissions.

Styrene Emissions Factor Table

For Open Molding Operations—Revision 3.0 July 1998 • (Styrene Emission Factors Listed as % of Resin Weight)

Resin or Gel Coat Styrene Content % WT.	Manual Resin Application: Bucket & Tool		Mechanical Resin Application: Uncontrolled Spray		Mechanical Resin Application: Controlled Spray		Mechanical Resin Application: Non-Atomized Application		Gel Coat Application: Uncontrolled Spray	Gel Coat Application: Controlled Spray	Filament Winding	
	Non-Vapor Suppressed	Vapor Suppressed	Non-Vapor Suppressed	Vapor Suppressed	Non-Vapor Suppressed	Vapor Suppressed	Non-Vapor Suppressed	Vapor Suppressed			Non-Vapor Suppressed	Vapor Suppressed
33%	4.1%	2.8%	5.6%	3.4%	4.3%	2.7%	2.8%	1.8%	14.7%	10.7%	6.1%	4.0%
34%	4.4%	2.8%	6.3%	3.9%	4.8%	3.0%	3.2%	2.0%	15.7%	11.5%	6.4%	4.1%
35%	4.7%	2.9%	7.0%	4.3%	5.4%	3.3%	3.6%	2.2%	16.8%	12.2%	6.6%	4.3%
36%	5.0%	2.9%	7.7%	4.8%	5.9%	3.7%	3.9%	2.4%	17.8%	13.0%	6.9%	4.5%
37%	5.3%	2.9%	8.4%	5.2%	6.5%	4.0%	4.3%	2.7%	18.8%	13.7%	7.2%	4.7%
38%	5.6%	3.0%	9.1%	5.7%	7.0%	4.4%	4.7%	2.9%	19.9%	14.5%	7.5%	4.8%
39%	5.9%	3.0%	9.8%	6.1%	7.6%	4.7%	5.0%	3.1%	20.9%	15.3%	7.7%	5.0%
40%	6.2%	3.1%	10.6%	6.5%	8.1%	5.0%	5.4%	3.3%	21.9%	16.0%	8.0%	5.2%
41%	6.4%	3.1%	11.3%	7.0%	8.7%	5.4%	5.7%	3.6%	33.0%	16.8%	8.3%	5.4%
42%	6.7%	3.2%	12.0%	7.4%	9.2%	5.7%	6.1%	3.8%	24.0%	17.5%	8.6%	5.6%
43%	7.0%	3.2%	12.7%	7.9%	9.8%	6.1%	6.5%	4.0%	25.0%	18.3%	8.8%	5.7%
44%	7.3%	3.3%	13.4%	8.3%	10.3%	6.4%	6.8%	4.2%	26.1%	19.0%	9.1%	5.9%
45%	7.6%	3.3%	14.1%	8.8%	10.9%	6.7%	7.2%	4.5%	27.1%	19.8%	9.4%	6.1%
46%	7.9%	3.3%	14.8%	9.2%	11.4%	7.1%	7.6%	4.7%	28.2%	20.6%	9.7%	6.3%
47%	8.2%	3.4%	15.6%	9.6%	12.0%	7.4%	7.9%	4.9%	29.2%	21.3%	9.9%	6.5%
48%	8.4%	3.4%	16.3%	10.1%	12.5%	7.8%	8.3%	5.1%	30.2%	22.1%	10.2%	6.6%
49%	8.7%	3.5%	17.0%	10.5%	13.1%	8.1%	8.7%	5.4%	31.3%	22.8%	10.5%	6.8%
50%	9.0%	3.5%	17.7%	11.0%	13.6%	8.4%	9.0%	5.6%	32.3%	23.6%	10.8%	7.0%

Percentage Emission
1. Select resin styrene content (% weight styrene monomer)
2. Select application method
3. Select Non-Vapor Suppressed or Vapor Suppressed
4. Find factor in table

Example:
Resin styrene content = 40%
Mechanical Application/Controlled Spray
Non-Vapor Suppressed
Emissions factor = 8.1% of Resin weight

Emissions calculation—
Resin weight X Emissions factor = Emissions weight

Example: 1000 lbs. Resin X 8.1% Emissions factor = 81 lbs. Emissions

Benchmarking Program Emissions Calculations

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26,000 – 4,500 = 21,500 Lbs. Solvent Emissions

541 5689

Calculating Styrene Emissions

Changes in Emissions Calculations: Styrene emissions must be calculated using the best available data. The result of comprehensive emissions testing is a revision of previous emissions factors. These revised factors will become the new AP-42 emisions standards. Please note that the new factors are expressed in emissions % per resin weight, as compared to the old method, which used factors of emisions per available styrene. These new factors do not reflect an actual change in pounds of styrene emitted, but apply the new and more accurate calculations to current and previous emissions.

Styrene Emissions Factor Table

For Open Molding Operations—Revision 3.0 July 1998 • (Styrene Emission Factors Listed as % of Resin Weight)

Resin or Gel Coat Styrene Content % WT.	Manual Resin Application		Mechanical Resin Application						Gel Coat Application		Filament Winding	
	Bucket & Tool		Uncontrolled Spray		Controlled Spray		Non-Atomized Application		Uncontrolled Spray	Controlled Spray		
	Non-Vapor Suppressed	Vapor Suppressed	Non-Vapor Suppressed	Vapor Suppressed	Non-Vapor Suppressed	Vapor Suppressed	Non-Vapor Suppressed	Vapor Suppressed			Non-Vapor Suppressed	Vapor Suppressed
33%	4.1%	2.8%	5.6%	3.4%	4.3%	2.7%	2.8%	1.8%	14.7%	10.7%	6.1%	4.0%
34%	4.4%	2.8%	6.3%	3.9%	4.8%	3.0%	3.2%	2.0%	15.7%	11.5%	6.4%	4.1%
35%	4.7%	2.9%	7.0%	4.3%	5.4%	3.3%	3.6%	2.2%	16.8%	12.2%	6.6%	4.3%
36%	5.0%	2.9%	7.7%	4.8%	5.9%	3.7%	3.9%	2.4%	17.8%	13.0%	6.9%	4.5%
37%	5.3%	2.9%	8.4%	5.2%	6.5%	4.0%	4.3%	2.7%	18.8%	13.7%	7.2%	4.7%
38%	5.6%	3.0%	9.1%	5.7%	7.0%	4.4%	4.7%	2.9%	19.9%	14.5%	7.5%	4.8%
39%	5.9%	3.0%	9.8%	6.1%	7.6%	4.7%	5.0%	3.1%	20.9%	15.3%	7.7%	5.0%
40%	6.2%	3.1%	10.6%	6.5%	8.1%	5.0%	5.4%	3.3%	21.9%	16.0%	8.0%	5.2%
41%	6.4%	3.1%	11.3%	7.0%	8.7%	5.4%	5.7%	3.6%	33.0%	16.8%	8.3%	5.4%
42%	6.7%	3.2%	12.0%	7.4%	9.2%	5.7%	6.1%	3.8%	24.0%	17.5%	8.6%	5.6%
43%	7.0%	3.2%	12.7%	7.9%	9.8%	6.1%	6.5%	4.0%	25.0%	18.3%	8.8%	5.7%
44%	7.3%	3.3%	13.4%	8.3%	10.3%	6.4%	6.8%	4.2%	26.1%	19.0%	9.1%	5.9%
45%	7.6%	3.3%	14.1%	8.8%	10.9%	6.7%	7.2%	4.5%	27.1%	19.8%	9.4%	6.1%
46%	7.9%	3.3%	14.8%	9.2%	11.4%	7.1%	7.6%	4.7%	28.2%	20.6%	9.7%	6.3%
47%	8.2%	3.4%	15.6%	9.6%	12.0%	7.4%	7.9%	4.9%	29.2%	21.3%	9.9%	6.5%
48%	8.4%	3.4%	16.3%	10.1%	12.5%	7.8%	8.3%	5.1%	30.2%	22.1%	10.2%	6.6%
49%	8.7%	3.5%	17.0%	10.5%	13.1%	8.1%	8.7%	5.4%	31.3%	22.8%	10.5%	6.8%
50%	9.0%	3.5%	17.7%	11.0%	13.6%	8.4%	9.0%	5.6%	32.3%	23.6%	10.8%	7.0%

Percentage Emission
1. Select resin styrene content (% weight styrene monomer)
2. Select application method
3. Select *Non-Vapor Suppressed or Vapor Suppressed*
4. Find factor in table

Example:
Resin styrene content = 40%
Mechanical Application/Controlled Spray
Non-Vapor Suppressed
Emissions factor = 8.1% of Resin weight

Emissions calculation—
Resin weight X Emissions factor = *Emissions weight*

Example: 1000 lbs. Resin X 8.1% Emissions factor = 81 lbs. Emissions

NORTH CAROLINA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF AIR QUALITY

NCDENR

JAMES B. HUNT JR.
GOVERNOR

WAYNE MCDEVITT
SECRETARY

ALAN W. KLIMEK, P.E.
DIRECTOR

November 30, 1998

P

Mr. John McKnight, Director
Environmental Safety and Compliance
National Marine Manufacturers Association
1819 L Street, N.W., Suite 700
Washington, D.C. 20036

SUBJECT: Interim Emission Estimating Procedures for Fiberglass Boat Manufacturing

Dear Mr. McKnight:

This letter is pursuant to your letter of October 29, 1998 to Alan Klimek regarding the review of the Environmental Protection Agency's (EPA) Office of Research and Development (ORD) Fiberglass Reinforced Plastics (FRP) Emission Factor Model.

The North Carolina Division of Air Quality (DAQ) holds each facility responsible for the accuracy and reliability of their emission estimates and requires use of the currently "best available information." Sometimes this will include requirements for testing. We recognize that individual facilities may have site-specific conditions which could cause estimates based on generalized emission factors or models to be too high or too low. Accordingly, until such time as initial facility design parameters are firmed up and the facility is operational and perhaps tested, there will be continued uncertainties as to the validity of emission estimates.

The North Carolina DAQ also recognizes the obligation to provide insights on what DAQ considers acceptable for estimating procedures when we review permit or subsequent inventory submittals. Consequently, our internal review team for these processes has concluded that information contained in, or derived from, the NMMA reports indicated in your letter (namely 12% for Resin - Hand Lay-up; 21% for Resin - Spray Lay-up; and 50% for Gel Coat) are reasonable and adequately conservative for boat manufacturers in NC to use for consistency among facilities, and have so advised operators in North Carolina. We also recognize that judgement and common sense are needed for the determination of when a specific factor and/or testing is appropriate for a specific facility's operations.

Guidance from Region 4 of EPA (Mr. Douglas Neeley) indicates that an additional estimate based on the ORD "FRP" computer model should be provided for comparison, and we have so advised the facilities. From our limited observations, we believe the emission estimates generated using the aforementioned NMMA emission factor values will generally be sufficiently conservative. For that reason, using the NMMA values is our preferred approach at this time for making judgements and decisions. We expect no substantial changes or refinements to this information in the near term (though EPA's Office of Air Quality Planning and Standards continues to get feedback and work on revising the national AP-42 guidance document), and therefore, see no reason that we would not generally accept the NMMA information as the "best available" for review of permit applications and emission inventories for the time being.

PLANNING SECTION
P.O. BOX 29580, RALEIGH NC 27626-0580 / 2728 CAPITAL BLVD., RALEIGH NC 27604
PHONE 919-715-7670 FAX 919-715-7476 WWW.EHNR.STATE.NC.US/EHNR/

For future applications/modifications and subsequent inventories, site-specific testing may be appropriate, unless our knowledge of these emissions is otherwise improved.

DAQ has also similarly encouraged facilities to use the Composite Fabricators Association (CFA) model where appropriate, and to communicate with CFA regarding to changes in those related materials and processes. Many of these facilities use open molding techniques to produce sinks, tubs, and spas.

We continue to encourage all facilities to increase their understanding of emissions as pertain to: 1) the facility's manufacturing processes (including operational constraints); and 2) available emission control techniques (such as vapor-suppressed resins and controlled spraying techniques). It is our intention to assist all facilities to reduce their Hazardous Air Pollutant (HAP) and Volatile Organic Compound (VOC) emission rates and to prepare for any future regulations (such as MACT standards).

I hope this information is responsive to your questions. We will continue to review the FRP model and other information available and are eager to improve the integrity of any emission estimates. We will continue to supply USEPA Region 4 and the companies represented by your organization with any new information and/or conclusions that we reach. Do not hesitate to contact Jim Southerland, chair of the internal review task force (919 715-7566), or another member of that task force, if you have any further questions or need additional information.

Sincerely,

B. Keith Overcash, P.E.
Deputy Director

cc: Laura S. Butler, Chief, Permits Section
R. Douglas Neeley, USEPA Region 4
Regional Emission Inventory Contacts
Fiberglass Emissions Estimation Task Force Members
Mike Aldridge, Chief, Stationary Sources Branch

D H E C

PROMOTE PROTECT PROSPER

2600 Bull Street
Columbia, SC 29201-1708

November 19, 1998

Mr. John McKnight
Environmental and State Compliance
National Marine Manufacturers Association
1819 L St., N.W.
Suite 700
Washington, D.C. 20036

Re: ORD Model Concerns

Dear Mr.McNight:

On October 29, 1998, you wrote a letter to our Bureau expressing concerns about recent guidance that we received from the Environmental Protection Agency (EPA) Region IV office. After reviewing the information you provided and contacting the EPA to follow-up on this issue we would like to provide you with the following response to your concerns.

While our program has received delegation to implement many of the provisions of the Federal clean Air Act, the EPA has primary responsibility for the development and approval of industry-wide emission factors such as those contained in EPA's *A Compilation of Air Pollutant Emission factors* (AP-42). Mr. Bob Betterton, manager of the Emissions Inventory Section called Mr. Ron Ryan at EPA's Office of Air Quality Planning and Standards (OAQPS) concerning the issues that you raised. Earlier this year the OAQPS discovered that the existing emission factors in AP-42 underestimated boat manufacturing emissions and pulled the emission factors. They were concerned that improper permit decisions would be made based on these incorrect factors.

Mr. Ryan also discussed the emission factors that your organization (National Marine Manufactures Association (NMMA)) developed through stack tests conducted at a Washington state boat manufacturer facility that were observed by EPA staff. While we understand that the test on the facility itself was fine there were several concerns expressed by the EPA about the representativeness of this data for the boat manufacturing industry. First, the facility tested was relatively high-tech. It had a boat rotator that allowed direct spraying with little overspray. However, many boat manufacturing facilities do not have this type of equipment and workers often have to get up on a ladder and on hands and knees to spray - resulting in a considerable amount of additional overspray than the tested facility. Second, the temperature in Washington state is on average considerably cooler than many other parts of the country. This would have a significant impact on underestimating emission rate estimates, especially in much warmer states such as South Carolina. A third concern was that the test did a high styrene and a low styrene test as well as a big hull and a small hull test. There were no mid points. Like the EPA, we also are concerned because of the above issues that this data would not properly reflect emissions at all fiberglass boat manufacturing. It is our understanding that the EPA's model developed by the Office of Research and Development (ORD) accounts for many of these variables/concerns.

We also understand that the ORD and NMMA results may agree pretty closely in some cases as far as emissions are concerned. But the critical issue is to use the best method for determining when MACT applies for a specific boat manufacturing facility and determining appropriate thresholds for the Title V permitting program. The ORD model was specifically developed to help States make MACT determinations for the boat building industry.

While we are sympathetic to your concerns, because of the reasons noted above, we are supportive of the September 16, 1998, memo from EPA Region IV. Facilities are not precluded from providing site specific emissions data if they believe that the ORD model estimates are not reflective of their actual emissions. It is also our understanding that the EPA is in the process of revising the emission factors for this industry. We suggest that you contact Mr. Rob Ryan EPA OAQPS, since he is heading up this effort. He can be reached at the following address:

Ron Ryan
U.S. EPA (MD-14)
RTP, NC 27711
Phone - (919) 541-4330
FAX - (919) 541-0684
EMAIL - ryan.ron@epamail.epa.gov

Please advise if I can be of any further assistance ((803) 734-4475).

Sincerely,

John E. Hursey

John E. Hursey, Director
Program Development and Support Division
Bureau of Air Quality

cc: James A. Joy, III, SC DHEC
Bob Betterton, SC DHEC
Winston Smith, EPA Region IV
Doug Neeley, EPA Region IV
✓Ron Ryan, EPA OAQPS

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2600 Bull Street
Columbia, SC 29201-1708

David — FYI.
EPA still needs
someone to make
MACT determinations, or
else we need to
make sure states know
its their responsibility.

November 19, 1998

Mr. John McKnight
Environmental and State Compliance
National Marine Manufacturers Association
1819 L St., N.W.
Suite 700
Washington, D.C. 20036

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We also understand that the ORD and NMMA results may agree pretty closely in some cases as far as emissions are concerned. But the critical issue is to use the best method for determining when MACT applies for a specific boat manufacturing facility and determining appropriate thresholds for the Title V permitting program. The ORD model was specifically developed to help States make MACT determinations for the boat building industry. ?

While we are sympathetic to your concerns, because of the reasons noted above, we are supportive of the September 16, 1998, memo from EPA Region IV. Facilities are not precluded from providing site specific emissions data if they believe that the ORD model estimates are not reflective of their actual emissions. It is also our understanding that the EPA is in the process of revising the emission factors for this industry. We suggest that you contact Mr. Rob Ryan EPA OAQPS, since he is heading up this effort. He can be reached at the following address:

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Phone - (919) 541-4330
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EMAIL - ryan.ron@epamail.epa.gov

Please advise if I can be of any further assistance ((803) 734-4475).

Sincerely,

John E. Hursey

John E. Hursey, Director
Program Development and Support Division
Bureau of Air Quality

cc: James A. Joy, III, SC DHEC
Bob Betterton, SC DHEC
Winston Smith, EPA Region IV
Doug Neeley, EPA Region IV
✓ Ron Ryan, EPA OAQPS

FROM : SC DHEC AIR QUALITY 8037342851 1998,11-12 12:26 #203 P.01/02

[redacted]

Post-it® Fax Note 7671	Date 11/12/98 # of pages ▶ 2
To Ron Ryan	From Bob Betterton
Co./Dept. EFIG	Co. BAQ, SC DHEC
Phone #	Phone # (803) 734-4549
Fax # (919) 541-0684	Fax #

(Suggest quick look @ letter as FYI)

John —
(Once you & staff get a chance to look let's discuss whether response is needed) Thx
TG

Natio
Ma
Manufactu
Associa

1819 L ST., N.W. • SUITE 700 • WASHINGTON, D.C. 20036 • (202) 861-1180 • FAX (202) 861-1181

October 29, 1998

Mr. James A. Joy, III
Bureau of Air Quality
SC Dept. of Health and Environmental Control
2600 Bull St.
Columbia, SC 29201

RECEIVED
NOV 02 1998
BUREAU OF
AIR QUALITY

RE: Boat builders Review of EPA ORD FRP Emission Factor Model

Dear Mr. Joy, III:

The National Marine Manufacturers Association (NMMA) has serious concerns regarding the applicability and enforceability of the recent Fiberglass Reinforced Plastic (FRP) styrene emission factor guidance that your office has received from EPA Region IV. NMMA has provided both EPA Region IV and the EPA Emission Monitoring Division with comments on this emission factor model developed by the Office of Research and Development (ORD) in collaboration with Research Triangle Institute (RTI). This FRP Model (version 1.0, 1998) is a research tool that attempts to provide a multi-variable model for estimating emissions of styrene from fiberglass manufacturing operations.

The bottom line is that this model does not adequately reflect the best available data. In particular, NMMA believes that the best available data for the boat manufacturing industry were generated in its EPA funded study conducted in 1997. The data specific to this industry, generated under actual operational conditions in a boat manufacturing plant, are the most representative for this industry. NMMA believes that our data should be used for boat manufacturing plants, as it is more representative of our industry practices and emissions than a model that attempts to characterize any and all fiberglass manufacturing operations.

Further, NMMA finds that the model as developed is not a valid for estimating emission factors. We believe that it is a tool to assess the relative effects of various parameters on an emission factor. However, it is not a true multi-variable model, taking into account the interactions of these parameters on the emission factors. This is vividly seen in the limitations of the model where parameters can be selected which result in estimated emission factors greater than 100 percent of the available styrene in the resin. Finally, NMMA does not believe that sufficient data exist to generate a reliable multi-variable model at this time.

NMMA has detailed comments on the model and its development in the enclosure. NMMA has also provided these comments to EPA Region IV in an effort to educate them as to the problems associated with using a multi-factor model for determining emissions. It has been over two

NMMA

months since these comments were sent to EPA Region IV. It is NMMA's hope that these comments will highlight the obvious problems with this model and spur a concerted effort to provide the boat building industry with updated emission factors based on representative data. We would be happy to discuss these comments with you or your staff and following your review we encourage and would greatly appreciate it if you could express your concerns with either Winston Smith, Doug Neeley, or Leonardo Ceron, EPA Region IV. Please feel free to call me at 202-721-1604.

Sincerely,

John McKnight

John McKnight, Director
Environmental and Safety Compliance

enclosures (2) - NMMA comments
EPA Region IV letter to state air offices

cc: Winston Smith, EPA Region IV
Doug Neeley, EPA Region IV
Leonardo Ceron, EPA Region IV
Robert Manning, Hopping, Green, Sams, & Smith
National Association of Boat Manufacturers

Ken Ryan

National
Marine
Manufacturers
Association

1819 L ST., N.W. • SUITE 700 • WASHINGTON, D.C. 20036 • (202) 861-1180 • FAX (202) 861-1181

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DIRECTORS OFFICE

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AIR QUALITY PLANNING

October 29, 1998

Jim Southerland

Mr. Alan Klimek
Division of Air Quality
NC Dept. of Environment, Health, and Natural Resources
P.O. Box 29580
Raleigh, NC 27626

RE: Boat builders Review of EPA ORD FRP Emission Factor Model

Dear Mr. Klimek:

The National Marine Manufacturers Association (NMMA) has serious concerns regarding the applicability and enforceability of the recent Fiberglass Reinforced Plastic (FRP) styrene emission factor guidance that your office has received from EPA Region IV. NMMA has provided both EPA Region IV and the EPA Emission Monitoring Division with comments on this emission factor model developed by the Office of Research and Development (ORD) in collaboration with Research Triangle Institute (RTI). This FRP Model (version 1.0, 1998) is a research tool that attempts to provide a multi-variable model for estimating emissions of styrene from fiberglass manufacturing operations.

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Sincerely,

John McKnight

John McKnight, Director
Environmental and Safety Compliance

enclosures (2) - NMMA comments
EPA Region IV letter to state air offices

cc: Winston Smith, EPA Region IV
Doug Neeley, EPA Region IV
Leonardo Ceron, EPA Region IV
Robert Manning, Hopping, Green, Sams, & Smith
National Association of Boat Manufacturers

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

SEP 16 1998

4APT-ARB

Ms. Tracy R. Carter, Director
Dept. of Environment & Conservation
Division of Air Pollution Control
9th Floor, L&C Annex
401 Church Street
Nashville, Tennessee 37243-1531

Subject: Emission Factors for Certain Polyester Resin Plastics Product Fabrication Processes

Dear Ms. Carter:

The Environmental Protection Agency (EPA), Region 4 office has reviewed comments received in reference to the March 3, 1998, guidance for emission estimations at certain polyester resin plastics product fabrication processes found at boat and open molding composite manufacturing facilities. The Region has decided to replace the draft letter issued March 3, 1998, with a recommendation that affected facilities use the enclosed Office of Research and Development (ORD) model for fiberglass reinforced plastics (FRP).

Affected facilities which use alternative emission estimation methodologies such as: the models developed by the Composites Fabricators Association (CFA); the specific data obtained by the National Marine Manufacturers Association (NMMA); other available models, must also submit emission estimation results obtained through the use of the ORD model provided herein. This comparison would be especially critical in any specific situation where threshold major source limits could be triggered. Additional information on models and data is available on the Chief internet web site located at (*http://www.epa.gov/ttn/chief/fyi.html*).

The ORD model provides a consistent and flexible basis for facilities to determine their overall emission estimations within the boat and composite manufacturing industries. The ORD model also provides a user friendly format which allows facilities to specify their particular process parameters and provide a comparison to "baseline" data in the model. Please note that the instructions included with the ORD model apply to each individual spray application. The ORD model therefore requires the user to quantify multiple layers, coats, or thicknesses which are applied to a specific product. Whenever possible, the model's default setting should be replaced with actual site specific data to ensure accurate emission estimations.

As previously stated, all facilities continue to have the flexibility of providing site specific emissions data, in lieu of using any emission estimation methodologies. Where appropriate, sources should be encouraged to seek technical assistance from your small business assistance program.

Region 4 is aware that CFA is suggesting to its members that they use the CFA model in addition to the ORD model. CFA believes that in many cases use of the CFA model will result in more conservative (higher) emission estimates. Region 4 does not object to the use of emission estimates derived by use of the CFA model in those cases where the estimates are higher than estimates obtained through use of the ORD model.

EPA Region 4, will continue to provide all our State and Local agencies with any new developments with regard to emission estimations for certain polyester resin plastics product fabrication processes found at boat and composite manufacturing facilities. Any questions or concerns regarding this guidance can be forwarded to Mr. Leonardo Ceron of my staff, at (404) 562-9129.

Sincerely,

Douglas Neeley

R. Douglas Neeley,
Chief
Air and Radiation Technology
Branch
Air, Pesticides and Toxics Management
Division

Enclosures

INTRODUCTION

The Office of Research and Development (ORD) of the U.S. Environmental Protection Agency (EPA) released in 1998 version 1.0 of a model for estimating emissions of styrene from open molding of fiberglass-reinforced plastic (FRP) parts. The FRP Model was developed by the EPA/NRMRL/APPCD in collaboration with Research Triangle Institute (RTI) in Research Triangle Park, North Carolina. These notes provide comments on the model, the paper accompanying the model, and the results achieved using the model.

We applaud the efforts of the EPA in attempting to develop a model for such a broad source category as the FRP manufacturing industry. There has been significant effort by the EPA and industry to generate reliable and meaningful data, representative of various subsets of the industry in the past several years. Using them in a coherent way to develop a general tool for estimating emissions from any FRP process is a worthy endeavor. We are convinced, however, that the data available, although significant, cannot be used to generate a true multi-variable model that yields accurate representations of emissions according to numerous parameters. (For example, selection of parameters at boundary conditions of the model yields unrealistic results of emission factors.) Further, we think that developing a generic model of this type may undesirably dilute the quality of the end result when it is used in lieu of actual data that exist for a specific source category such as boat manufacturing.

The model as developed provides useful insight into some factors that affect emissions. Although not a true multi-variable model, we believe the FRP model is generally useful in assessing the relative influence of a single parameter on emissions. The model, however, is inappropriate for assessing the synergistic effects of more than one parameter. The model was developed using data collected from general testing, not from testing done to assess the effect of a single parameter, holding all other parameters constant. So the results obtained from testing represents the effects of several parameters. The model evaluates the influence of each parameter (which may be valid) and then combines the individual effects into a single correction or adjustment factor (which is not a valid, precise measure of emission factor). Although the model has apparently been constructed to yield "correct answers" in some cases (in the context of emission factors and measurement accuracy); it does not necessarily follow that the model is correct and universally applicable. There are cases where the model does not provide correct answers. The model also fails to address materials that contain more than a single volatile reactive constituent, for example the presence of methyl methacrylate (MMA) in marine gel coats.

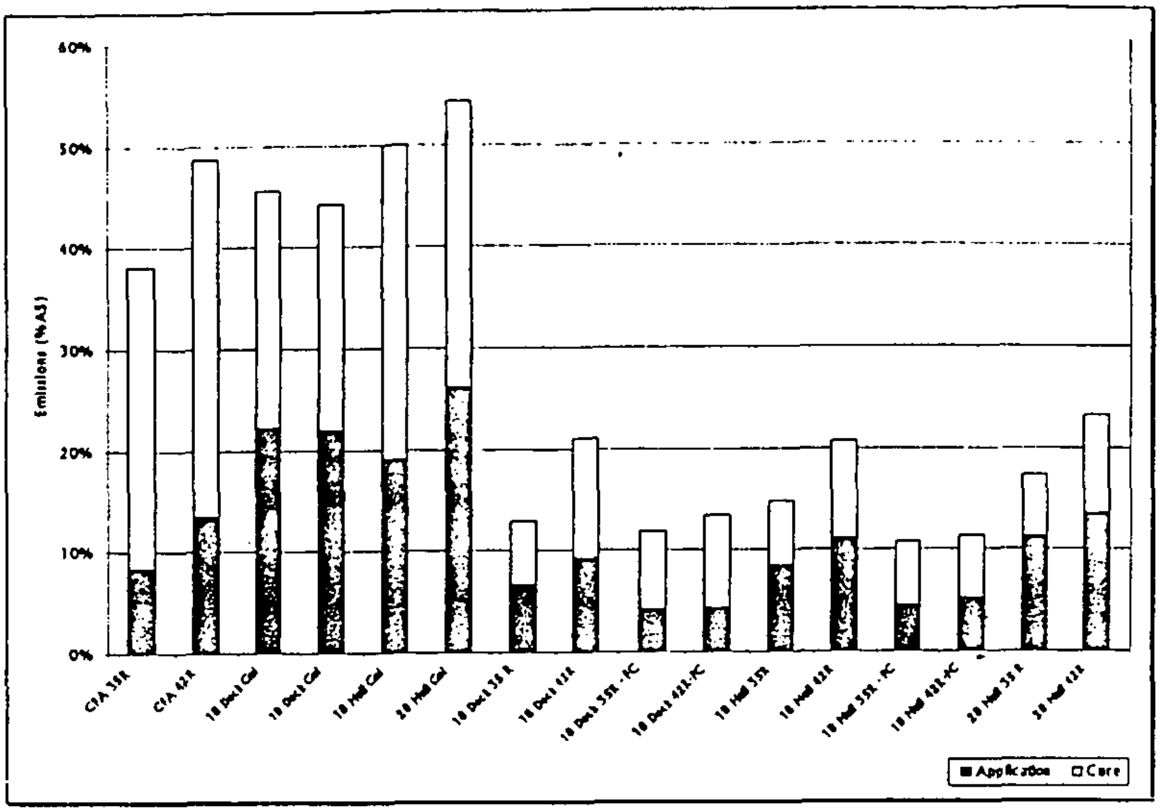
Finally, the model is written to run on personal computers running under a Windows95® operating system, or better. This is a serious limitation for many users. For many boat manufacturing operations, the personal computers in use are not the latest Pentium®-based machines. Also, many of these machines operate on older operating systems, such as Windows 3.1 or even Windows 3.11 for Workgroups. The model cannot even be installed on these machines, making it impossible to use. As a practical matter, the model should be available in formats used throughout the industry if it is to be available to general user in the industry.

NMMA DATA

The testing conducted by the National Marine Manufacturers Association (NMMA) in March and April 1997 and reported in August 1997 provides the best available data for FRP manufacturing for the marine industry. We have not prepared a computer emission model from these data, but instead provide our data in a number of formats to allow our members the ability to use the results to reflect their operations appropriately. Some operations may elect to use the most generic approach, that is, one of the discrete emission factors published in our summary report. Others may use all the data to generate an emission factor for their operation through interpretation of the data on styrene content in the resin, distance from the mold during application, and application technique.

We have continued to evaluate our results and hereby present a further refinement of the results. In the following figure we present the emission factors for each test, segmented by the two phases of operation: resin application and curing. We believe that this presentation is useful in assessing factors affecting emissions, and in comparing the NMMA data and estimates of emission factors obtained using the FRP model.

FIGURE 1: NMMA EMISSION FACTORS BY CONTRIBUTION OF SPRAY AND CURE



MODEL APPROACH

The FRP model proposed by the EPA is an empirical model, based solely on the available data, which interpolates the data using various equation formats. The model extrapolates beyond the bounds of the available data using these same equations. (The bounds of each variable are not clearly defined in the model. They can be determined, but the model does not provide the user a clear sense of the bounds of the base data.) There is no clear rationale for selecting various formats of the equations to describe the relationship between the independent variables and emissions.

The model, as currently drafted, is far more complex than warranted by the amount of data available. Not all the model parameters are truly independent variables; others have little effect on emissions. The data for other parameters is insufficient to warrant the degrees of weighting given in the model.

Parameters

The technical basis of the list of parameters (or variables) evaluated for use in the model is unclear (Table 1). A research effort such as the development of a model would typically use the technical description of the problem as the starting point in defining the independent model parameters and expected ranges. We do not see evidence that this type of technical foundation has been established.

Table 1: Variables in the FRP Model

Variable	Type	Observed Effect
Styrene content (%)	Independent	Significant
Distance from spray gun to mold (in)	Independent	Larger
Dried material off mold (%)	Dependent	Not a large effect on emission factor
Laminate (gel coat) thickness (mil)	Independent	Larger
Cup gel time (min)	Independent	No significant effect observed
Application rate (lb/hr)	Independent	No significant effect observed
Air temperature (°F)	Independent	No significant effect observed
Air velocity (ft/min)	Independent	No significant effect observed

Even a model based solely on empirical data would use multi-variable data reduction in developing a model relating independent variables with the dependent variables or, in this case, the emission factor. Unfortunately, the use of multi-variable analysis necessitates a tremendous amount of carefully collected data. Although a great deal of information has been developed regarding emissions from FRP manufacturing operations, the data serve more to indicate trends rather than to support the development of a complex model relating numerous factors. Model reduction could be applied to eliminate those parameters not really having observed influences on the emission factor. Again, the assessment of the theory of emission generation could provide insight into those factors affecting emissions and the observed results could indicate those factors having less significant influence.

Styrene Content

Styrene content has long been recognized as having a significant influence on the emission factor for open molding using unsaturated polyester resins. Historically, the relationship has been assumed to be linear, as suggested in the existing guidance documentation (AP-42). The FRP model assumes a non-linear quadratic relationship. The data on emissions do not appear to be sufficient to warrant use of the higher level model, especially given the absence of data for resins containing less than 31-32 percent styrene. While a non-linear relationship may fit the data, there is insufficient data to indicate that the relationship should be quadratic or that it should represent styrene contents in resin much less than a reasonable range, much less representing a zero styrene content resin. To characterize the relationship in these regions, additional data on emissions from use of resins containing less than 30 percent styrene should be collected.

Realistically, the styrene content in unsaturated polyester resins will have a natural floor, a content below which the resin cannot be effectively formulated. It is that range of realistic formulations that should guide the development of the model. Also, it is perfectly sound to use a relationship between resin styrene content and emission factor that either is linear or does not traverse the origin. In this case, the selection of model format should be based on fit of available data (all available data) to the candidate formats, taking into consideration the realistic limitation of the actual resins used. Our results indicate that for certain shapes and application techniques, there is good linearity in the emission factor as a function of styrene content over the range of conditions found in the boat manufacturing industry. The slopes of emission factor as a function of resin styrene content for the three mold shapes evaluated indicate this linearity (Table 2). Although the 18-ft deck mold showed slight differences from the other two molds evaluated, this difference can be attributed to the combination of spray and hand application necessary on this complex shape.

TABLE 2: LINEARITY OF RESIN STYRENE CONTENT EFFECT ON EMISSION FACTOR

Case	Slope of Emission Factor v. Resin Styrene Content
18-ft Deck	1.14
18-ft Hull	0.83
28-ft Hull	0.84

Distance from Application Equipment to Mold

An observation from the NMMA testing was a perceived relationship between emission factor and distance between the operator and the mold. Our brief 8-page paper (provided to the EPA in late 1997) summarizing the results of the study presented a figure illustrating the emission factors for spray chopper application of glass and 35.1-percent styrene content resin. The distances observed from the testing were about 18 inches for the 18-ft deck, 36 inches for the 18-ft hull, and 60 inches for the 28-ft hull. We anticipated some relationship between emission factors and distance between operator and mold; this is consistent with mass transfer theory. For greater distance between operator and mold, the residence time for resin while in droplet form (i.e., at maximum surface area) will be greater, providing increased opportunity for evaporation before reaction. We evaluated our emission data, generating emission factors for two periods: application and cure. The application period included those times when the spray equipment was actually operated. Cure periods included roll-out of the glass and resin, as well as the conventional resin curing cycle. This assessment showed a linear relationship between distance and emission levels for the limited cases and distances tested (Figure 2); a nearly identical trend was seen for application of both resins, however. We also considered the emissions during cure; these emissions were seen to be relatively constant for the tests conducted (Figure 3). Only the tests for 42-percent styrene resin applied to the 18-ft deck yielded results slight greater than those for hulls. This could be attributed to differences in part shape, although we did not see this same sort of difference with the 35-percent styrene resin.

FIGURE 2: EFFECT OF APPLICATION DISTANCE ON EMISSION FACTOR - SPRAY

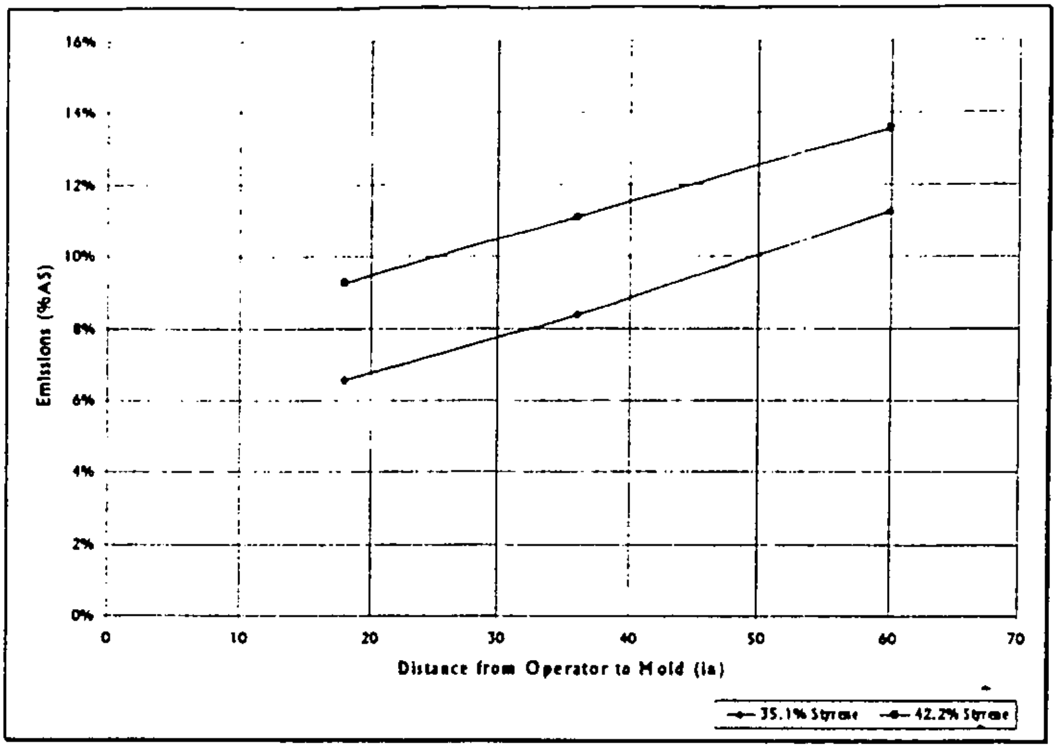
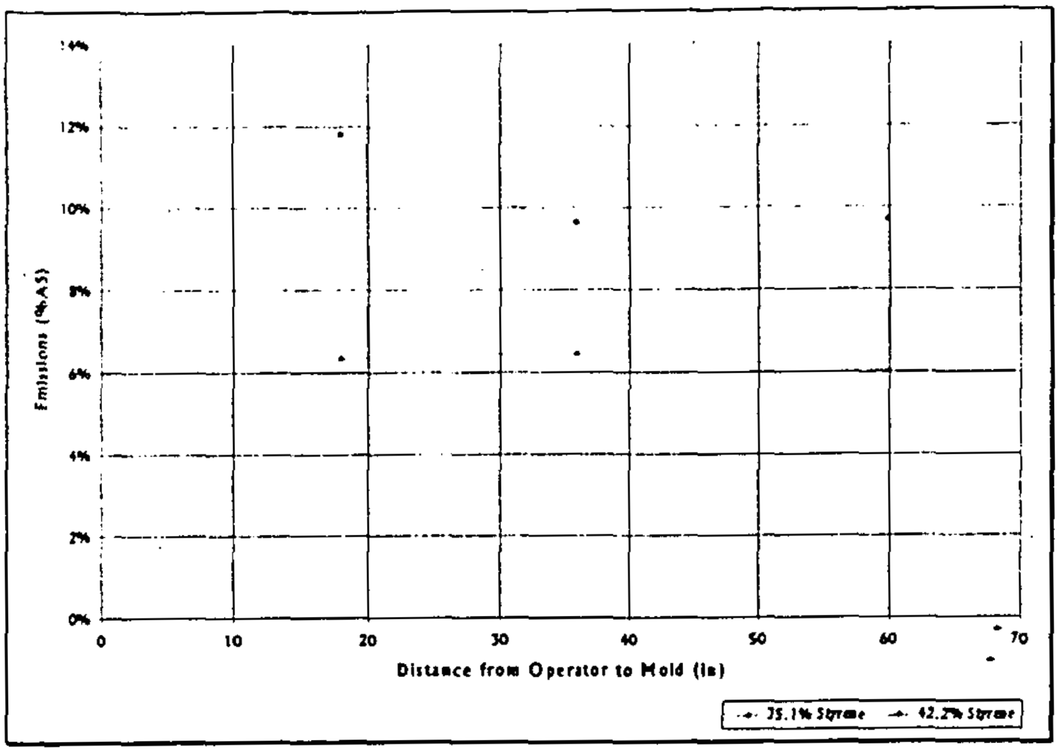

Emissions (%AS)
16%
14%
12%
10%
8%
6%
4%
2%
0%
0
10
20
30
40
50
60
70
Distance from Operator to Mold (in)
35.1% Styrene
42.2% Styrene

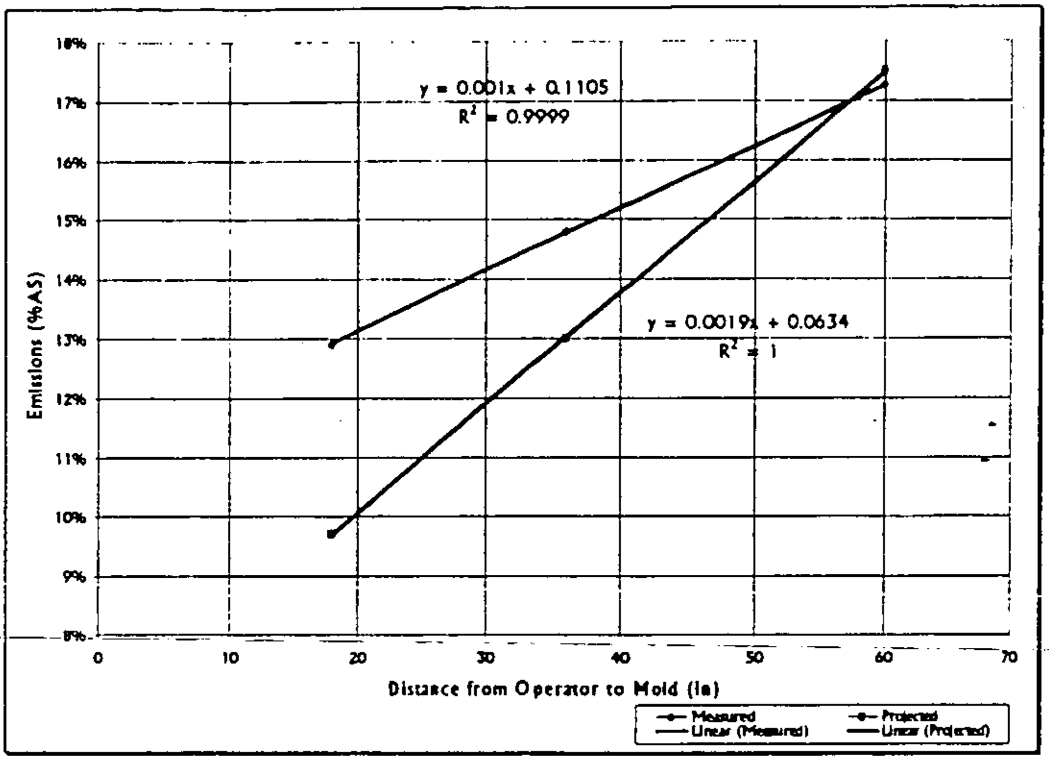
FIGURE 3: EFFECT OF APPLICATION DISTANCE ON EMISSION FACTOR - CURE



We compared the results obtained from our testing to the results of the FRP model using our inputs (Figure 4). The results shown compare the emission factors for applying 35 percent styrene resin from three distances. We believe that the 60-in application distance observed during lamination of the 28-ft hull is at the greater end of the expected distances. The FRP model does indicate the appropriate direction of change in emission factor with distance, that is decreasing emission factor with decreasing distance between operator and mold surface. However, we believe that the FRP model will under-predict the actual emission factor at closer distances. This difference from actual emissions may be attributed to the impression of the distances used as the model inputs, which is an inherent problem with the multi-variable approach.

While we can see some obvious trends in the data, the use of these scant data in developing an exact correlation does not seem justified. Nor do we believe that most operations using open molding techniques can actually use this parameter as a precise measurement. Rather, we feel that the base data (such as our graphical presentation) can be used in making judgments about the selection of appropriate emission factors.

FIGURE 4: COMPARISON OF ACTUAL (NMMA) AND PROJECTED (FRP MODEL) EFFECT OF APPLICATION DISTANCE ON EMISSIONS



Dried Material off Mold

The amount of dried material off the mold (as a percentage of total dried material applied) is really a dependent variable, related more to article size, application equipment, and application technique. It is true that the amount of material off the mold (call it over-spray) can affect total emissions but the influence on emission factor is not well described, especially for production circumstances. Over-spray is costly and is really less of an issue with larger parts like boat hulls. This variable was not measured during the NMMA testing, but it is safe to say that the amount of material not applied to the mold surface was less than 0.5 percent. This is really an insignificant factor and should therefore not be included in this model. Certainly, the amount of material in over-spray must be included in the total amount of material used when calculating total emissions.

The effect of over-sprayed material on emission factor would be minimal, compared with the emissions measured from applied resins. The over-sprayed material is likely much less than that applied to the mold, meaning a much thinner laminate. This might lead to greater emissions, except that the thickness is undoubtedly too small to cure quickly. Also, the material would not be rolled out, a process that will increase actual emissions.

We did review the data used in developing the correction for over-spray presented in an earlier draft of the FRP model. From the draft material, the correction is based on only two data points, insufficient to provide reliable results for all possible scenarios. Certainly for a factor that as presented can have equal weight to the final result as laminate thickness and distance to mold, and greater importance than styrene content in the neat resin, the underlying data is inadequate for a reliable model. Until better information is generated, this factor should not be included in the model.

Laminate (Gel Coat) Thickness

Observing the data available on FRP manufacturing makes it clear that there can be a significant influence on emission factors from laminate thickness. Thinner laminates yield greater emissions per unit mass of resin (or gel coat) applied than thicker laminates. This can be explained simply by the actual polymerization process wherein the free styrene cross-links with the polyester resin as the resin cures. In thinner laminates, more styrene can be released from the surface of the laminate; in thicker laminates, the free styrene in the laminate matrix (and not on the surface) is available within the thicker laminate and cross-links with other free styrene and polyester. Evaporation is mot possible and migration to the surface is unlikely before the styrene is reacted.

In boat manufacturing the laminates are much thicker than had been previously tested. The NMMA study used representative boat molds and representative laminate schedules. The skin coats used during the NMMA study were 90 mil thick and the full build-up layers were approximately 340 mil thick (on average). In some cases, such as the keel of the larger boat hull, the laminate thickness was greater than 400 mils thick. The test plan for the NMMA study projected that the laminate thickness would affect the results. Less styrene would be available as emissions for each pound of resin applied. Also, the material was applied in a time schedule that built up the laminate schedule without waiting for complete cure between incremental layers. Again, this was to mirror actual production practices. The emission tail (i.e., those emissions during cure after resin has been applied) was cut off, reducing the total emissions per pound of material applied.

In evaluating the FRP model, it is evident that the NMMA data were not incorporated in the development of this modification factor. Laminate thickness greater than 70 mils is considered outside the range of the model inputs. We were unable to assess the correlation developed for laminate thickness because the data were not presented. This is surprising, given the apparent importance of this parameter as suggested by the aggregate modification factor. Further, the model modification factor for laminate thickness greater than 40 mils (resin spray operations) is $1.14-0.002x$, where x is the laminate thickness in mils. Under this scenario, a laminate thickness of 250 mils (reasonable from our study) would have emissions 64 percent of the baseline. This seems to be too great a correction when actual data are available for this relationship. This model assumes a linear relationship, which appears invalid at the thickness tested during the NMMA study.

Our data indicate that there is an increase in emission factor of 9-11 percent from the 90 mil skin coat to the 250 mil bulk coat. We can rely upon this as a quantitative measure only to the extent that it represents the data from this series of tests. For practical purposes, these results can be considered equal. The emission tail of the skin coat had not completely cured; so emissions attributed to the bulk application could actually represent skin coat.

These results do raise a question about the relationship between laminate thickness and emission factor. It can be inferred from these results, that the emission factor will decrease with increasing laminate thickness to a point, dictated by the geometry of the part, application equipment, and resin/catalyst system. The NMMA study does show that the thinner laminates, such as those applied to the CFA mold and those applied during gel coating, contribute to greater emission factors than those laminate schedules that are thicker (representing structural production parts). For the boat manufacturing industry, the structural parts making up the vast majority of resin consumption have thicker laminate, schedules where thickness has not further effect on emission factor. Those effects are already seen in the data generated during our study.

Although we have produced data for boat manufacturers, it is clear from the data that there is some effect of laminate thickness on the emission factor. Additional data could be generated to define this relationship more conclusively and to define that point at which the effect is no longer noted. However, the utility of incorporating this factor may be less than the benefit of recognizing the effect. Multiple laminate thicknesses may be used manufacturing the same boat. In this case, numerous calculations would be necessary to describe the emissions from the manufacture of a single boat design. This procedure would be nearly impossible to track for each boat manufactured and more resource intensive than warranted for the data.

Cup Gel Time

This variable is included as a parameter in the model but is not discussed in the paper. The model uses a correlation for spraying resin and gel coat that is most nearly 1 (unity). This indicates little effect on the emission factor. We recommend that this parameter not be included in the model as adding complexity that is unwarranted based on the model equations. Typically in a production environment, a variety of gel times will be used to compensate for various climatological factors and for the specific equipment used that day. Also, the cup gel time might be varied over the course of a day to account for changes in these climatological factors.

The model uses a completely different equation for the modification factor for hand lay-up, pressure-fed rollers, and flow coaters. Again, the data are not presented, making an assessment of the relationship impossible.

The NMMA study included testing of flow choppers for two parts: 18-ft deck and 18-ft hull. Cup gel time was not varied from those gel times used during spray chopper experiments. There was no compelling reason to expect any different trend with respect to cup gel time for the flow choppers, however, because the effect of cup gel time would be seen on emissions from the cure portion of the application cycle. Emissions from the cure portion should not vary significantly from hand lay-up, to spray chopper, to flow chopper application, because the mechanisms for emissions from the mold surface would be the same, regardless of how the resin and glass had been applied.

Application Rate

Application rate was not evaluated as part of the NMMA study. The resin application evaluation was conducted at basically a 6.5-lb/hr resin application rate. So, our data do not permit testing of this factor. And, the model actually indicates no effect at resin application rates greater than 4 lb/hr. The application rate might have some influence on the emission factor but it is expected to be an insignificant factor compared with other factors (e.g., resin styrene content, distance between operator and mold, and laminate thickness). The influence of this parameter is probably incorporated in the distance algorithm, because the closer distance to the mold would preclude greater application rates. Therefore, we recommend elimination of the parameter as unnecessary.

Air Temperature

We do not believe that air temperature is a parameter affecting emissions. Mass transfer theory would indicate that this parameter would have minimal impact on the rate of mass transfer. The temperature of the material applied and the temperature of the resin in the mold would have a bearing on the emission generation and mass transfer characteristics, including vapor pressure and mass transfer coefficients. Even so, the temperature can represent two competing factors. Increasing temperature increases vapor pressure (the driving force for mass transfer), but also increases the reaction rate (which removes the styrene as polymer). This balance of competing factors is not known and has not been defined through a defined testing program. We believe air temperature (presumably ambient air temperature) would only have an influence as it relates to the temperature of the materials being applied.

The paper states that there will be a modification factor change of about 1 percent for every 1°F above or below the 75°F baseline temperature. Our assessment of the model indicates that the effect is slightly less than this value for gel coat application (an increase of approximately 0.6 percent of available styrene), and much less for resin application using spray and flow chopper application (an increase of only 0.1-0.2 percent of available styrene). The validity and strength of this relationship cannot be assessed because the data are not presented in either this version of the model or the previous version released to NMMA last year. Unless compelling data are presented that clearly demonstrate the relationship, this influence should be considered minor and deleted from consideration.

Air Velocity

Data collected from the various test programs are inconclusive. The model uses a disconnected function, two straight lines. The data indicating reduced emissions at air velocities less than 30-35 ft/min were for testing at pultrusion operations and for Dynatron-Bondo resins (filled resins). Other data from this range of air velocities (RTI bench-scale studies using Ashland resins) show little or no change from typical emission factors. Data from the NMMA studies essentially held the air velocity constant; however, comparing the data with other reported emission factors for FRP operations indicate that there is little influence at nominal air velocities that might be expected at production facilities where workplace air must be changed with a degree of regularity mandated by OSHA.

Theoretical projections from mass transfer theory indicate an increase in emissions with an increase in the air velocity across the material surface. However at some point, the effect of air velocity over the surface ceases to result in increased or reduced emissions. Empirical data indicate little influence on emission factor by this parameter. Further, it would be extremely difficult and impractical to measure air velocity at each point of a complex part, which is implied to be necessary to apply the model to obtain "accurate" results. Accordingly, we recommend eliminating this variable from the model as (1) having an insignificant effect and (2) being impractical to implement.

LIMITATIONS OF THE MODEL

We evaluated the effects of using the parameters at their extreme values. We found that we could yield emission factors of greater than 100 percent of available styrene (%AS). Clearly this cannot be possible. This is a limitation of the model that should have been tested before release, or at least those bounds should have been assessed before release and proper warnings made. This clearly indicates the potential for users to "game" the model (i.e., to obtain the desired results through clever selection of inputs), which surely is not one of the EPA's objectives.

TABLE 3: ASSESSMENT OF MODEL LIMITATIONS

Parameter	Spray Resin	Gel Coat	Gel Coat
Styrene content (%)	50	50	50
Distance from spray gun to mold (in)	40	40	40
Dried material off mold (%)	10	10	10
Laminate (or gel coat) thickness (mil)	50	10	20
Cup gel time (min)	50	50	50
Application rate (lb/hr)	1	1	1
Air temperature (°F)	95	95	95
Air velocity (ft/min)	200	200	200
Baseline factor (%AS)	18.9	54.8	54.8
Calculated factor (%AS)	103.1	145.5	114.3

PAPER

The paper would be better served as an assessment of trends noted in the data collected from testing at various FRP manufacturing sites instead of a tool for estimating emission factors. The paper provides a description of the current state of the science of emission measurements for styrene emissions from FRP industries. It describes the approach used in developing the model and provides practical examples. The descriptions above indicate technical issues with individual aspects of the model. The paper itself is lacking in some of its explanations.

The paper, however, is slightly confusing with the use of the term "emissions." Because the paper describes a model used to estimate factors for use in inventory development, the term "emissions" would be assumed to mean emission factor, emissions per unit of material used. (In the case of FRP manufacture, this factor has traditionally taken the format of styrene emitted as a percentage of available styrene, or free styrene in the monomer.) The term "emissions" in the paper, however, is also used to mean total emissions. Although those discussions are interesting, and perhaps even germane to inventory assessments, they appear inappropriate for the initial description, presentation, and explanation of the model.

The model itself brings together "all" of the data available from FRP manufacturing operations in the hopes of representing the widest portion of the industry. The results do not appear to have been used across all of the assessments, though. For example, the data generated by the National Marine Manufacturers Association (NMMA) indicated a relationship between emissions and distance from the mold. These data were reported used in the development of the modification factor in the FRP Model for distance from the mold, although this study is not listed in Table 3 of the paper showing the studies used in developing inputs for the model.

As an explanation on the development of the model, the absence of the data used in developing the relationships is significant. Also, not all variables used in the model are described.

CONCLUSION

We appreciate the efforts of the EPA in striving to present a model that can be used to estimate emission factors. Unfortunately, this approach to the model is not adequate to the task. It is useful in indicating trends of relative effects of individual parameters, but not for combining those effects in estimating the emission factor.

Any future model efforts should keep in mind that only those factors with significant influence on emission factor should be included. Models should be as simple as possible so that obfuscation does not become the result of the model. Simplification is particularly needed for the widespread use by the industry segment.

We would be happy to work with you in developing a list of potential parameters and helping reduce the number of parameters to a reasonable, workable number.

ENGINEERING ENVIRONMENTAL
CONSULTING SERVICES
Robert A. Haberlein, Ph.D., QEP
robhab@erols.com

TWO FISK CIRCLE
ANNAPOLIS, MD 21401
(410) 268-7367
(410) 267-8174 FAX

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July 9, 1998	Fax:	(919) 541-0684
page 1 of 3	Phone:	(919) 541-4330

Ron Ryan
U. S. EPA
EMAD MD-14
Research Triangle Park, NC 27711

Dear Mr. Ryan,

CFA recently completed two sessions of Phase III emissions testing at the Dow lab facility in Freeport, Texas. The results of this testing showed good support for the CFA emission factors that were initially developed for controlled spray, vapor-suppressant, non-atomized application, and combinations thereof, within the 33% to 50% styrene content range. The models appear to be good conservative estimators for these control techniques within this range.

Based upon this additional test data, the CFA has completed the three partial columns in Table 2.16 of the CFA Emission Model for the Reinforced Plastics Industries using the initial control factors.

I have attached the completed table and the new CFA Phase III data.

I will also send you this fax via E-mail transmission.

Please let me know if you need any further assistance.

Best personal regards,

Robert A. Haberlein, Ph.D., QEP

cc:	John Schweitzer	Fax:	(734) 622-0122
	Steve McNally	Fax:	(703) 525-0743
	Bob Lacovara	Fax:	(215) 721-0668

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Ron Ryan - EMAD
June 19, 1998

Comparison of the Phase III Results and the CFA Models (Feb 28, 1998 versions)

Test Run #	Process Tested	Testing Conditions see note below	CFA/ Dow Phase III Data Styrene Content (% resin wt)	Styrene Emitted (% resin wt)	CFA Model Predicted Styrene Emitted (% resin wt)	
First Session at Dow Freeport						w/o CS
033198A	Gelcoating	CS	25.8	12.26	5.3	7.2
033198B	Gelcoating	CS	28.7	12.55	7.5	10.2
033198C	Gelcoating	CS	28.7	11.97	7.5	10.2
033198D	Gelcoating	CS	25.1	10.83	4.7	6.5
040198A	Flow Chop		33.7	3.29	3.1	
040198B	Flow Chop		33.7	3.33	3.1	
040298A	Pressure-fed Roller		33.7	4.21	3.1	
040298C	Pressure-fed Roller	VS	33.7	2.14	1.9	
040298C	Flow Chop	VS	33.7	1.62	1.9	
040298D	Flow Chop	VS	42.05	1.14	1.9	
040398A	Pressure-fed Roller	VS	42.05	1.78	1.9	
040398B	Flow Chop		42.05	3.18	3.1	
040398C	Replicate of 121495A		N/A	11.90	N/A	
040398D	Flow Chop	VS	33.7	1.66	1.9	
Second Session at Dow Freeport						
052798A	Flow Chop		42.05	4.35	6.1	
052798B	Flow Chop	VS	42.05	0.81	3.8	
052798C	Flow Chop		48.9	8.98	8.6	
052798D	Flow Chop	VS	48.9	2.90	5.3	
052898A	Spray Lay up	CS	42.05	8.20	9.3	
052898B	Spray Lay up	VS & CS	42.05	4.26	5.7	
052898C	Spray Lay up	CS	48.9	10.36	13.0	
052898D	Spray Lay up	VS & CS	48.9	5.88	8.1	
052998A	Gelcoating	Clear	51.3	34.32	33.6	
052998B	Gelcoating	Clear CS	51.3	25.91	24.6	
052998C	Spray Lay up		48.9	12.63	16.9	
052998D	Spray Lay up		34.7	8.54	6.8	

Notes
= test date VS = vapor suppressed resin CS = control spray application

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Ron Ryan - EMAD
July 9, 1998
page 3 of 3

add'l data added for lo-sty gel coat. Model underpredicts

CFA EMISSION FACTORS

(Styrene Emission Rates listed as % of Neat Resin Weight as applied)

Styrene Content	Manual Resin Application		Mechanical Resin Application						Gelcoat Application		Filament Winding	
	Bucket & Tool		Uncontrolled Spray		Controlled Spray		Non-Atomized Application		Uncontrolled Spray	Controlled Spray		
% wt	Non-Vapor Suppressed	Vapor-Suppressed	Non-Vapor Suppressed	Vapor-Suppressed	Non-Vapor Suppressed	Vapor-Suppressed	Non-Vapor Suppressed	Vapor-Suppressed			Non-Vapor Suppressed	Vapor-Suppressed
33%	4.1%	2.8%	5.6%	3.4%	4.3%	2.7%	2.8%	1.8%	14.7%	10.7%	6.1%	4.0%
34%	4.4%	2.8%	6.3%	3.9%	4.8%	3.0%	3.2%	2.0%	15.7%	11.5%	6.4%	4.1%
35%	4.7%	2.9%	7.0%	4.3%	5.4%	3.3%	3.6%	2.2%	16.8%	12.2%	6.6%	4.3%
36%	5.0%	2.9%	7.7%	4.8%	5.9%	3.7%	3.9%	2.4%	17.8%	13.0%	6.9%	4.5%
37%	5.3%	2.9%	8.4%	5.2%	6.5%	4.0%	4.3%	2.7%	18.8%	13.7%	7.2%	4.7%
38%	5.6%	3.0%	9.1%	5.7%	7.0%	4.4%	4.7%	2.9%	19.9%	14.5%	7.5%	4.8%
39%	5.9%	3.0%	9.8%	6.1%	7.6%	4.7%	5.0%	3.1%	20.9%	15.3%	7.7%	5.0%
40%	6.2%	3.1%	10.6%	6.5%	8.1%	5.0%	5.4%	3.3%	21.9%	16.0%	8.0%	5.2%
41%	6.4%	3.1%	11.3%	7.0%	8.7%	5.4%	5.7%	3.6%	23.0%	16.8%	8.3%	5.4%
42%	6.7%	3.2%	12.0%	7.4%	9.2%	5.7%	6.1%	3.8%	24.0%	17.5%	8.6%	5.6%
43%	7.0%	3.2%	12.7%	7.9%	9.8%	6.1%	6.5%	4.0%	25.0%	18.3%	8.8%	5.7%
44%	7.3%	3.3%	13.4%	8.3%	10.3%	6.4%	6.8%	4.2%	26.1%	19.0%	9.1%	5.9%
45%	7.6%	3.3%	14.1%	8.8%	10.9%	6.7%	7.2%	4.5%	27.1%	19.8%	9.4%	6.1%
46%	7.9%	3.3%	14.8%	9.2%	11.4%	7.1%	7.6%	4.7%	28.2%	20.6%	9.7%	6.3%
47%	8.2%	3.4%	15.6%	9.6%	12.0%	7.4%	7.9%	4.9%	29.2%	21.3%	9.9%	6.5%
48%	8.4%	3.4%	16.3%	10.1%	12.5%	7.8%	8.3%	5.1%	30.2%	22.1%	10.2%	6.6%
49%	8.7%	3.5%	17.0%	10.5%	13.1%	8.1%	8.7%	5.4%	31.3%	22.8%	10.5%	6.8%
50%	9.0%	3.5%	17.7%	11.0%	13.6%	8.4%	9.0%	5.6%	32.3%	23.6%	10.8%	7.0%

prepared on 7/6/98 - emission rates based on revised 12/8/97 CFA Matrix Models

bottom of column new

entire column new

06/08/98 16:03 ☎919 541 5689 EPA ESD CCPG 001

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

JUN 5 1998

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Mr. John Schweitzer/Mr. Steve McNally
Composite Fabricators Association
1655 North Fort Myer Drive, Suite 510
Arlington, Virginia 22209

Dear John and Steve:

This is to express my concerns with your use of the EPA's April 1997 Open Molding Database to support the CFA emission models. I have found several inappropriate references to this information in the report titled "CFA Emission Models for the Reinforced Plastics Industries" dated February 28, 1998. I feel this is a mischaracterization and misapplication of the information which we have shared with you, and request that you remove any references to this information from your report and from any further discussions of your model.

A substantial basis used to support the CFA Emission Models is the comparison of these models with the emission estimates contained in the EPA's April 1997 Open Molding Database. This comparison is inappropriate. The purpose of our sending you the database was to provide background information on the approaches we were considering to do the MACT ranking. The purpose of the column on estimated emissions was for us to approximate the impact of the MACT floor; it did not serve as any kind of recommended approach to estimate a facility's emissions. In fact, a disclaimer we put on the spreadsheet attempted to avoid this inappropriate use of the information. Your report cites this information as "available data" and further indicates that the EPA provided no basis for it. These citations greatly mischaracterize this information. We shared this information even though it was incomplete in order to provide you with detailed information on the options being considered. When we propose the standard, we will have complete documentation supporting the development of the standard.

In addition, this, as well as all other versions of our databases, are still draft. As you know, our MACT emissions estimation approach changed, and we provided you with this updated information before you developed your report.

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL 6/8/98 # of pages ▶ 2

To Ron Ruan	From Madeleine Strum
Dept./Agency	Phone #
Fax # 1-5684	Fax # 1-5689
NSN 7540-01-317-7368 5099-101	GENERAL SERVICES ADMINISTRATION

We are concerned that our efforts to provide you with information being considered in the development of the rule have resulted in misuse and mischaracterization of that information. Such misuse affects our ability to share preliminary information with you. We would appreciate your removing any references to the EPA's April 1997 Open Molding Database from your report and from any further discussions of your model.

Sincerely,

Madeleine

Madeleine Strum
Environmental Engineer
Coatings and Consumer Products Group

DAVID MOBLEY

→ Ryan rec'd 1/14/98

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

JAN 13 1998

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Response to your memorandum dated December 3, 1997, titled "Requested Revision of Existing Emission Factors for Polyester Resin Plastic Products Fabrication"

FROM: William F. Hunt Jr., Director
Emissions, Monitoring, and Analysis Division (MD-14)

TO: Winston A. Smith, Director
Air, Pesticides, and Toxics Management Division

The Emissions, Monitoring and Analysis Division (EMAD) personnel have reviewed the "Summary of Data Results" prepared by Region IV personnel. We agree that this is an accurate, though greatly simplified, representation of the test program results. Further, we agree, as we have stated in several meetings and teleconferences, that the current AP-42 emission factors are antiquated, based on limited data, and probably underestimate emissions significantly for most sources in this industry.

It is our understanding that the guidance offered by our Information Transfer and Program Integration Division (ITPID) is that the "best available data", NOT necessarily AP-42, should be used for permitting decisions. We can appreciate the efforts required of the Region IV staff to stay abreast of this issue and to evaluate all of the data sets as they have become available over the past year, and we encourage you to use this data as you see fit in your permitting decisions. However, while we are interested in assisting in the dissemination of information and in the documentation of accepted emissions estimating methods through AP-42, we do not have the resources to take the lead on new data development for all source categories now requiring permits. In addition, we do not think it is appropriate for us to make permitting policy decisions via the AP-42 process, and we would encourage the Regional and Headquarters permitting staff to continue to communicate with each other and with the affected industry regarding permitting decisions which must be made in the short term.

List them,

You also requested information on our time table for revising the existing AP-42 section. Because we chose not to devote any additional contractor resources to the studies being conducted by the Emission Standards Division, the Office of Research and Development, and by two trade associations, our schedule for this project has been dependent on other's efforts. It appears that those efforts are now approaching a successful conclusion, and it is our hope to have a draft section available for comment within two months. The educated opinions and comments of your staff would be most welcome in either development of the draft or on the final draft for external review.

cc: Tom Curran (MD-12)
Bruce Jordan (MD-13)
Steve Hitte (MD-12)
David Mobley (MD-14)
David Misenheimer (MD-14)

You also requested information on our time table for revising the existing AP-42 section. Because we chose not to devote any additional contractor resources to the studies being conducted by the Emission Standards Division, the Office of Research and Development, and by two trade associations, our schedule for this project has been dependent on other's efforts. It appears that those efforts are now approaching a successful conclusion, and it is our hope to have a draft section available for comment within two months. The educated opinions and comments of your staff would be most welcome in either development of the draft or on the final draft for external review.

cc: Tom Curran (MD-12)
Bruce Jordan (MD-13)
Steve Hitte (MD-12)
David Mobley (MD-14)
David Misenheimer (MD-14)

FYI- I think I cc'd the
factors group on my draft response
to RY'S memo to Hunt. This has
now finished review & been signed. The
only change to the draft was that
the word "ably" was struck from
the very end of the 2nd line ~~on~~ this page.

RR

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET, SW
ATLANTA, GEORGIA 30303-8909

postmarked 12-5, Fri
rec'd 12-9, Tues

DEC 3 1997

4APT-ARB

MEMORANDUM

SUBJECT: Requested Revision of Existing Emission Factors for Polyester Resin Plastic Products Fabrication

FROM: Winston A. Smith, Director
Air, Pesticides and Toxics Management Division

TO: William F. Hunt Jr.,Director
Emissions, Monitoring, and Analysis Division,
Office of Air Quality Planning and Standards (MD-14)

As an active participant in the maximum achievable control technology (MACT) partnership program for developing the Boat and Reinforced Composite Manufacturing regulations, Region 4 has been involved with many detailed analyses of hazardous air pollutants (HAPs) emissions. During the data acquisition and evaluation phase, it became apparent that industry relies heavily on Environmental Protection Agency (EPA) emission factors, and therefore, accurate emissions data are critical to the success of the MACT program. However, Region 4 has reviewed several research reports which indicate that the existing EPA emission factors used to estimate emissions from uncontrolled polyester resin product fabrication processes are antiquated.

Based on the recently published EPA research document entitled Evaluation of Pollution Prevention Techniques to Reduce Styrene Emissions From Open Contact Molding Processes, Volume I & II, Final Report, EPA-600/R-97-018a -018b, March 1997, and two (2) supporting research documents published by industry entitled Baseline Characterization of Emissions from Fiberglass Boat Manufacturing, August 1997, by the National Marine Manufacturers Association (NMMA) and Phase I-Baseline Study, Hand Lay-Up, Gel Coating, Spray-Up Final Report, September 1996, by the Composites Fabricators Association (CFA), it is this Region's position that the existing AP-42 emissions factors for this category of sources greatly underestimates actual emissions of HAPs.

The Regional office is very supportive of all activities provided by your Division to supply accurate emissions data. To that end, the Region has compiled the attached "Summary of Data Results" which provides a revised tool to carry out existing permitting and compliance requirements for certain polyester resin plastic products fabrication, while maintaining a high degree of protection to human health and the environment. Region 4, as sub-lead region for air toxics, requests your review of this information and an indication of whether your office could support the results.

Concurrently, the Regional office acknowledges that the ultimate responsibility for the maintenance of all AP-42 emissions data lies within the Emissions, Monitoring, and Analysis Division. Therefore, Region 4 also requests your assistance in revising the appropriate AP-42 emission factors. I would appreciate an indication from you regarding the time table involved in making adjustments to AP-42 for this industry category.

If this Regional office can be of further assistance in the development of these respective emission factors or models, please contact Mr. Leonardo Ceron of my staff at (404) 562-9129.

Attachments:

cc: Ron Ryan EMAD
Madeleine Strum, ESD
Carlos Nunez, ORD
Kirt Cox, IPTID
Greg Foot, OGC
Cary Secrest, ORE
Robert Dresdner, OC
Floyd Ledbetter, R4 ECB

~~544-4332~~

Summary of Emission Data Results:

Date: October 27, 1997		NVS[1]	VS[2]
Resin Non-Spray Layup	**(Emissions as a percent (%) of Available Monomer)**		
	AP-42	5 - 10	2 - 7
	EPA / RTI (Uncontrolled[3])	14.2[4] - 15.3[5]	NA
	NMMA (Uncontrolled)	NA	NA
	CFA (Uncontrolled)	9.8 - 21.1 15.45	NA
	Range of New Data / default	14.2 - 15.3 ? 15.2	NA
	Midpoint[6] (Uncontrolled)	~~15.1[7]~~ 14.75	NA - ?
	EPA / RTI (controlled[8])	NA	NA
flow chopper? →	NMMA (controlled)	10.8 - 13.4	NA
	CFA (controlled)	NA	NA
	Range of New Data / default	10.8 - 13.4	NA
	Midpoint (controlled)	12.1 ✓	NA
Resin Spray Layup	**(Emissions as a percent (%) of Available Monomer)**		
what resin %?	AP-42	9 - 13	3 - 9
	EPA / RTI (Uncontrolled)	27.1	NA
	NMMA (Uncontrolled)	NA	NA
	CFA (Uncontrolled)	17.1 - 38	NA
	Range of New Data / Default	17.1 - 38	NA
	Midpoint (Uncontrolled)	27.~~45~~	NA - ?
	EPA / RTI (Controlled)	17.5	10.6
	NMMA (controlled)	12.9 - 23.3	NA
	CFA (controlled)	NA	NA
	Range of New Data / Default	12.9 - 23.3	~~10.6~~
	Midpoint (controlled)	18.1 ✓	10.6 ?
Gel Coat Spray/Non-Spray	**(Emissions as a percent (%) of Available Monomer)**		
	AP-42	26 - 35	8 - 25
	EPA / RTI (Uncontrolled)	62.5	NA
	NMMA (Uncontrolled)	NA	NA
	CFA (Uncontrolled)	43.5 - 61.8	NA
	Range of New Data / Default	43.5 - 62.5	NA
	Midpoint (Uncontrolled)	~~56~~ 53	NA - ?
	EPA / RTI (Controlled)	49.2 - 60.2	NA
	NMMA (controlled)	45 - 53	NA
	CFA (controlled)	NA	NA
	Range of New Data / Default	45 - 60.2	NA
	Midpoint (controlled)	52.6 ✓	NA

Copies of :

Evaluation of Pollution Prevention Techniques to Reduce Styrene Emissions From Open Contact Molding Processes, Volume I & II, Final Report, EPA-600/R-97-018a, March 1997, by EPA Research Triangle Institute (RTI).

Baseline Characterization of Emissions from Fiberglass Boat Manufacturing, August 1997, by the National Marine Manufactures Association (NMMA).

Phase I-Baseline Study, Hand Lay-Up, Gel Coating, Spray-Up Final Report, September 1996, by the Composites Fabricators Association (CFA).

1. NVS = non-vapor surpressed.

2. VS = vapor surpressed.

3. Uncontrolled = normal spraying technique without conscious control of over spray from flanges and inconsistent spray angles to mold. This is considered the normal spray technique for all styrene emissions.

4. Non-Spray, uncontrolled data is based on flow coater.

5. Non-Spray, uncontrolled data is based on pressure fed roller.

6. Midpoint - Regionally accepted as best available data.

7. Non-spray pressure fed roller data values will be accepted for hand lay-up and filament winding in lieu of AP-42 values.

8. Controlled = spraying technique with conscious control to reduce over spray and a constant 90^0 angle to mold. The use of this spray technique will require documentation by source owners and / or operators.

~~541-4485~~

CFA models – (of phase I data) sent 9/18/97 to md. stuve inc.. contr & uncontr.

bunch of new phase II data

?

Fax to Ron Ryan
541-0684
phone 541 4330
From M Strum 541 2383

Draft -- do not quote or cite

Note: I am still trying to find the latest version from my contractor.

MEMORANDUM

SUBJECT: Observations from National Marine Manufacturers Association Emission Testing Program

FROM: Madeleine Strum, Environmental Engineer
Coatings and Consumer Products Group (MD-13)

TO: Linda S. Herring, Group Leader
Coatings and Consumer Products Group (MD-13)

The purpose of this memorandum is to document a few observations made regarding the National Marine Manufacturers Association (NMMA) sponsored test program at the U.S. Marine Facility in Arlington, Washington. I visited the testing on April 14 and 15, 1997, and was able to see some of the resin spraying process on the 18-foot boat hull and deck molds. The primary purpose of the test is to establish baseline emission factors for the boat manufacturing industry. The test data is also useful to compare spray versus nonspray resin application of two different styrene contents.

1. Resin Spray Technique

→ i.e. better than typical

The technique used during the testing appeared to be excellent, and it appeared to result in minimal overspray. The distance from the operator to the part was typically two and a half feet and no more than 4 feet at any particular time. Distance from the mold was minimized by ~~the ability of the operator~~ to rotate the mold so it was facing him at all times. In addition, the operator sprayed no more than an inch off of the mold. When spraying off of the mold, a very small fraction of the fan pattern was actually off of the mold. The operator began spraying on the mold rather than beginning off of the mold and moving onto the mold. The operator did not spray continuously, but rather turned the gun on and off at various times to adjust the mold or change positions.

< ORD model = 15"

How is this different technique?

The technique used for resin spray-up seen in production also appeared to be excellent, however, not much lamination was seen. In addition, the production lamination was for a much larger part than for the testing.

not all boat manuf. facilities have these "rotating molds"

Because of the optimal techniques/distance from the mold, the emission factors measured during the testing may be lower than those typical of a facility in which the technique is not optimized. Based on previous emission testing performed by the Composite Fabricators Association on large molds, optimizing the spray technique for resin spraying achieved about a 20 percent emission reduction. May adjust spray #s upward by 20%.

Note: operator performing test was corporate trainer.

2. Air flow in the vicinity of the mold.

There appeared to be little air movement in the booth during the emission testing. Values obtained by industry were in the range of 20 to 40 feet per minute. It was found that air velocities have no impact on emissions between 50 and 100 feet per minute, but no testing was done below 50 feet per minute. If lamination is done near fans in actual facilities, and, if air velocities below 50 feet per minute suppress emissions, then the emission factors obtained in the NMMA tests would be lower than those in actual facilities.

-- This issue will addressed ... May change slightly or delete

3. Data collection

The runs may have been terminated too early. Any outgassing of the laminate after data collection ended would not be counted in the test results; this would have the effect of producing factors which underpredict actual emissions. However, the test plan noted that the results would take that into account so this may not cause any underprediction in emissions.

4. Test versus Actual Production

The Arlington production facility does not produce boats less than 28 feet in length; so we were unable to compare the production steps with the test steps. I did notice, however, that the installation of stringers, bulkheads, wood reinforcements, and foam, which is part of boat production, was not done during emission testing. In viewing some of these steps in the production facility, I noticed that the wood/foam were often wetted out with a thin layer of resin by spraying them on the floor. Because of this thin layer and the larger quantity of overspray associated with these operations, I would guess that the emission factor for these steps would be greater. This would thus raise the emission factor obtained for the hull during the testing. This would probably not be too significant an increase since the quantity of resin used for these operations is much less than the resin used for laminating the hull. — why?

5. Small Parts

Boats consist not only of hulls and decks, but also small parts. An example of a small part we saw was a tub/shower unit (for large boats). Small parts likely have thinner laminates and, therefore, could have a higher emission factor. In addition, small parts are more likely to have more overspray which would also increase the emission factor. Small parts were not tested in the NMMA test program; the quantity of resin used for small parts may need to be determined and a different emission factor used in computing an emission factor for boat facilities.

OAQPS/ESD/CCPG:MSTRUM/JECK(X7946):NCM(MD-13):5/27/97:MADELEINE1/OBS.497

6. Ambient ~~Temperature~~: Question ~~typical~~ representativeness

It was pretty cold & certainly not typical of a FL/TN plant in summer.

NATIONAL MARINE MANUFACTURERS ASSOCIATION

14 August 1996

Dr. Madeleine Strum
U.S. Environmental Protection Agency
Office of Air Quality and Planning Standards
MD-13
Research Triangle Park, North Carolina 27711

RE: Boat Manufacturing Emission Factor Issues

Dear Dr. Strum;

Per our recent conversation, it has come to the attention of the National Marine Manufacturing Association (NMMA) that emission related information from the recent report, Evaluation of Pollution Prevention Techniques To Reduce Styrene Emissions from Open Contact Molding Processes, Draft Report, prepared by Research Triangle Institute (RTI) in cooperation with U.S. EPA., EPA Cooperative Agreement CR 818419-03, September 1995, (RTI report), is being inappropriately used to represent emission factors for the boat manufacturing industry. In fact, several regulatory agencies have suggested, including EPA Region IV, that the RTI data is the only acceptable data which will be approved by their agency. The two enclosed letters / + a note? provide examples of the type of situation which appears to be developing within certain regulatory agencies.

This issue is a major concern to the NMMA and its members for several reasons which have been outlined in this letter for your review.

Applicability of FRP Fabrication Emission Factors to Boat Building

First, the RTI report was not intended, designed or implemented to develop emission factors for the boat manufacturing industry. NMMA does not support utilizing data which is not representative of the processes and which may not provide reasonably expected emission factors for the industry. NMMA has commissioned, Emission Factor Evaluation Fiberglass Reinforced Plastic Open Molding, which evaluated emission study references, including the RTI report. The current draft of this document is being provided for your reference. The review concluded that the RTI data is not representative of conditions in boat manufacturing operations.

As you are aware, RTI and CFA have conducted lab and bench-scale tests to evaluate emissions associated with certain application techniques. While these studies provide valuable information they are not directly applicable to boat (large part) manufacturing facilities. Based on ERM's evaluation of the RTI report, the CFA study and other open molding FRP fabrication emission studies, emission factors determined in lab and bench scale FRP fabrication studies are not representative of emissions from boat building operations. Due to variable FRP fabrication process parameters (e.g., higher percentage of over spray, thinner laminate thickness, smaller mold size, different mold shapes, etc.), lab and bench-scale studies overestimate emission factors for large scale FRP open molding processes, such as boat manufacturing.

how do you know? How can they be adjusted?

large parts?

In addition, emission factors developed from synthetic marble open molding and panel manufacturing emission studies (i.e., RTI reference studies) are also not representative of boat building operations. The size and shape of molds used for these products, as well as the application sequence employed (e.g., gelcoating of cast synthetic marble fixtures rather than molds), are considerably different than those used for boat building. Consequently, these operations should not be used to evaluate boat building emissions.

what difference does seq. make?

Uniformity of National Emission Factors and Impact of Altered AP-42 Factors

No

NMMA believes that there is a misunderstanding of the impact altering AP-42 will have on the boat manufacturing industry. Millions of dollars have been expended during the past several years to comply with a wide range of federal and state mandated programs including:

- NSR
- Title V
- PSM
- Construction permit programs
- Air Toxics programs

Any change in AP-42 must be based on solid scientific studies designed to develop emission factors representative of the boat manufacturing industry.

- point out jeopardy to industry using low factors

NMMA believes it is inappropriate to issue guidance materials that will have the effect of a rule and that are not subject to formal rulemaking, peer review, and dialogue with the regulated industry. This has the effect of establishing an emissions-limiting standard whether that is the intention or not. As you are aware state and local agencies, and even the EPA, strictly adhere to various EPA guidance documents and memos for implementing regulatory programs and whether this should be the case is moot due to the fact that precedent for doing so has become an integral part of the regulatory process.

Noble's memo?

NMMA does not believe that EPA intended for RTI's data to be used out of the context of its originally designed purpose. EPA must realize, for obvious reasons, that there must be continuity in setting standards, guidance and regulations at the federal level..

so?

Efforts to Advance Forward

NMMA is willing and supportive of moving forward to assist EPA with developing emission factors which are truly representative of the boat manufacturing industry. NMMA has been working on this issue for some time. ERM was engaged to evaluate AP-42, the RTI report, and other styrene emission studies. This process is ongoing, although we are providing EPA with this draft report. NMMA has also established a task force and allocated funds for emission testing. NMMA requests EPA assign a case manager at this

how much? protocol? - follow RTI's of their oversight?

see M.S. letter

time to expedite the process along and develop standards which are accurate and relevant to the boat manufacturing industry. As you know, the NMMA has demonstrated it's willingness to be proactive in developing sound regulations and technical data and will do so throughout the project.

We believe it is absolutely necessary and request that EPA issue an interim guidance memo to EPA regional offices and states regulatory agencies requesting that the RTI data not be utilized as emission factors until this data can be verified in a boat manufacturing setting or representative data can be developed. NMMA appreciates your continued attention to these issues and welcomes the opportunity to discuss these comments with you at any time.

what to use instead?

need to tie in states

Sincerely:

John McKnight

John McKnight, Director
Environmental and Safety Compliance

cc: Geddes Ramses, USEPA, RTP, NC
Bruce Jordan, USEPA, RTP, NC
Mike Trutna, USEPA, Durham, NC
Marie Malave, USEPA, Washington DC
Ron Ryan, USEPA, RTP, NC
Leonardo Ceron, USEPA, Region IV, Atlanta, Georgia
NMMA Clean Air Task Force

METROPOLITAN GOVERNMENT of NASHVILLE and DAVIDSON COUNTY

STEPHANIE B.C. BAILEY, M.D., M.S.H.S.A.
Director of Health

METROPOLITAN HEALTH DEPARTMENT
311 - 23rd Avenue, North
Nashville, Tennessee 37203
FAX: (615) 340-5665
Writer's Direct Telephone Number:
(615) 340-5653
~~Writer's Direct FAX Number:~~
(615) 340-2142

July 16, 1996

It has come to my attention that the U.S. Environmental Protection Agency, Region IV, is of the opinion that the existing AP-42 emission factors for polyester resin plastic products fabrication should no longer be used for projecting emissions from spraying and hand lay-up of gelcoat and polyester resin. At this time I am enclosing copies of the information that I have been able to obtain to date. As you can see, the test results outlined in Table 6-8 of the Research Triangle Institute Draft Project Report indicate that the AP-42 emission factors underestimate emissions by a factor of 2.0 to 2.5.

According to Mr. Leo Ceron of Region IV, an informational package regarding this matter will be mailed in approximately two months to all State and local agencies within the Region. However, due to timing constraints regarding the submittal of Title V applications. I am providing you with the information that has been made available to this office to date and I will provide you with any additional information that I receive in the future regarding this matter.

If you have any questions regarding this matter, please contact me at 340-5653.

Very truly yours,

Rob Raney

Rob Raney, P.E., Division Engineer
Division of Pollution Control

RR/nr
Enclosure

7/10/96

Rob,

Region 4 considers the attached emission factors to be the best available data.

If you have any questions please call Leo Ceron at 404/347-3555 x 496.

Alan Drake

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

DEC 17 1996

MEMORANDUM

SUBJECT: Request for Quality Assurance/Quality Control Review of National Marine Manufacturers Association Test Program at U.S. Marine, Washington State

FROM: Madeleine Strum M Strum
Coatings and Consumer Products Group, ESD (MD-13)

TO: Bill Lamason, Group Leader
Source Characterization Group - A, EMAD (MD-14)

THRU: Linda Herring, Group Leader Jaci Meyer for Linda Herring
Coatings and Consumer Products Group, ESD (MD-13)

This is to request that the Emission Measurement Center (EMC) provide oversight for the quality assurance for the emission test program to be conducted by the National Marine Manufacturers Association (NMMA) at a laboratory of the U.S. Marine facility in Arlington, Washington. The purpose of the industry-sponsored test program is to assist development of the Maximum Achievable Control Technology (MACT) standard for Boat Manufacturing and to assist in the development of an emission factor model for reinforced plastic composites. The NMMA will be developing the test plan with the goal of performing the project under EPA/OAQPS Category 2 Quality Assurance/Quality Control (QA/QC) guidelines. The request from our group is, therefore, to conduct the necessary review of their plan and conduct the necessary audits and, if appropriate, send a letter stating that the NMMA project met EPA/OAQPS Category 2 QA/QC requirements. As part of this effort, we also request that EMC work with the NMMA to detemine how the largest number of different scenarios could be tested within the NMMA time frame without jeopardizing data quality.

BACKGROUND

A group of stakeholders from EPA, industry and State air programs was formed to address issues raised by the industry and State stakeholder groups in the development of the Presumptive MACT for Boat Manufacturing. The group is called the Emission Data Issue Group, and part of its scope is to develop and approve the industry sponsored test program and ensure it collects the data needed to address issues raised during presumptive MACT development. The EPA stakeholders consist of ESD, EMAD (both EMC and the AP-42 group), ORD, and an EPA

Regional Office. EPA, State representatives and the NMMA have been meeting as part of the Emission Data Issue Group since early October and are making progress towards helping NMMA put together a successful and useful test program. While ORD originally agreed to review NMMA's plan and provide auditing, funding issues between OAQPS and ORD could not be resolved. (ORD has no funding in this project.) It is estimated that the funding for the audit would be approximately $10,000. (The total cost of this request for QA review may be more, depending on whether the quality assurance review will be done in-house or contracted out.) Because EMC is also a partner in this effort and has both the expertise and funding mechanism, it is requested that EMC lead the process.

The test program itself is the responsibility of the NMMA. They have hired Radian International to do the testing and prepare the Quality Assurance Plan (QAP). Their goal is to submit the QAP in early January and carry out the testing in February of 1997. The testing will be done in a laboratory spray booth designed to meet the EPA definition of a permanent total enclosure. The laboratory is at a US Marine boat manufacturing facility located in the city of Arlington in Washington State. The NMMA will conduct a processing step in the spray booth (such as the spray up and curing of a hull) and measure both the concentration of hazardous air pollutants and air flow rate from the enclosure using EPA test methods.

The NMMA plans to conduct 21 days of testing. They expect a single test to take a full day, since curing emissions take place for a long time after the resin is applied. Thus, 21 days will allow them to test seven different scenarios, each run in triplicate. If they can still meet the precision required for data measured at Category 2 level QA by shortening tests or by doing duplicates in place of triplicates for some test runs, more scenarios would be able to be performed. The Emission Data Issue Group would prefer the most test scenarios to be run as possible without jeoparding data quality, and would request that EMC help to determine options for the NMMA to run the most test scenarios possible.

The reason that NMMA requested EPA/OAQPS provide oversight at the category 2 level is twofold: 1) they want to assure that the performance of their project follows EPA/OAQPS category 2 guidelines, which gives them a level of confidence in the quality of data they collect, and 2) the Composites Fabricators Association (CFA) carried out a similar test program in which the phase 1 testing was performed under EPA/ORD's category II guidelines. Since NMMA's project is directed towards providing data for consideration in developing AP-42 emission factors and may provide data which will be useful in developing the MACT standard, we are requesting that the EMC lead the QA for this effort.

COORDINATION

We request that the Emission Measurement Center's effort be coordinated with the Emission Data Issue Group (Solomon Ricks is a participant of this group) and in particular John McKnight, (202) 944-4980, of the NMMA, and Ron Ryan (X4330) of the Emission Factor and Inventory Group. It would also be helpful to coordinate with Shirley Wasson (X1439) of ORD since she provided the EPA/ORD QA/QC Category 2 oversight for the CFA testing and has a great deal of experience in this area.

cc: Ron Ryan, OAQPS, (MD-14) ✓
Shirley Wasson, ORD, (MD-91)

ATTACHMENT 4

A discussion of the present AP - 42 factors underestimating VOC (or monomer evaporative) emissions from polyester resin material operations

A discussion requested at the first boat manufacturing presumptive MACT meeting

by Madeleine Strum
November 1995

Throughout EPA's recent studies of the reinforced plastic industry (1992 thru present), efforts have been made to collect emissions data for the various fabrication processes. Through this data collection, a contractor to EPA's Office of Research and Development, Research Triangle Institute (RTI) found the following data:

4 source test results for gelcoating: 1) EPA/Southern Research Institute testing at Eljer Plummingware (now Carolina Classics); 2) EPA/Radian testing at Venetian Marble; 3) EPA/Radian testing at General Marble, and 4) Radian (for the facility) testing at Cortec, Ohio.

2 source tests results for resin sprayup, one using a vapor suppressed resin, and the other using a non-vapor suppressed resin: 1) EPA/Southern Research Institute testing at Eljer Plumbingware (now Carolina Classics) - vapor suppressed; 2) Bison Engineering testing at GEA Dynamic Fabricators in Idaho- non vapor suppressed.

In all cases except for the testing at Cortec (gelcoating), the source tests were above the AP-42 midpoint value by at least 2.2. Note that these tests were above the AP-42 "high" value of the range by 1.8. The Cortec results were 1.4 times the AP-42 midpoint for the "baseline" gelcoat, and 1.0 times the midpoint for a "high performance" gelcoat (faster gel time.). The Cortec facility gelcoating operation involved an automated system where the spray gun was mounted in place and was spraying a flat surface perpendicular to the surface. Due to negligible overspray in such a system, and the fact that the spray gun was a constant and likely significantly shorter distance to the surface than it would be at a facility in which an operator was spraying the gun on a non-flat part, it is expected that the emission factor would be significantly lower at the Cortec facility.

In addition to the above published source tests, tests were performed on two facilities in the west, Lasco Bathware in Maopa, Nevada, and Aquaglass in Oregon. In both these cases it was determined that the permitted yearly emission rates based on AP - 42 were significantly below values determined from source testing.

To explore why these more recent tests (done between 1991 through 1994) were consistently above AP-42, RTI examined the source of AP-42, concentrating on the report publsihed in 1982 by Science Applications, Inc. (SAI) , prepared for the California State Air Resources Board. The AP-42 values for non vapor suppressed gel coat spray up and non vapor suppressed resin spray up (as well as some closed mold fabrication processes) were taken from this report. The other factors published in AP-42 came from "industry experts" and a research paper done by a large resin supplier on the effect of vapor suppressents on emissions which indicated suppressents may reduce emissions by 30-70%. AP-42 factors for hand lay up were significantly lower (factor of 3) than those in the SAI report.

SPRAY UP

In examining the SAI report, it was determined that the resin spray up emission factor range came from a single source test performed on a tank manufacturer. RTI hypothesized that the reason the emission factor was lower than that calculated from recent testing was that the linear air velocity in the vicinitiy of the surface of the part was significantly lower than that seen at today's spray up facilities (and at all the recent source tests they found). The tank manufacturer's velocity was 18 feet/minute comparte to 120 feet/minute at Eljer plumbingware. This higher velocity is much more representative of spray up operations in the industry.

RTI sent a letter on September 22, 1994, to Bob Lacovara, of the Composite Fabricators Association (CFA), explaining this.

GELCOAT

Since that time another possible hypothesis has arisen, which would explain not only the spray lay up results, but also, the gel coating results. The upper bound for gelcoat came from a single test at a cultured marble facility. It was noted that SAI "corrected" their organic vapor analyzer results, which were consistently higher, with the charcoal trap sampling results, . It is conjectured that It is more likely that the charcoal trap results underestimated emissions than the organic vapor analyzer over estimated them. Therefore, the organic vapor analyzer should not have been corrected.. This would affect emissions by approximately 30% (i.e. they would be too low by 30%). This does not completely explain the significant difference between AP-42 and the more recent gel coating results. Another possibility is that the assumption that all emissions from the gelcoating operations were captured and measured was not necessarily correct. Clearly, we do not have a complete explanation for why the older test is far below the newer tests.

ADDITIONAL TESTING

A summary of the above results with additional results from RTI's emission testing was distributed with the material provided for the first presumptive MACT meeting for Boat Manufacturing (Item 5 of the October 20, 1995 letter to Presumptive MACT participants). We have also received information from the CFA testing in which hand lay up emissions were significantly above AP-42. They indicated that the gelcoating results were also above AP-42, but not quite so high as a factor of two. We will look forward to analyzing this data, and any other emissions data that may help us understand emissions from these open processes.

ATTACHMENT 5

CASE STUDY ASSIGNMENTS FOR POLLUTION PREVENTION TECHNOLOGIES IN BOAT MANUFACTURING

Instructions:

Roundtable participants have been assigned to call the boat manufacturers using the pollution prevention technologies listed in Attachment 5a. They should collect information from the boat manufacturers according to the questions listed in Attachment 5b and then prepare a telephone contact report similar to the examples provided in Attachment 5c. Please feel free to trade assignments if desired. Do not record or summarize any information that the manufacturer claims is confidential business information. Each contact report must be sent (by mail or fax) to the person contacted so that he or she can review the report for accuracy and completeness

ATTACHMENT 5a

Users of Pollution Prevention Technologies in Boat Manufacturing

Resin Infusion Molding

Mike Davidson/Hank Nauer:
- Ocean Technical Services, Harvey, LA
  - ~~Mike Wildman, (504) 245-1571~~
- Bollinger Shipyard, Lockport, LA (504) 532-2554

John McKnight:
- Textron Marine Systems Division, New Orleans, LA (504) 245-6600
- Ingalls Shipbuilding, Pascagoula, MS (601) 935-1122

Rubin Deza/Mike Mittelholzer:
- Sabre Corporation, South Casco, ME (207) 655-3831
- Holby Marine, Bristol, RI (401) 253-1711

Cindy Brandt:
- C & C International, Niagara-on-the-Lake, Ontario, Canada (905) 468-2901

Flow Coaters and Resin Rollers

Mohan Balagopalan:
- Corsair Marine, Chula Vista, CA (619) 585-3055

Beth Hardin:
- Correct Craft, Orlando, FL (407) 855-4141
- Pro-Line Boats, Homosassa, FL (904) 795-4111

Jerry Kissell:
Thoroughbred Powerboats, Sanford, FL (407) 328-8882

John McKnight:
Sunfish Laser, Portsmouth, RI (401) 683-5900

Richard Tripp:
Trident Shipworks, Inc., Belton, SC (803) 231-8854

Leonardo Ceron:
OMC Javelin Boats, Old Hickory, TN (615) 895-5190

Christine Vineyard:
Scout Boats, Summerville, SC (803) 821-0068
Beneteau Boats, Marion, SC (803) 423-4201

Resin Transfer Molding

Darrell Harmon:
Kawasaki Motors, Lincoln, NE: Larry Nissan (402) 476-6600

Vapor Suppressed Resin

Mohan Balagopalan:
Catalina Yachts, Woodland Hills, CA (818) 884-7700

ATTACHMENT 5b

Questions to ask boat manufacturers that are using pollution prevention technologies:

Name of company contacted:

Name and title of contact:

Address and telephone number:

Date of call:

Would you describe your operation as a production boat manufacturing facility or as a custom boat manufacturing facility?

On what types of boats is this technology used (e.g., sail or power, size)?

How many boats do you build per year?

How long have you been using this particular technology?

If this technology is not used on all the boats you manufacture, why not?

What were the reasons for which you switched to the current technology?

What types of application technology were you using in the areas in which you now use this technology?

For what situations is this technology especially applicable?

In what situations do you use this technology rather than others?

Are there special requirements for your products that require you to use certain resins, gelcoats, reinforcements, or application technologies?

Have you experienced or noticed any change (increase or decrease) in the performance characteristics of your product (e.g, tensile *or flexural strength, secondary bonding) with the new technology? If so, please describe those changes. Have they been quantified?*

What percent of the total resin used per year is applied using this technology?

What are the characteristics of the resin used with this technology?

Are any other advantages provided by using this system, such as reduced costs or safety hazards?

What have been the costs of adopting this system?

On what types of boats, if any, is this technology not feasible or practical; have you tried it on these types?

What were the problems that you encountered when you first started using this technology? How were they resolved, if at all, and did those solutions create other problems?

Are there specific areas of a typical boat part or mold on which this technology can not be used, such as in tight corners?

Have you experienced any problems with dry spots or excess resin in the reinforcements when using this technology? If so, how were they solved?

Have you experienced any problems with resin curing or hardening in the distribution lines or application equipment while using this technology? If so, how were they solved?

Have you experienced any problems with cleaning this type of application equipment? If so, how were they solved? What type of solvent do you use?

Are there specific types of reinforcements or core materials on which this technology cannot be used? Why?

Is there anything else we should now about this technology when it is used for fiberglass boat manufacturing?

ATTACHMENT 5c

Sample Contact Reports for Pollution Prevention Case Studies

M E M O R A N D U M

TO: Madeleine Strum, EPA/ESD

FROM: Brian Palmer, Radian Corp.

DATE: November 21, 1995

SUBJECT: Telephone conversation with John Spaulding, The Hinckley Company, Southwest Harbor, Maine, to collect information on the use of resin infusion molding in boat manufacturing. November 9, 1995; (207) 244-5531 (fax: 9433).

Would you describe your operation as a production boat manufacturing facility or as a custom boat manufacturing facility?

The Hinckley Company is a semi-custom boat manufacturer. They build about 20 boats per year that range from 36 to 82 feet in length, including both power and sailboats. They fabricate some hulls for other builders and also finish some hulls that they purchase from outside builders. They may purchase a hull to finish because they do not have the mold for that particular hull. Mr. Spaulding says that this is not uncommon in the boat manufacturing industry. There is also a service and repair facility located at the same site.

On what types of boats is this technology used (e.g., sail or power, size)?

Hinckley Yachts is currently using Seeman Composites Resin Infusion Molding (SCRIMP) on all the boats for which they have molds. They do not use SCRIMP for "one-off" custom boats because a mold may not be built for these boats. Molds for SCRIMP also must meet certain requirements that may not be found on typical boat molds. Therefore, they do not use SCRIMP on some parts made with older molds. However, as these molds are replaced, the new molds are SCRIMP-compatible so Hinckley expects to increase the percentage of parts that are made with SCRIMP.

How many boats do you build per year?

Hinckley Yachts builds about 20 boats per year, but this depends on the size of boat they are building and the demand for certain models. For example, they recently completed twentyeight 36-foot powerboats that Mr. Spaulding referred to as "picnic boats."

How long have you been using this particular technology?

Hinckley Yachts purchased a SCRIMP license in October, 1993 and began using the process in January 1994. So far, they have built about 30 boats using SCRIMP.

If this technology is not used on all the boats you manufacture, why not?

Hinckley Yachts uses the SCRIMP process on nearly all of their hulls and on about one-half of the decks that they produce. However, not all of their molds meet the physical requirements for using the SCRIMP process, such as having a specific type of mold flange. In other cases, such as the decks, SCRIMP is not used for cosmetic reasons because the process currently produces some "print through" on the finished part. For most hulls and decks built by Hinckley, this is not a problem because the parts are painted. However, some deck molds contain a non-skid surface pattern and paint cannot be applied over this pattern on the finished deck. Therefore, SCRIMP cannot be used to build these decks.

Hinckley has used SCRIMP to produce the deck of a 72 foot sailboat. In this case, the cosmetic appearance of the deck was not a problem because the deck was eventually covered with wooden planks of teak.

What were the reasons for which you switched to the current technology?

Mr. Spaulding says that there is no one single reason for switching to SCRIMP. One incentive is that Maine has an air toxics regulation that required Hinckley to control air emissions. Other reasons were to improve worker safety and reduce exposure to styrene. Another reason was to improve the overall shop environment by reducing the need to wear protective gear and to minimize contact with resins and catalysts. Finally, they were looking for a way to produce lighter and stronger parts and to minimize material consumption.

What types of application technology were you using in the areas in which you now use this technology?

In the past, Hinckley has used a combination of spray-up with chopper guns, wet-hand lay-up with spray applicators and flow coaters, resin impregnators, and wet vacuum-bagging to produce different parts. These different methods still account for about 20 percent of the resin that they apply.

For what situations is this technology especially applicable?

DISCUSSION ON AP-42

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

November 28, 1995

Dear Presumptive MACT Participant:

Enclosed are the minutes of the first round table teleconference for the presumptive MACT for the Boat Manufacturing category which was held October 31, 1995. The minutes have six attachments, two of which deserve special attention. Attachment 5 contains the case study assignments and a protocol and examples for conducting a case study; please feel free to make any changes you see fit in conducting your specific study. Attachment 6 is the communication protocol which directs the leads to whom to send this package. In addition, please note the action items that are listed in the minutes.

We request case studies be completed by January 19, 1996. Please send them to me by E-mail and I will distribute them per the communication protocol.

If you have any questions or comments regarding this information, please call me at (919) 541-2383.

Sincerely,

Madeleine Strum

Madeleine Strum
Environmental Engineer
Coatings and Consumer Products Group

Enclosure

ADDRESSEES:

Linda Chappell, OAQPS/AQSSD (sent electronically)
Beth Hardin, Florida DEP (sent electronically) *
Linda Herring, OAQPS/ESD (sent electronically)
Norm Kaplan, ORD (sent electronically) *
John McKnight, NMMA (sent electronically) *
Hank Nauer, Illinois EPA (sent electronically) *
Nancy Pate, OAQPS/ITPID (sent electronically)
Solomon Ricks, OAQPS/EMAD (sent electronically)
Richard Tripp, Region 7 (sent electronically) *

* Lead Participant (will forward this package to other participants)

M E M O R A N D U M

TO: Madeleine Strum, U.S. EPA/ESD

FROM: Brian Palmer, Radian/RTP

DATE: November 28, 1995

SUBJECT: Boat Manufacturing P-MACT Teleconference, October 31, 1995

I. PURPOSE

This was the first meeting of the Roundtable for the boat manufacturing presumptive MACT (P-MACT) process. The primary objectives of the meeting were to describe the requirements of the Clean Air ACT (the Act) and the P-MACT process; to describe the information collected by the EPA and the information still needed to develop P-MACT; to discuss options for the format of a styrene emissions standard; and to agree on work to be accomplished before the next meeting.

II. LOCATION AND MEETING PARTICIPANTS

Place: U.S. Environmental Protection Agency
N.C. Mutual Life Building, Room 1101
Durham, North Carolina

Date: October 31, 1995, 1:30 - 3:45 pm

Participants:

Table 1 contains a list of meeting participants, their affiliations, and phone numbers.

Table 1. Meeting Participants

Name	Affiliation	Phone
Mohan Balagopalan	South Coast Air Quality Management District	(909) 396-2704
Dan Boyd	Consultant to the NMMA	(410) 827-6244
Cindy Brandt	Wisconsin Dept. of Natural Resources	(414) 492-5879

Table 1. Meeting Participants (Continued)

Name	Affiliation	Phone
Bob Burmark	Washington Dept. of Ecology	(360) 407-6812
Leonardo Ceron	EPA Region 4	(404) 347-3555
Linda Chappell	EPA/AQSSD	(919) 541-2864
Richard Cooper	EPA Region 7	(913) 551-7566
Roger Crawford	Outboard Marine Corp.	(708) 689-5219
Mike Davidson	Illinois Environmental Protection Agency	(217) 785-1722
Rubin Deza	Maryland Dept. of the Environment	(410) 631-3255
Eric Goehl	Radian Corp.	(919) 461-1367
Beth Hardin	Florida Dept. of Environmental Protection	(904) 488-0114
Darrel Harmon	Lincoln Lancaster Health Dept.	(402) 441-6235
Doug Hoffman	Grady White Boats	(919) 752-2111
Norm Kaplan	EPA/ORD	(919) 541-2556
Jerry Kissell	Florida Dept. of Environmental Protection (Tampa)	
Mary McConnell	Genmar Industries	(612) 337-1803
John McKnight	National Marine Manufacturers Assoc. (NMMA)	(202) 944-4980
Hank Nauer	Illinois Environmental Protection Agency	(217) 785-1716
Brian Palmer	Radian Corp.	(919) 461-1218
Nancy Pate	EPA/ITPID	(919) 541-5347
Geddes Ramsey	EPA/ORD	(919) 541-7963
Joette Steger	Radian Corp.	(919) 461-1277
Madeleine Strum	EPA/ESD	(919) 541-2383
Kevin Thompson	Sea Ray Boats	(615) 522-4181
Richard Tripp	EPA Region 7	(913) 551-7566
Christine Vineyard	EPA Region 9	(415) 744-1197

III. DISCUSSION

Madeleine Strum began the meeting by asking the participants to introduce themselves, including their affiliation and interest in participating on the P-MACT Roundtable. She then described the goals of the meeting as presented in the briefing package.

The remainder of this meeting summary addresses the topics that were discussed according to the order given in the briefing package distributed prior to the meeting (see Attachment 1).

Clean Air Act Requirements: Section 112, Hazardous Air Pollutants

Madeleine Strum described the requirements of the Act. Major sources of hazardous air pollutant (HAP) emissions will be subject to regulation under section 112. A major source is defined as a source with a potential to emit 10 tons or more per year of a single HAP or 25 tons or more per year of multiple HAP. For boat manufacturing, the principle HAP is styrene, so most major sources will be so on the basis of the 10 ton per year criteria. The 189 HAPs are listed in section 112(b) of the Act and boat manufacturing was listed by the EPA as a major source category of HAPs under section 112(c) of the Act.

According to section 112, new sources must meet a level of control no less stringent than the best controlled source in the boat manufacturing category or an appropriate subcategory. Existing sources must meet a level of control that is no less stringent than the average level of control achieved by the best performing 12 percent of existing sources for categories or subcategories with 30 or more sources. If there are fewer than 30 sources in a category or subcategory, then existing sources must meet a level of control no lower than the average level of control achieved by the average of the top 5 sources.

Madeleine Strum pointed out that these criteria only establish a minimum level of control known as "the floor." The Act presumes that the EPA will do analyses to consider costs and other factors in examining levels of control more stringent than the floor. The relevant parts of section 112(d) of the Act are included as Attachment 2.

Madeleine Strum then described the P-MACT process for implementing section 112 including the function of the P-MACT determination. The EPA's current schedule for the boat manufacturing P-MACT process is to recommend a P-MACT determination to the Director of the Emission Standards Division by May 1, 1996.

Madeleine Strum added that the EPA is still looking for an interested environmentalist to participate in this P-MACT Roundtable. She asked the group to let her know of any environmental groups that may be interested in participating.

Source Category Profile

Madeleine Strum described the steps in the boat manufacturing process that EPA has identified as potential HAP emission sources. Hank Nauer suggested that the EPA add "detailing" to the list of process steps; this involves applying stickers, logos, and decorative materials to finished boats. The detailing materials may use adhesives that contain toluene, methyl ethyl ketone, or other HAP.

Ruben Deza asked if the EPA is including boat maintenance and repair operations in this source category. Roger Crawford responded that maintenance and repair would more likely occur at marinas and boat yards than at manufacturing facilities. Other participants noted that boat maintenance and repair operations at separate facilities would probably not be major HAP emission sources. John McKnight commented that the National Marine Manufacturers Association (NMMA) represents boat manufacturers, but not boat yards and marinas, and could not provide much information on boat yards and marinas.

Madeleine Strum asked the meeting participants to consider which processes and products should be the focus of this P-MACT study and whether some processes should be a higher priority for discussion than others.

Since the Roundtable will need to again discuss which processes and products should be the focus of the P-MACT (after the data from the industry survey is analyzed), the following considerations should be made:

1. Does the emission source occur at major sources? For example, if maintenance and repair would not occur at facilities which are major, we would likely not want to spend time on this source.

2. Are there applicable emission reduction techniques (pollution prevention or add-on control) for this emission source?

3. Can this emission source be potentially covered by another MACT standard? For example, the finishing of furniture parts inside a yacht would be covered by the wood furniture NESHAP, if the facility that performs this operation is a major source.

4. Is it beneficial for the group to research this emission source within P-MACT? If not, is it beneficial for EPA to spend efforts researching this emission source after P-MACT?

5. Can the emission source be covered by applying emission limits from another standard (e.g., shipbuilding and ship repair painting limits)?

Emissions Profile

1. Toxic Release Inventory (TRI) Data

Madeleine Strum then described the distribution of boat manufacturers by State, according to the National Association of Boat Manufacturers (NABM) membership list, and the distribution of boat manufacturers that are major sources, according to the TRI database. Several meeting participants noted that the TRI data presented did not match information for specific facilities. Madeleine Strum stated that the EPA would review the TRI data and update the summary tables, if necessary. Brian Palmer described how the data would eventually be used by the EPA to develop "model plants" for estimating typical emissions and potential emission reductions from different control options.

[Note to meeting participants: The TRI data were reviewed after the meeting and an error was discovered in the TRI data summary; Attachment 3 contains a corrected TRI data summary, as confirmed by several of the industry and State meeting participants.]

Hank Nauer and Bob Burmark commented that the States will soon have data from manufacturers that have submitted their Title V Operating Permit Applications and these data may be more complete and up-to-date than the TRI data.

2. RTI/EPA Resin and Gelcoat Emission Testing Program

Madeleine Strum summarized the results of the RTI/EPA cooperative testing program and noted that the measured styrene emissions from gel coat spraying and open molding were 1.6 to 2.5 times higher than if the emissions were predicted using the current AP-42 emission factor midpoints. (Pages 42 and 48 to 50 of the draft RTI/EPA styrene emission test report were distributed to the Roundtable before the meeting.) Geddes Ramsey stated that the RTI/EPA emission study would be released as an EPA report once the EPA peer review has been completed. Madeleine Strum asked the group to submit any styrene emission data they may have available that could be used to help update the AP-42 emission factors. She also asked the industry representatives to consider the possibility of sponsoring additional emissions testing.

Mary McConnell asked if the AP-42 emission factors would be updated as a result of the testing and whether any updating of the factors would be performed as part of the MACT rulemaking process. Madeleine Strum responded that emission factors are usually updated after the rulemaking process because relevant data are often collected during the rulemaking.

Roger Crawford asked if the EPA had considered all relevant data, including those data for the current AP-42 emission factors, before concluding that the current AP-42 emission factors should be revised. Madeleine Strum responded that all available data had been considered in developing and evaluating the RTI/EPA testing program and its conclusions. These analyses were documented in technical memoranda and were summarized in the RTI/EPA test report. These analyses could not explain the differences between the data used to develop the AP-42 emission factors and the current RTI/EPA test results, but the RTI/EPA test data show similar styrene emission rates as other styrene emission tests performed between 1991 and 1995.

Roger Crawford stated that some industry test results were not consistent with the latest RTI/EPA test results and that the industry is considering some new testing. He asked the EPA for a discussion of why the EPA has concluded the AP-42 emission factors underestimate styrene emissions. Attachment 4 contains a brief discussion of this issue.

Emission Control Profile

Madeleine Strum described the pollution prevention and add-on controls that have been demonstrated in boat manufacturing or in the reinforced plastic parts industry. Roger Crawford asked in what types of facilities the add-on controls had been demonstrated. Madeleine Strum responded that they had been demonstrated at facilities producing fiberglass tubs and showers and truck caps. Doug Hoffman added that these fixtures are large, but they are smaller than boats, especially large luxury yachts. Madeleine Strum agreed but reminded the group that the EPA must consider the complete range of boat types and emission sources within the industry. Some pollution prevention or add-on controls may be feasible as MACT for some subcategories or emission sources, but not for others.

Madeleine Strum stated that the EPA was looking for case studies of successful applications of pollution prevention or add-on control technologies. The EPA has a list of facilities that could be sources of case studies and will assign Roundtable members to research these case studies. The EPA would also welcome other examples from the States and industry. Attachment 5 contains assignments and guidance for Roundtable members to collect case histories.

Dan Boyd commented that it may be difficult to apply add-on controls to boat manufacturing because of the high ventilation flow rates that are typically needed in boat plants. Madeleine

Strum responded that the EPA needs to determine whether these high flow rates are necessary for all subcategories or whether some types of boats and processes can be enclosed in a spray booth with a lower flow rate. Dan Boyd agreed there is a lot of diversity in the industry but noted that the typical flow rate from even a small spray booth is 60,000 cubic feet per minute (cfm).

Jerry Kissell agreed that enclosures for large boats may not be practical, but stated that the group needs to consider the best available controls, even if the top 12 percent of the industry is not achieving significant emission reductions. Madeleine Strum added that the EPA has to analyze all available controls because the Act establishes the MACT floor only as a minimum level of control. She stated that the floor for existing sources would probably not include add-on controls. However, the floor may include some pollution prevention measures such as resin rollers, that could achieve substantial emission reductions. Mary McConnell commented that the group should focus on pollution prevention measures rather than add-on controls.

NMMA Industry Survey Preliminary Results

Madeleine Strum described the preliminary results from the first 60 industry survey respondents; these results were compiled by the NMMA. She noted that none of the respondents had performed HAP emission testing, but added that Roger Crawford knew of some industry members that have measured styrene emissions.

Hank Nauer asked if the NMMA could be sure that the survey covered a good cross-section of the industry. He noted that some of the smaller facilities may not have good representation and that there is substantial size and process variation even among major sources. John McKnight responded that the NMMA has collected additional responses since the summary was completed. The NMMA now has responses from most of those facilities that would be major sources and that represent a large percentage of the total sales volume. He added that the survey respondents included facilities with as few as 15 employees to more than 400 employees and that small and medium sized builders are also members of the P-MACT Roundtable.

Roger Crawford asked if the survey responses included sailboat manufacturers. John McKnight answered that he had responses from some sailboat manufacturers and that he would make sure the major sailboat manufacturers were not missing from the database. He noted that only 4 or 5 sailboat manufacturers are major emission sources.

Madeleine Strum asked if the NMMA could determine who had not responded to the survey and if any effort had been made to contact builders that are not NMMA members. John McKnight responded he would provide the EPA with a list of respondents and NABM members that did not respond. He noted that non-NMMA builders are generally smaller custom builders that are probably not major emission sources. Dan Boyd added that one of the more popular boat building magazines published an editorial asking all builders to obtain and complete a copy of the NMMA survey. Madeleine Strum and Roger Crawford suggested that the States could also compare the list of respondents to the permits they have on file for boat manufacturers.

[Due to a confidentiality agreement between the NMMA and the survey respondents, the NMMA cannot provide a list of survey respondents to the EPA. However, the TRI data summary in attachment 3 indicates those facilities from which a survey response is not expected because the facility is not an NABM member. Additional information on these facilities must be collected from the States or through an additional survey. Roger Crawford has also indicated that the TRI data summary based on 1993 data presents an artificially low number of major sources because 1993 was a poor production year as a result of the economic recession of the early 1990's.]

Developing Subcategories

Madeleine Strum described the reasons for considering subcategories when developing MACT standards and the issues associated with developing subcategories. She said that the industry survey data should help the EPA identify appropriate subcategories for this industry. One issue to be resolved by the Roundtable is whether P-MACT should be determined for all subcategories of boat manufacturers or whether the Roundtable should focus on only the larger subcategories of manufacturers.

Leonardo Ceron asked if it would be possible to share some of the information collected in the reinforced plastic parts NESHAP. Madeleine Strum responded that it would be better to keep some aspects of the two projects separate because the industries are different. However, some information could be shared, such as information on add-on controls, and pollution prevention (this information was provided to the Roundtable before the meeting), and the RTI/EPA styrene emissions testing program. It may also be possible to use the same format for the standard, but no format has been selected for the reinforced plastic parts P-MACT.

Possible Formats for a Styrene Emissions Standard

Madeleine Strum described the possible options for the format of the standard. She noted that one option not included in the list in the briefing package is a numerical emission rate or concentration limit. She asked the State and Industry representatives to consider what is a practical format for a styrene emission standard and to provide feedback to the EPA.

Hank Nauer pointed out that other standards, such as the chromium electroplating NESHAP, have adopted performance-based emission standards based on pollution prevention technologies. He and Madeleine Strum also described a format that assigns credits or points to different control options based on their emission reduction potential and sets a standard in terms of a minimum number of credits or points a facility must "earn" by using one or more control options.

Norm Kaplan stated that if a standard specifies a certain control technology, a facility should be able to use a different control option as long as they can prove that they are achieving an equal level of control.

Dan Boyd stated that an ambient or concentration standard may be feasible because styrene has a 3-hour half-life in the atmosphere. Madeleine Strum noted that the EPA must also reduce exposure to people located near the source and that the Act requires technology-based emission standards. She stated that a concentration-based standard could be used only as long as dilution was prevented. Mohan Balagopalan added that monitoring compliance with such a standard may be difficult. John McKnight pointed out that an ambient standard may be difficult in a situation, such as in Florida, in which several facilities may be located close to each other.

Madeleine Strum pointed out that the half-life of styrene is irrelevant to the development of P-MACT for boat manufacturing because styrene is listed as a HAP and as a possible human carcinogen. Furthermore, the Act requires technology-based emission standards, rather than risk-based emission standards (see Attachment 2). However, several participants indicated they would be interested in reviewing Dan Boyd's information on the half-life of styrene. Madeleine Strum agreed to distribute it. (This will be done via the communication protocol.)

Electronic Information Distribution

Hank Nauer asked whether an electronic bulletin board similar to the MACT subject heading on the AIRS bulletin board on the EPA's Technology Transfer Network (TTN) would be useful for exchanging and distributing information among the P-MACT Roundtable members. Roger Crawford asked how a bulletin board could be used while protecting the confidentiality and integrity of some information. Madeleine Strum noted that most of the information the EPA would like to exchange should not be considered confidential business information (CBI), such as emissions data and control device information. The EPA has published a Federal Register notice on what constitutes CBI that could be distributed to the group with the EPA's CBI procedures.

Norm Kaplan recommended that the group could use electronic mail (email) instead of a bulletin board to exchange some information. The meeting participants agreed to provide their email addresses to the EPA if they had access to email. Madeleine Strum agreed to prepare a communication protocol for distributing information (see Attachment 6). She noted that some documents could not be sent by email because electronic originals are not available and this would be addressed in the protocol. Table 2 contains a list of meeting participants with email addresses.

Madeleine Strum asked for volunteers to be leads for distributing information to other members of the group. John McKnight volunteered as the industry lead and representatives from Florida and Illinois volunteered to be the State leads.

Table 2. Meeting Participants With Email Addresses

Participant	Email
Mohan Balagopalan	mohanb@aqmd.gov
Cindy Brandt	brandc@dnrmai.dnr.wisc.gov
Bob Burmark	rbur461@ecy.wa.gov
Leonardo Ceron	ceron.leonardo@epamail.epa.gov
Linda Chappell	chapell.linda@epamail.epa.gov
Richard Cooper	cooper.richard@epamail.epa.gov
Eric Goehl	eric_goehl@radian.com
Beth Hardin	hardin_e@bep.state.fl.us
Norm Kaplan	kaplan.norm@epamail.epa.gov
Hank Naour	epa2211@epa.state.il.us

Table 2. Meeting Participants With Email Addresses (Continued)

Participant	Email
Brian Palmer	brian_palmer@radian.com
Nancy Pate	pate.nancy@epamail.epa.gov
Geddes Ramsey	gramsey@engineer.aeerl.epa.gov
Joette Steger	joette_steger@radian.com
Madeleine Strum	strum.madeleine@epamail.epa.gov
Richard Tripp	tripp.richard@epamail.epa.gov
Christine Vineyard	vineyard.christine@epamail.epa.gov

Summary of Next Steps

Madeleine Strum summarized the steps the EPA wants to accomplish before the next meeting as described in the briefing package:

- The NMMA will provide the EPA with all available survey responses and an electronic copy of the database; the EPA will complete the survey data entry and analysis and provide the NMMA with a copy of the completed database.
- The NMMA will also provide EPA with a list of survey respondents. [This will not be done]
- The EPA will investigate and resolve the problem with the TRI data summary.
- The EPA will provide a brief history of how the AP-42 emission factors were developed.
- The EPA will assign case studies to the meeting participants and provide them with guidance on collecting information and an example of a case study.
- The meeting participants will complete the case studies before the next meeting, tentatively scheduled for the end of January.
- The industry representatives will provide the EPA with more information on potential HAP emission sources in the boat manufacturing industry, such as detailing and aluminum boat painting.

- All meeting participants will consider which emission sources should be covered in this P-MACT process and will provide comments to the EPA prior to the next meeting.

- Bob Burmark will provide the Roundtable with information on the results of the Washington State pollution prevention planning program.

- The States will keep the meeting participants informed on the availability of Title V operating permit data.

- Roundtable members will provide comments to the EPA on possible formats for a styrene emission standard.

ATTACHMENT 1

Briefing Package for First Boat Manufacturing P-MACT Meeting

October 31, 1995

1:30 pm EST Teleconference

(Revised November 14, 1995)

I. Introductions

EPA, including Regional Offices and contractors

State/Local Agency representatives

NMMA and other industry representatives

II. Meeting Purposes

- Describe the requirements of the Clean Air Act (the Act) and the presumptive MACT (P-MACT) process.
- Summarize the information that we have available; identify additional information that is needed; and develop action items for collecting the additional information.
- Discuss issues related to the format of the standard.
- Agree on what we should accomplish before the next meeting.

III. CAA Requirements: Section 112, Hazardous Air Pollutants

Major source: a potential to emit . . .

- 10 tons per year or more of any single HAP; or
- 25 tons per year or more of any combination of HAP.

Section 112 lists the HAP subject to regulation.

Boat manufacturing is a HAP emission source category scheduled for regulation by 2000.

Standards for new sources: no less stringent than the emission control achieved in practice by the best controlled similar source.

Standards for existing sources: no less stringent than the average emission limitation achieved by the best performing 12 percent of the existing sources for which the Administrator can reasonably obtain emissions information (the "floor").

Implementing 112: EPA's Presumptive-Mact Partnership Program

1. What is the P-MACT determination?

   It is a judgement of MACT based on information that can be obtained in a short time frame.

   It is not a rule; rather, it provides a basis for the development of a proposed and final MACT rule.

2. What is the primary goal of the P-MACT process?

   Accelerate the development of national emission standards.

   Identify important issues early and focus analysis on these issues.

   Primary target: P-MACT recommendation to the ESD Director on May 1, 1996.

IV. Source Category Profile

Common processes at a boat manufacturing facility that are potential HAP sources:

- Mold construction (tooling)
- Mold cleaning and preparation
- Spraying gelcoat
- Laminating by spray up, hand lay up, or closed molding:
  - Applying resin to the laminate
  - Curing of the laminate
- Flotation foam spraying
- Wood finishing
- Gluing
- Solvent cleaning
- Painting fiberglass or aluminum

Types of products from the boat manufacturing industry:

- motor yachts
- power boats
- sail boats
- personal watercraft
- miscellaneous small boats

Issues:

- *Are all of the relevant processes and products included in the lists above?*
- *Is additional information available from the industry or States on HAP emission sources other than styrene and possible control options?*
- *What particular products or processes should be the focus of this P-MACT determination?*

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Geographic Distribution of Boat Manufacturing Facilities

State	NABM Members	TRI HAP Sources	TRI Major Sources	Presumed Major Sources[a]
FL	89	32	18	25
CA	24	9	2	5
IN	22	9	7	7
MI	18	6	4	6
TN	16	14	9	10
MN	15	6	3	5
NC	13	8	5	6
WA	13	10	2	3
WI	13	5	1	3
NJ	11	2	1	1
MD	11	3	3	3
IL	11	5	4	4
MO	10	6	1	1
SC	6	6	6	6
KS	5	4	0	1
All other States	92	33	21	25
TOTAL	**358**	**158**	**88**	**111**

a Total HAP emissions for presumed major source status were estimated using TRI HAP emissions as reported except for styrene, which was doubled based on EPA/RTI emission test results.

V. Emissions Profile

1. Toxic Release Inventory (TRI) Data

TRI Data Summary for All Boat Manufacturers.[a,b]

Pollutant	Emissions (ton/yr)	Percent of Total HAP	Number of Manufacturers
Styrene	3,448 (6,896)	90.0 (94.7)	144
Toluene	153	4.0 (2.1)	16
Xylene	80	2.1 (1.1)	9
Methyl methacrylate	27	0.7 (0.4)	6
Methylene diphenyl diisocyanate	5	0.1 (0.1)	22

a Total emissions do not include 1,1,1-trichloroethane (methyl chloroform); this compound will be phased-out in 1995.

b Emissions and percents are calculated from emissions as reported to TRI; numbers in parentheses are calculated after doubling the styrene emissions, based on EPA/RTI test results.

Distribution of Plants by Total Estimated HAP Emissions.[a]

HAP Emission Range (tpy)	Number of Facilities
0 - 10	47
10 - 20	24
20 - 30	12
30 - 40	10
40 - 50	10
50 - 60	10
60 - 70	7
70 - 80	5
80 - 90	7
90 - 100	6
100 - 200	16
200 - 300	1
> 300	2

[a] Total HAP emissions based on TRI data after doubling styrene emissions.

Issue:

- *Does TRI contain all facilities that are major HAP emission sources?*

2. RTI/EPA Gelcoat and Resin Emission Testing Program

- Controlled tests in a spray booth to quantify styrene emissions from open molding.
- Emissions were 1.6 to 2.5 times those predicted by AP-42 emission factor midpoints.
- These and other test data indicate that the current AP-42 emission factors under-estimate actual open-molding emissions.

Issue:

- *Can States or industry provide additional emission information (e.g., test results) from this or related industries to develop improved emission factors?*

VI. Emission Control Profile

1. Pollution prevention measures demonstrated for this industry:

- Resin rollers and flow coaters,
- Resin impregnator,
- Resin infusion molding process (e.g., SCRIMP),
- Resin transfer molding (RTM),
- Lower-styrene content resin, and
- Vapor-suppressed resin.

2. Add-on controls demonstrated in the reinforced plastics industry:

- Polyad concentrator adsorption system,
- Activated carbon adsorption system,
- Biofiltration, and
- Thermal/catalytic oxidation.

Next Step:

- *Develop detailed case-histories of either add-on or pollution prevention measures that have been attempted for this or a related industry, both successful and unsuccessful.*

  The case-histories should:

  - *Fully describe the setting and the emission source to which the measure was applied and the control measure itself.*
  - *Discuss the effectiveness of the measure for reducing styrene or other HAP emissions.*
  - *Discuss the pros and cons of the measure as it was applied to this or a related industry.*

VII. NMMA Industry Survey Preliminary Results

Background:

- Sent to all members of the National Association of Boat Manufacturers (NABM, 358 members).
- Sixty responses analyzed by the NMMA.
- An additional 60 responses have been received.

Preliminary results compiled by NMMA:

- All respondents use spray guns to apply gelcoat.
- Layup method for open molding:

Hand layup:	79 percent
Spray layup:	86 percent
Pressure Rollers:	3 percent

  Use both hand and spray layup: 65 percent

- Other molding methods:

Resin transfer:	4 percent
Bag molding:	12 percent

- 95 percent of plants report that respirators are needed.
- No plants have performed HAP emissions testing.

- Emission reduction measures:

- Low styrene resin:	76 percent
- Vapor-suppressed resin:	10 percent
- AAA spray guns:	61 percent
- HVLP spray guns:	19 percent
- Pressure-fed rollers	6 percent
- Flow coaters	10 percent
- Add-on controls	0 percent

Next Steps:

- *Collect any outstanding responses.*
- *Finish data entry and analysis.*
- *Obtain a list of facilities that responded to the survey and determine which segment of the industry is represented or not by the survey respondents.*

Issue:

- *Is more information needed on the facilities that did not respond to the NMMA survey?*

VIII. Developing Subcategories

Reasons for establishing separate subcategories:

- Differences in the types of HAP emitted.
- Differences in applicability and effectiveness of control options.
- Differences in economic impacts of control options.

These differences must be associated with a distinct and clearly definable segment of the industry.

Issues:

- *What are appropriate sub-categories for the boat manufacturing industry?*
- *Which subcategories should be the focus of this P-MACT determination?*

IX. Possible Formats for a Styrene Emissions Standard

1. Emission factor limit, e.g., kg styrene/kg of resin applied.

2. Emission limit based on unit area, e.g., kg styrene per square meter of surface.

3. Weight percent limit on styrene content in resin.

4. Control technology requirement, e.g., capture and at least 95-percent destruction.

5. Process technology requirement, e.g., all resin curing must be in a closed system.

6. Point system, e.g., assign points for different control techniques and write standard in terms of a minimum number of points.

7. Work practice or operational standard.

8. A combination of the above.

Next Steps:

- *Industry should provide feedback on implementing and complying with standards in each format.*

- *EPA Regional and State/local representatives should provide feedback on implementing and enforcing standards in each format.*

- *Identify the pros and cons of each format.*

- *Identify the information/data needs for developing a standard in each format.*

X. Summary of Next Steps for the Roundtable

General:

- Complete data collection and distribution prior to next meeting (early January, 1996).
- Determine if there are any data gaps and develop a plan for collecting that additional information.
- Conduct preliminary MACT analyses of the data that have been collected.

EPA/ESD:

- Complete the survey data entry and analysis; begin developing subcategories from the survey data and other information collected.
- Develop briefing materials for next P-MACT meeting, including instructions for the Roundtable on developing P-MACT options.

EPA/Regional, State/Local, and Industry Representatives:

- Provide additional emissions data, if available, that can be used to improve HAP emission estimates from the TRI database.
- Collect case-histories of pollution prevention measures currently in use, including closed molding options and alternatives to resin spraying.
- Provide comments to the EPA on different format options for the standard.

Industry Representatives:

- Provide information on HAP emission sources other than styrene and possible control options for those sources.
- Provide the EPA with a list of respondents to the NMMA survey.

Attachment 2

Clean Air Act Section 112, Hazardous Air Pollutants

(d) Emission standards

* * * * *

(2) Standards and methods

Emissions standards promulgated under this subsection and applicable to new or existing sources of hazardous air pollutants shall require the maximum degree of reduction in emissions of the hazardous air pollutants subject to this section (including a prohibition on such emissions, where achievable) that the Administrator, taking into consideration the cost of achieving such emission reduction, and any non-air quality health and environmental impacts and energy requirements, determines is achievable for new or existing sources in the category or subcategory to which such emission standard applies, through application of measures, processes, methods, systems or techniques including, but not limited to, measures which--

(A) reduce the volume of, or eliminate emissions of, such pollutants through process changes, substitution of materials or other modifications.

(B) enclose systems or processes to eliminate emissions,

(C) collect, capture or treat such pollutants when released from a process, stack, storage or fugitive emissions point,

(D) are design, equipment, work practice, or operational standards (including requirements for operator training or certification) as provided in subsection (h) of this section, or

(E) are a combination of the above.

None of the measures described in subparagraphs (A) through (D) shall, consistent with the provisions of section 7414(c) of this title, in any way compromise any United States patent or United States trademark right, or any confidential business information, or any trade secret or any other intellectual property right.

(3) New and existing sources

The maximum degree of reduction in emissions that is deemed achievable for new sources in a category or subcategory shall not be less stringent than the emission control that is achieved in practice by the best controlled similar source, as determined by the Administrator. Emission standards promulgated under this subsection for existing sources in a category or subcategory may be less stringent than standards for new sources in the same category or subcategory but shall not be less stringent, and may be more stringent than--

(A) the average emission limitation achieved by the best performing 12 percent of the existing sources (for which the Administrator has emissions information), excluding those sources that have, within 18 months before the emission standard is proposed or within 30 months before such standard is promulgated, whichever is later, first achieved a level of emission rate or emission reduction which complies, or would comply if the source is not subject to such standard, with the lowest achievable emission rate (as defined by section 7501 of this title) applicable to the source category and prevailing at the time, in the category or subcategory for categories and subcategories with 30 or more sources, or

(B) the average emission limitation achieved by the best performing 5 sources (for which the Administrator has or could reasonably obtain emissions information) in the category or subcategory for categories or subcategories with fewer than 30 sources.

ATTACHMENT 3

SUMMARY OF TOXIC RELEASE INVENTORY (TRI) HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS DATA

There are 158 boat manufacturers in the TRI data base that reported HAP emissions in 1993. Tables 1 and 2 summarize these HAP emissions data, but do not include reported emissions of acetone or 1,1,1-trichloroethane (methyl chloroform). Although acetone was reported in the TRI data, it is not listed as a HAP; 1,1,1-trichloroethane will not be used after 1995 because it is an ozone depleting chemical.

Table 1 is a summary of styrene emissions as reported in the TRI database. There are 144 boat manufacturers that reported styrene emissions; of these 144 manufacturers, 84 reported styrene emissions greater than 20,000 pounds (10 tons) and would be considered major sources based on reported styrene emissions.

Table 2 is a summary of total HAP emissions, including styrene and other HAP's reported in the TRI database. However, in this table, the major source status of a facility was determine (presumed) after increasing the reported styrene emissions by a factor of 2.0 (i.e., doubling the reported styrene emissions). This was done to account for the fact that the AP-42 emission factors, from which most manufacturers estimate styrene emissions, may under-predict actual emissions. According to the results of the RTI/EPA cooperative testing program and other emission tests conducted since 1991, actual emissions are 1.6 to 2.5 the AP-42 emission factor midpoints for open molding. Therefore, a correction factor of 2.0 was used to estimate styrene emissions for the purposes of estimating total HAP emissions.

There are 158 manufacturers that have reported HAP emissions. Of these, 111 are major HAP emission sources based on estimated total HAP emissions. Of the 111 major HAP sources, 4 are major sources on the basis of HAP emissions other than styrene, in particular toluene and xylene, and have no styrene emissions. From the company names, these 4 sources appear to be aluminum boat manufacturers and the xylene and toluene emissions are probably associated with painting operations.

Table 1. SUMMARY OF 1993 STYRENE EMISSIONS AS REPORTED TO THE TOXIC RELEASE INVENTORY.
Major source status is determined from as-reported styrene emissions alone, and does not include other HAP.

Company Name	City	ST	Styrene Emissions (lbs)	Major Source?
DYNASTY BOATS INC.	VINEMONT	AL	23,020	Yes
CHAMPION BOATS INC.	MOUNTAIN HOME	AR	54,711	Yes
RANGER BOATS WOOD MFG. CO. INC.	FLIPPIN	AR	40,809	Yes
BASS CAT BOATS	MOUNTAIN HOME	AR	30,200	Yes
KENNER MFG. CO. INC.	KNOXVILLE	AR	22,056	Yes
STEELE PLASTICS INC.	CONWAY	AR	2,652	
PRECISION BOATING INC.	MOUNTAIN HOME	AR	1,100	
SEA RAY BOATS INC.	PHOENIX	AZ	130,000	Yes
CATALINA YACHTS INC.	WOODLAND HILLS	CA	87,884	Yes
MACGREGOR YACHT CORP. MACGREGOR 65	COSTA MESA	CA	50,824	Yes
FINELINE IND. INC.	MERCED	CA	19,466	
MALIBU BOATS WEST INC.	MERCED	CA	19,041	
PACIFIC SEACRAFT CORP.	FULLERTON	CA	15,300	
WILLARD MARINE INC.	ANAHEIM	CA	10,300	
HOBIE CAT CO.	OCEANSIDE	CA	5,128	
PERFORMANCE CATAMARANS INC.	SANTA ANA	CA	4,580	
SURVIVAL SYS. INTL. INC.	VALLEY CENTER	CA	4,500	
WELLCRAFT MARINE PLANT 6	SARASOTA	FL	136,723	Yes
BOSTON WHALER INC.	EDGEWATER	FL	104,000	Yes
REGAL MARINE IND. INC.	ORLANDO	FL	96,848	Yes
WELLCRAFT MARINE PLANT 2	AVON PARK	FL	95,791	Yes
PRO-LINE BOATS INC.	HOMOSASSA	FL	89,128	Yes
OMC CHRIS CRAFT INC.	SARASOTA	FL	76,642	Yes
LUHRS CORP.	SAINT AUGUSTINE	FL	75,109	Yes
HUNTER MARINE CORP.	ALACHUA	FL	74,584	Yes
U.S. MARINE/BAYLINER	TALLAHASSEE	FL	68,410	Yes
FABBRO MARINE GROUP	MILTON	FL	64,500	Yes
SEA RAY BOATS INC.	PALM COAST	FL	53,000	Yes
SEA RAY BOATS INC.	MERRITT ISLAND	FL	52,000	Yes
CORRECT CRAFT INC.	ORLANDO	FL	35,800	Yes
CENTURY BOATS CENTURY	PANAMA CITY	FL	30,800	Yes
ANGLER BOAT CORP.	MIAMI	FL	30,000	Yes
S2 YACHTS PURSUIT DIV.	FT. PIERCE	FL	29,100	Yes
CIGARETTE RACING TEAM INC.	NORTH MIAMI BEACH	FL	23,688	Yes
CATALINA YACHTS MORGAN DIV.	LARGO	FL	23,553	Yes

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Company Name	City	ST	Styrene Emissions (lbs)	Major Source?
BLACKFIN YACHT CORP.	FORT LAUDERDALE	FL	20,544	Yes
DONZI YACHTS BY ROSCIOLI	BRADENTON	FL	17,000	
DUSKY MARINE INC.	DANIA	FL	16,183	
MAGNUM MARINE CORP. PLANT 2	NORTH MIAMI	FL	14,588	
SEA RAY BOATS INC.	MERRITT ISLAND	FL	14,000	
BERTRAM YACHT INC. BERTRAM YACHT DIV.	MIAMI	FL	11,100	
SEA RAY BOATS INC. PRODUCT DEVELOPMENT	MERRITT ISLAND	FL	11,000	
DONZI MARINE	SARASOTA	FL	8,320	
AMERICAN INDUSTRIES INC.	HOLLYWOOD	FL	7,700	
STAMAS YACHT INC.	TARPON SPRINGS	FL	7,592	
REX-MEYER YACHTS	SANFORD	FL	7,270	
MOHAWK MFG. CO.	LONGWOOD	FL	5,400	
MOLDED FIBERGLASS IND.	ORLANDO	FL	6,325	
ARJAY IND. INC.	LARGO	FL	2,761	
U.S. MARINE/BAYLINER	VALDOSTA	GA	68,410	Yes
CARAVELLE BOAT CO. INC.	AMERICUS	GA	20,330	Yes
CROWNLINE BOATS INC.	WEST FRANKFORT	IL	359,987	Yes
MARIAH BOATS INC.	BENTON	IL	86,000	Yes
CELEBRITY BOATS INC.	BENTON	IL	79,325	Yes
SEA SPRITE INC.	CRESCENT CITY	IL	33,334	Yes
ENVISION BOATS INC.	MONMOUTH	IL	2,330	
STARCRAFT POWER BOAT CORP.	TOPEKA	IN	69,550	Yes
OMC CHRIS-CRAFT .	GOSHEN	IN	55,323	Yes
THUNDERBIRD PRODS.	DECATUR	IN	46,882	Yes
GODFREY CONVEYOR CO. INC. DBA GODFREY	ELKHART	IN	40,400	Yes
RINKER BOAT CO. INC.	SYRACUSE	IN	34,032	Yes
GOSHEN SASH & DOOR SMOKER CRAFT DIV.	NEW PARIS	IN	18,800	
HARRIS KAYOT INC.	FORT WAYNE	IN	9,086	
FIBERGLASS ENG. INC. COBALT BOATS	NEODESHA	KS	19,525	
PRESTIGE INC.	NEODESHA	KS	6,370	
FIBERGLASS ENG. PRODS. INC. COBALT BOATS	NEODESHA	KS	6,370	
HOLIDAY MANSION	SALINA	KS	5,371	
ARMADA MFG. CO. INC.	RAVENNA	KY	23,250	Yes
VIVIAN IND. INC.	VIVIAN	LA	90,000	Yes
MASTERCRAFTERS CORP.	WINNSBORO	LA	71,623	Yes
BOSTON WHALER INC.	ROCKLAND	MA	33,260	Yes
U.S. MARINE/BAYLINER	CUMBERLAND	MD	98,998	Yes
U.S. MARINE/BAYLINER	CUMBERLAND	MD	86,350	Yes
U.S. MARINE/BAYLINER	SALISBURY	MD	44,926	Yes
SABRE CORP.	RAYMOND	ME	7,650	

Company Name	City	ST	Styrene Emissions (lbs)	Major Source?
NORTH END MARINE & FIBERGLASS ENGINEERING	ROCKLAND	ME	3,700	
FLYE POINT MARINE INC.	BROOKLIN	ME	3,465	
HINCKLEY CO.	SOUTHWEST	ME	2,777	
OMC FOUR WINNS SPORT DIV. SPORT DIV.	CADILLAC	MI	290,801	Yes
OMC FOUR WINNS CRUISER DIV.	CADILLAC	MI	144,191	Yes
S2 YACHTS INC.	HOLLAND	MI	53,000	Yes
THOMPSON BOAT CO. WTYS 4 DBA	SAINT CHARLES	MI	48,627	Yes
OMC FOUR WINNS ENGINEERING DIV.	CADILLAC	MI	12,892	
POWERQUEST BOATS INC.	HOLLAND	MI	11,000	
LARSON BOATS DIV. OF GENMAR	LITTLE FALLS	MN	155,983	Yes
U.S. MARINE/BAYLINER	PIPESTONE	MN	126,922	Yes
BLUEWATER MARINE INC. AMERICA	MORA	MN	13,904	
GRADY-WHITE BOATS INC.	GREENVILLE	NC	90,581	Yes
HATTERAS YACHTS INC.	NEW BERN	NC	46,000	Yes
FOUNTAIN POWERBOATS INC.	WASHINGTON	NC	42,872	Yes
PARKER MARINE ENTS. INC.	BEAUFORT	NC	27,018	Yes
HATTERAS YACHTS INC.	HIGH POINT	NC	26,000	Yes
TRI-STATE CUSTOM FIBERGLASS INC.	BAILEY	NC	13,000	
LANNESS K. MCKEE & CO. INC.	FAIRMONT	NC	6,599	
REGULATOR MARINE INC.	EDENTON	NC	6,500	
SILVERTON MARINE CORP.	MILLVILLE	NJ	125,268	Yes
POST MARINE CO. INC.	MAYS LANDING	NJ	2,900	
BAJA BOATS INC.	BUCYRUS	OH	193,376	Yes
IMPERIAL BOAT CO.	STOW	OH	7,651	
BAYLINER MARINE CORP.	MIAMI	OK	78,710	Yes
BAYLINER MARINE CORP.	MIAMI	OK	56,579	Yes
SEASWIRL BOATS INC. SEASWIRL BOATS	CULVER	OR	91,522	Yes
U.S. MARINE/BAYLINER	ROSEBURG	OR	51,592	Yes
BLUE WATER BOATS INC.	SPRINGFIELD	OR	33,344	Yes
KAL KUSTOM ENTS.	SALEM	OR	30,831	Yes
MARLIN KK BOAT ENTERPRISE	WHITE CITY	OR	14,113	
TPI INC.	WARREN	RI	47,457	Yes
SUNBIRD BOAT CO.	COLUMBIA	SC	96,968	Yes
RENKEN BOAT MFG. CO. INC.	CHARLESTON	SC	68,100	Yes
KEY WEST BOATS INC.	RIDGEVILLE	SC	42,681	Yes
BENETEAU	MARION	SC	35,343	Yes
STINGRAY BOAT CO.	HARTSVILLE	SC	34,777	Yes
SEA-PRO BOATS INC.	CHAPIN	SC	29,684	Yes
SEA RAY BOATS INC.	VONORE	TN	210,000	Yes
OMC FISHING BOAT GROUP INC. A DIV. OF OMC	MURFREESBORO	TN	154,000	Yes

Company Name	City	ST	Styrene Emissions (lbs)	Major Source?
MARINE GROUP INC.	MURFREESBORO	TN	123,947	Yes
OMC FISHING BOAT GROUP INC.	OLD HICKORY	TN	117,081	Yes
SEA RAY BOATS INC.	KNOXVILLE	TN	110,000	Yes
MASTERCRAFT BOAT CO.	MARYVILLE	TN	103,804	Yes
SEA RAY BOATS INC. RIVERVIEW	KNOXVILLE	TN	55,000	Yes
U.S. MARINE/BAYLINER	DANDRIDGE	TN	40,092	Yes
EBBTIDE CORP.	WHITE BLUFF	TN	28,793	Yes
VISION BOATS INC.	OLD HICKORY	TN	15,093	
BCA FIBERGLASS FABRICATION PLANT	GALLATIN	TN	8,241	
MALIBU BOATS WEST INC.	LOUDON	TN	6,546	
MIDDLE TENNESSEE FIBERGLASS INC.	TULLAHOMA	TN	5,503	
FIBERGLASS WORKS INC.	DICKSON	TN	1,276	
SKEETER PRODS. INC.	KILGORE	TX	59,800	Yes
WAHOO! BOATS UNLIMITED	ASHLAND	VA	15,790	
U.S. MARINE/BAYLINER	SPOKANE	WA	115,728	Yes
U.S. MARINE/BAYLINER	ARLINGTON	WA	75,010	Yes
MIRAGE HOLDINGS INC.	ARLINGTON	WA	14,832	
CHRISTENSEN MOTOR YACHT CORP.	VANCOUVER	WA	9,611	
WRIGHT BROS. INC.	BELLINGHAM	WA	7,285	
ARIMA MARINE	AUBURN	WA	5,162	
OLYMPIC BOAT CO.	MONROE	WA	5,054	
REIFF MFG. INC.	WALLA WALLA	WA	4,613	
C-DORY INC.	KENT	WA	3,201	
TOLLYCRAFT YACHTS CORP.	KELSO	WA	3,120	
CARVER BOAT CORP.	PULASKI	WI	143,771	Yes
KCS INTL. INC. PLANT 1	OCONTO	WI	18,597	
KCS INTL. INC. PLANT 2	OCONTO	WI	10,376	
LAKELAND SPORTS CENTER INC.	GREENBUSH	WI	6,888	
NORTHPORT INC.	GILLETT	WI	2,491	

Table 2. TOTAL HAP EMISSIONS ESTIMATED FROM THE TRI DATABASE. Major source status is based on a doubling of the reported styrene emissions in the TRI database.

Company name	City	ST	Total reported HAP emissions (lbs.)	Presumed major source?	Other Data Needed[a]
DYNASTY BOATS INC.	VINEMONT •	AL	23,020	Yes	
CHAMPION BOATS INC.	MOUNTAIN HOME	AR	95,403	Yes	•
RANGER BOATS WOOD MFG. CO. INC.	FLIPPIN	AR	40,810	Yes	
BASS CAT BOATS	MOUNTAIN HOME	AR	30,200	Yes	•
ALUMACRAFT BOAT CO.	ARKADELPHIA	AR	29,000	Yes	
KENNER MFG. CO. INC.	KNOXVILLE	AR	22,056	Yes	•
SEAARK MARINE INC.	MONTICELLO	AR	5,150		
STEELE PLASTICS INC.	CONWAY	AR	2,652		•
PRECISION BOATING INC.	MOUNTAIN HOME	AR	1,100		•
SEA RAY BOATS INC.	PHOENIX	AZ	130,005	Yes	
MACGREGOR YACHT CORP. MACGREGOR 65 CORP.	COSTA MESA	CA	50,824	Yes	•
WILLARD MARINE INC.	ANAHEIM	CA	22,514	Yes	•
FINELINE IND. INC.	MERCED	CA	19,466	Yes	•
MALIBU BOATS WEST INC.	MERCED	CA	19,041	Yes	
PACIFIC SEACRAFT CORP.	FULLERTON	CA	15,300	Yes	•
HOBIE CAT CO.	OCEANSIDE	CA	5,128		
PERFORMANCE CATAMARANS INC.	SANTA ANA	CA	4,580		•
SURVIVAL SYS. INTL. INC.	VALLEY CENTER	CA	4,500		•
WELLCRAFT MARINE PLANT 6	SARASOTA	FL	136,968	Yes	
WELLCRAFT MARINE PLANT 2	AVON PARK	FL	109,000	Yes	
BOSTON WHALER INC.	EDGEWATER	FL	104,000	Yes	
LUHRS CORP.	SAINT AUGUSTINE	FL	100,462	Yes	
REGAL MARINE IND. INC.	ORLANDO	FL	96,848	Yes	
HUNTER MARINE CORP.	ALACHUA	FL	91,690	Yes	
PRO-LINE BOATS INC.	HOMOSASSA	FL	89,128	Yes	
OMC CHRIS CRAFT INC.	SARASOTA	FL	76,642	Yes	
U.S. MARINE/BAYLINER	TALLAHASSEE	FL	68,411	Yes	
FABBRO MARINE GROUP	MILTON	FL	64,500	Yes	•
SEA RAY BOATS INC.	PALM COAST	FL	53,000	Yes	

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Company name	City	ST	Total reported HAP emission s (lbs.)	Presumed major source?	Other Data Needed[a]
SEA RAY BOATS INC.	MERRITT ISLAND	FL	52,000	Yes	
CORRECT CRAFT INC.	ORLANDO	FL	36,295	Yes	
CATALINA YACHTS MORGAN DIV.	LARGO	FL	31,671	Yes	•
CENTURY BOATS CENTURY	PANAMA CITY	FL	30,800	Yes	
ANGLER BOAT CORP.	MIAMI	FL	30,000	Yes	
S2 YACHTS PURSUIT DIV.	FT. PIERCE	FL	29,100	Yes	
CIGARETTE RACING TEAM INC.	NORTH MIAMI BEACH	FL	23,688	Yes	
BERTRAM YACHT INC. BERTRAM YACHT DIV.	MIAMI	FL	22,284	Yes	
BLACKFIN YACHT CORP.	FORT LAUDERDALE	FL	20,544	Yes	
DONZI YACHTS BY ROSCIOLI INTL.INTERNATIONAL	BRADENTON	FL	17,000	Yes	
DUSKY MARINE INC.	DANIA	FL	16,183	Yes	
MAGNUM MARINE CORP. PLANT 2	NORTH MIAMI	FL	14,588	Yes	
SEA RAY BOATS INC.	MERRITT ISLAND	FL	14,000	Yes	
SEA RAY BOATS INC. PRODUCT DEVELOPMENT	MERRITT ISLAND	FL	11,000	Yes	
DONZI MARINE	SARASOTA	FL	8,320		
AMERICAN INDUSTRIES INC.	HOLLYWOOD	FL	7,700		•
STAMAS YACHT INC.	TARPON SPRINGS	FL	7,592		
REX-MEYER YACHTS	SANFORD	FL	7,270		
MOLDED FIBERGLASS IND.	ORLANDO	FL	6,325		•
BOSTON WHALER INC.	EDGEWATER	FL	6,100		
MOHAWK MFG. CO.	LONGWOOD	FL	5,400		•
ARJAY IND. INC.	LARGO	FL	2,761		•
U.S. MARINE/BAYLINER	VALDOSTA	GA	68,410	Yes	
CARAVELLE BOAT CO. INC.	AMERICUS	GA	20,330	Yes	•
CROWNLINE BOATS INC.	WEST FRANKFORT	IL	359,987	Yes	
MARIAH BOATS INC.	BENTON	IL	86,000	Yes	
CELEBRITY BOATS INC.	BENTON	IL	79,325	Yes	
SEA SPRITE INC.	CRESCENT CITY	IL	33,334	Yes	
ENVISION BOATS INC.	MONMOUTH	IL	2,330		
STARCRAFT POWER BOAT CORP.	TOPEKA	IN	157,414	Yes	•

Company name	City	ST	Total reported HAP emissions (lbs.)	Presumed major source?	Other Data Needed[a]
GOSHEN SASH & DOOR SMOKER CRAFT DIV.	NEW PARIS	IN	88,000	Yes	
OMC CHRIS-CRAFT .	GOSHEN	IN	55,323	Yes	
GODFREY CONVEYOR CO. INC. DBA GODFREY MARINE	ELKHART	IN	51,500	Yes	
THUNDERBIRD PRODS.	DECATUR	IN	46,882	Yes	
RINKER BOAT CO. INC.	SYRACUSE	IN	34,032	Yes	
OMC ALUMINUM BOAT GROUP SYRACUSE DIV.	SYRACUSE	IN	33,221	Yes	
BLUE FIN IND. INC.	NAPPANEE	IN	17,538		
HARRIS KAYOT INC.	FORT WAYNE	IN	9,086		
FIBERGLASS ENG. INC. COBALT BOATS	NEODESHA	KS	19,525	Yes	
FIBERGLASS ENG. PRODS. INC. COBALT BOATS	NEODESHA	KS	6,370		
PRESTIGE INC.	NEODESHA	KS	6,370		*
HOLIDAY MANSION	SALINA	KS	5,371		
ARMADA MFG. CO. INC.	RAVENNA	KY	23,250	Yes	
MASTERCRAFTERS CORP.	WINNSBORO	LA	105,421	Yes	
VIVIAN IND. INC.	VIVIAN	LA	94,000	Yes	
BOSTON WHALER INC.	ROCKLAND	MA	35,519	Yes	
U.S. MARINE/BAYLINER	CUMBERLAND	MD	98,999	Yes	
U.S. MARINE/BAYLINER	CUMBERLAND	MD	86,351	Yes	
U.S. MARINE/BAYLINER	SALISBURY	MD	44,926	Yes	
SABRE CORP.	RAYMOND	ME	7,650		
NORTH END MARINE & FIBERGLASS ENGINEERING INC.	ROCKLAND	ME	3,700		
FLYE POINT MARINE INC.	BROOKLIN	ME	3,465		*
HINCKLEY CO.	SOUTHWEST HARBOR	ME	2,777		*
OMC FOUR WINNS SPORT DIV. SPORT DIV.	CADILLAC	MI	301,601	Yes	
OMC FOUR WINNS CRUISER DIV.	CADILLAC	MI	144,196	Yes	
S2 YACHTS INC.	HOLLAND	MI	53,000	Yes	
THOMPSON BOAT CO. WTYS 4 DBA	SAINT CHARLES	MI	48,627	Yes	
OMC FOUR WINNS ENGINEERING DIV.	CADILLAC	MI	12,892	Yes	

Company name	City	ST	Total reported HAP emissions (lbs.)	Presumed major source?	Other Data Needed[a]
POWERQUEST BOATS INC.	HOLLAND	MI	11,000	Yes	
LARSON BOATS DIV. OF GENMAR	LITTLE FALLS	MN	162,686	Yes	
U.S. MARINE/BAYLINER	PIPESTONE	MN	126,924	Yes	
LUND BOAT CO.	NEW YORK MILLS	MN	29,083	Yes	
ALUMACRAFT BOAT CO.	SAINT PETER	MN	20,118	Yes	
BLUEWATER MARINE INC. AMERICA	MORA	MN	13,904	Yes	
CRESTLINER BOATS INC.	LITTLE FALLS	MN	13,306	Yes	
OMC ALUMINUM BOAT GROUP	LEBANON	MO	127,392	Yes	
TRACKER MARINE BOLIVAR	BOLIVAR	MO	11,867		
LANDAU MFG. CO.	LEBANON	MO	11,613		
GENERATION III	LEBANON	MO	10,346		
TRACKER MARINE CLINTON	CLINTON	MO	115		
TRACKER MARINE LEBANON	LEBANON	MO	7		
BRUNSWICK MARINE	WEST POINT	MS	14,354		
GRADY-WHITE BOATS INC.	GREENVILLE	NC	90,581	Yes	
HATTERAS YACHTS INC.	NEW BERN	NC	70,000	Yes	
FOUNTAIN POWERBOATS INC.	WASHINGTON	NC	53,672	Yes	
PARKER MARINE ENTS. INC.	BEAUFORT	NC	27,018	Yes	
HATTERAS YACHTS INC.	HIGH POINT	NC	26,000	Yes	
TRI-STATE CUSTOM FIBERGLASS INC.	BAILEY	NC	13,000	Yes	•
LANNESS K. MCKEE & CO. INC.	FAIRMONT	NC	6,599		•
REGULATOR MARINE INC.	EDENTON	NC	6,500		
SILVERTON MARINE CORP.	MILLVILLE	NJ	125,268	Yes	
POST MARINE CO. INC.	MAYS LANDING	NJ	2,900		
BAJA BOATS INC.	BUCYRUS	OH	193,376	Yes	
IMPERIAL BOAT CO.	STOW	OH	7,651		
BAYLINER MARINE CORP.	MIAMI	OK	78,710	Yes	
BAYLINER MARINE CORP.	MIAMI	OK	56,579	Yes	
SEASWIRL BOATS INC. SEASWIRL BOATS	CULVER	OR	91,522	Yes	
U.S. MARINE/BAYLINER	ROSEBURG	OR	51,592	Yes	
BLUE WATER BOATS INC.	SPRINGFIELD	OR	33,344	Yes	
KAL KUSTOM ENTS.	SALEM	OR	30,831	Yes	

Company name	City	ST	Total reported HAP emissions (lbs.)	Presumed major source?	Other Data Needed[a]
MARLIN KK BOAT ENTERPRISE	WHITE CITY	OR	14,113	Yes	•
TPI INC.	WARREN	RI	47,457	Yes	•
SUNBIRD BOAT CO.	COLUMBIA	SC	96,973	Yes	
RENKEN BOAT MFG. CO. INC.	CHARLESTON	SC	68,100	Yes	
KEY WEST BOATS INC.	RIDGEVILLE	SC	42,681	Yes	•
BENETEAU	MARION	SC	35,343	Yes	
STINGRAY BOAT CO.	HARTSVILLE	SC	34,777	Yes	
SEA-PRO BOATS INC.	CHAPIN	SC	29,684	Yes	•
SEA RAY BOATS INC.	VONORE	TN	210,005	Yes	
OMC FISHING BOAT GROUP INC. A DIV. OF OMC	MURFREESBORO	TN	173,200	Yes	
OMC FISHING BOAT GROUP INC.	OLD HICKORY	TN	127,181	Yes	
MARINE GROUP INC.	MURFREESBORO	TN	123,947	Yes	
MASTERCRAFT BOAT CO.	MARYVILLE	TN	114,379	Yes	
SEA RAY BOATS INC.	KNOXVILLE	TN	110,000	Yes	
SEA RAY BOATS INC. RIVERVIEW	KNOXVILLE	TN	55,000	Yes	
U.S. MARINE/BAYLINER	DANDRIDGE	TN	40,092	Yes	
EBBTIDE CORP.	WHITE BLUFF	TN	28,793	Yes	
VISION BOATS INC.	OLD HICKORY	TN	15,093	Yes	•
BCA FIBERGLASS FABRICATION PLANT	GALLATIN	TN	8,241		•
MALIBU BOATS WEST INC.	LOUDON	TN	6,546		
MIDDLE TENNESSEE FIBERGLASS INC.	TULLAHOMA	TN	5,503		•
FIBERGLASS WORKS INC.	DICKSON	TN	1,276		•
SKEETER PRODS. INC.	KILGORE	TX	66,600	Yes	
WAHOO! BOATS UNLIMITED	ASHLAND	VA	15,790	Yes	
U.S. MARINE/BAYLINER	SPOKANE	WA	115,729	Yes	
U.S. MARINE/BAYLINER	ARLINGTON	WA	75,010	Yes	
MIRAGE HOLDINGS INC.	ARLINGTON	WA	14,832	Yes	
CHRISTENSEN MOTOR YACHT CORP.	VANCOUVER	WA	9,611		•
WRIGHT BROS. INC.	BELLINGHAM	WA	7,285		•
ARIMA MARINE	AUBURN	WA	5,162		
OLYMPIC BOAT CO.	MONROE	WA	5,054		•
REIFF MFG. INC.	WALLA WALLA	WA	4,613		•

Company name	City	ST	Total reported HAP emission s (lbs.)	Presumed major source?	Other Data Needed[a]
C-DORY INC.	KENT	WA	3,201		•
TOLLYCRAFT YACHTS CORP.	KELSO	WA	3,120		
CARVER BOAT CORP.	PULASKI	WI	143,771	Yes	
KCS INTL. INC. PLANT 1	OCONTO	WI	18,597	Yes	•
KCS INTL. INC. PLANT 2	OCONTO	WI	10,376	Yes	•
LAKELAND SPORTS CENTER INC.	GREENBUSH	WI	6,888		•
NORTHPORT INC.	GILLET	WI	2,491		

[a] No survey response is expected from facilities marked with a "•" because they are not NABM members and were not sent a survey. Therefore, additional data from these facilities must be collected from the States or through an additional survey.

ecrt82-08

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

AUG 5 1998

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

Mr. Steve McNally
Composite Fabricator's Association
1735 North Lynn Street
Suite 950
Arlington, VA 22209-2022

Dear Mr. McNally:

Per our telecon of July 22, enclosed is a copy of our Office of Research and Development's (ORD) model for predicting styrene emissions from the manufacture of fiber-reinforced plastics, a one-page user's guide for the model, and the paper which has been prepared as documentation for the model. The paper has not yet been published, but it has been submitted to the Journal of the Air & Waste Management Association, and it has undergone ORD's internal peer review. I look forward to any comments you may want to provide on these materials as we develop our AP-42 section for these operations.

Sincerely,

Ronald B. Ryan
Environmental Engineer
Emission Factor and Inventory Group

Enclosures

cc: John McKnight, NMMA

FRP MODEL / PROCESS = Resin sprayup

BASE

Neat resin styrene content (% W/W)	=	38;	mod. factor = 1.001
Styrene suppressant?	=	0;	mod. factor = 1.000
Distance from spray gun to mold (in.)	=	15;	mod. factor = 1.000
Dry material off mold / material sprayed (%)	=	6;	mod. factor = 1.000
Thickness (mils)	=	70;	mod. factor = 1.000
"Cup" gel time (min)	=	15;	mod. factor = 1.000
Application rate (lb/min)	=	4;	mod. factor = 1.000
Air temperature (°F)	=	75;	mod. factor = 1.000
Air velocity over mold (ft/min)	=	100;	mod. factor = 1.000

=======================================

Baseline emission (% AS) = 18.9
Calculated emission (% AS) = 18.9
Overall modification factor = 1.00

=======================================

9 Mod factors for each of 5 processes

6/10/98 3:03:02 PM

CARLOS - I need a journal article to post → Mark B. - will be a while

- only runs in W'95
- "% Filler" ~~on~~ is greyed out
- slight round off errors for mod factors for
  - styrene content
  - distance to mold
  - % overspray
  - air velocity (all 5 processes)

  } Resin sprayup — Less on printout only 3 decimals
- change "New Value" to "Your Value"
- "process" pulldown spells option 5 - "pressure" wrong
- "About FRP" (& its Baseline & Example) don't have a Print Screen & Get Mod Factors Screen needs print button → essentially above, but a "PRINT SCREEN" to show baseline & New mod factors?
  - the resin studies used (& individual data are not available)
  - no reference to journal article or report
- Good that both Styrene Suppressant & Filler % go grey for gel coating.

⇒ ARE THE "BASELINE" Values for each parameter acceptable as "Defaults"? to CFA? HMMA? strom? < Need to make this clear to ~~Carlo~~ Leonardo

- Bottom Line on screen (close) doesn't show if you have the W'95 status bar.

- ADDING A Box to input "lbs of this resin used" would allow calculation of emissions - w/out error possibility

Exception distance to mold - 24" more typical than 15" - modif. from HMMA test

% of mold - boats close to 0

6 close to mold pts, e.g. small parts

FRP MODEL / PROCESS = Gel coating

Neat resin styrene content (% W/W)	=	38;	mod. factor = 1.000
Styrene suppressant?	=	N/A	
Distance from spray gun to mold (in.)	=	15;	mod. factor = 1.000
Dry material off mold / material sprayed (%)	=	6;	mod. factor = 1.000
Thickness (mils)	=	20;	mod. factor = 1.000
"Cup" gel time (min)	=	15;	mod. factor = 1.000
Application rate (lb/min)	=	2;	mod. factor = 1.000
Air temperature (°F)	=	75;	mod. factor = 1.000
Air velocity over mold (ft/min)	=	100;	mod. factor = 1.000

===

Baseline emission (% AS) = 54.8

Calculated emission (% AS) = 54.8

Overall modification factor = 1.00

===

6/10/98 3:19:25 PM

FRP MODEL / PROCESS = Resin sprayup

Neat resin styrene content (% W/W)	=	38;	mod. factor =	1.001
Styrene suppressant?	=	0;	mod. factor =	1.000
Distance from spray gun to mold (in.)	=	15;	mod. factor =	1.000
Dry material off mold / material sprayed (%)	=	6;	mod. factor =	1.000
Thickness (mils)	=	70;	mod. factor =	1.000
"Cup" gel time (min)	=	15;	mod. factor =	1.000
Application rate (lb/min)	=	4;	mod. factor =	1.000
Air temperature (°F)	=	75;	mod. factor =	1.000
Air velocity over mold (ft/min)	=	100;	mod. factor =	1.000

==

Baseline emission (% AS) = 18.9
Calculated emission (% AS) = 18.9
Overall modification factor = 1.00

==

6/10/98 3:19:34 PM

FRP MODEL / PROCESS = Hand layup

Neat resin styrene content (% W/W)	=	38;	mod. factor = 1.000
Styrene suppressant?	=	0;	mod. factor = 1.000
Distance from spray gun to mold (in.)	=	N/A;	
Dry material off mold / material sprayed (%)	=	N/A;	
Thickness (mils)	=	70;	mod. factor = 1.000
"Cup" gel time (min)	=	15;	mod. factor = 1.000
Application rate (lb/min)	=	N/A;	
Air temperature (°F)	=	75;	mod. factor = 1.000
Air velocity over mold (ft/min)	=	100;	mod. factor = 1.000

===

Baseline emission (% AS) = 12.3

Calculated emission (% AS) = 12.3

Overall modification factor = 1.00

===

6/10/98 3:19:45 PM

FRP MODEL / PROCESS = Flow coater

Neat resin styrene content (% W/W)	=	38;	mod. factor = 1.000
Styrene suppressant?	=	0;	mod. factor = 1.000
Distance from spray gun to mold (in.)	=	15;	mod. factor = 1.000
Dry material off mold / material sprayed (%)	=	N/A;	
Thickness (mils)	=	70;	mod. factor = 1.000
"Cup" gel time (min)	=	15;	mod. factor = 1.000
Application rate (lb/min)	=	N/A;	
Air temperature (°F)	=	75;	mod. factor = 1.000
Air velocity over mold (ft/min)	=	100;	mod. factor = 1.000

===

Baseline emission (% AS) = 11.3

Calculated emission (% AS) = 11.3

Overall modification factor = 1.00

===

6/10/98 3:19:53 PM

FRP MODEL / PROCESS = Pressure-fed roller

Neat resin styrene content (% W/W)	=	38;	mod. factor = 1.000
Styrene suppressant?	=	0;	mod. factor = 1.000
Distance from spray gun to mold (in.)	=	N/A;	
Dry material off mold / material sprayed (%)	=	N/A;	
Thickness (mils)	=	70;	mod. factor = 1.000
"Cup" gel time (min)	=	15;	mod. factor = 1.000
Application rate (lb/min)	=	N/A;	
Air temperature (°F)	=	75;	mod. factor = 1.000
Air velocity over mold (ft/min)	=	100;	mod. factor = 1.000

==

Baseline emission (% AS) = 12.6

Calculated emission (% AS) = 12.6

Overall modification factor = 1.00

==

6/10/98 3:20:00 PM

FRP Model Version 1.0

for estimating styrene emissions from fiber-reinforced plastics fabrication processes

Welcome to the FRP Model version 1.0. This card is designed to help you with the installation and use of the FRP Model version 1.0. The FRP Model is an empirical mathematical model to estimate styrene emissions from the manufacture of fiber-reinforced plastics/composite (FRP/C) products.

Installing the FRP Model Version 1.0

Minimum System Requirements

- Microsoft Windows™ 95
- Personal computer using 80486 or higher microprocessor
- Minimum 4MB of internal memory
- 3.5" high-density (1.44 MB) disk drive
- VGA or any video adapter supported by Microsoft Windows ™ 95

Installation

You can run the FRP Model v.01 directly from the 3.5" high-density (1.44 MB) diskette or you can install it on your computer hard drive. If you decide to install it on your computer follow the steps below:

1. Close any open applications on your computer, make sure Windows is running, and then go to the Windows Explorer.
2. Insert the disk containing the FRP Model version 1.0 into drive A.
3. Create a new folder on your hard drive called FRP Model by choosing New from the Windows Explorer File menu and then choosing Folder. Type the words FRP Model follow by the Enter key.
4. From Windows Explorer, point and click on drive A. A folder name *Int* and the application file *FRP* will display.
5. Select both the folder and the application file by holding down the shift key, pointing to each one, and clicking your left mouse button.
6. Copy them to the Clipboard by holding down the Ctrl key and hitting on the letter C.
7. Now, point to your hard drive letter (it is usually C) and click once with left mouse button. Click on the new folder you created for the FRP Model.
8. Paste the copied folder and files by holding down the Ctrl key and hitting the letter V.
9. If you wish to make an icon of the FRP Model on your desktop, follow the instructions from your Windows User's Guide.

Using the FRP Model Version 1.0

1. Open the FRP Model version 1.0 program.
2. The first screen you will see is the title page for the model. Use your left mouse button to click the button at the bottom of the screen, labeled "OK".
3. From the second screen , choose the appropriate process (gel coating, resin sprayup, hand layup, etc.) by clicking your left mouse button on the circle next to the process, or on the letters of the process itself.
4. Choosing a process will cause the "baseline" input values for that process to be displayed in both the left-hand and right-hand columns.
5. In the right-hand column, replace the "baseline" values with "new values" that are applicable to your plant, for each of the following model inputs:

   Neat resin styrene content (%, by weight). The term "neat" refers to the styrene content (by weight) of the resin, before filler is added, if filler is added.

Styrene suppressant? (Yes/No). Indicate whether the resin contains a styrene suppressant (styrene suppressants are wax additives that are added to resins to reduce styrene emissions).

% Filler. This is the percentage (by weight) of the applied resin system that is filler. Fillers are added to resins in some lamination processes, typically to provide fire retardancy and to reduce material costs. Typical fillers are alumina trihydrate, calcium carbonate, and calcium sulfate (gypsum).

Distance from Spray Gun to Mold (in.). This is measured as the distance traveled by the resin from the spray gun to the mold surface.

Dry Material Off the Mold / Material Sprayed (%). This is a ratio of the material that does not land on the mold, divided by the total material sprayed. This ratio is expressed as a percentage. Note that the amount of material off the mold is measured after it has dried (i.e. after styrene evaporation and curing), but the amount of material sprayed is measured as it leaves the gun (i.e., "wet"). These input forms allow fairly straightforward determinations for both the numerator and denominator of the ratio. In the data used to generate this model, the fiberglass "chop" was included in measurements of both the "dry material off the mold" and the "total material sprayed".

Thickness (mils). This is the thickness in mils (i.e., thousandths of an inch) for a single spraying or laminating session, which may include 2-3 passes with the spray gun.

Cup gel time (min). This is the gel time (in minutes) for a standard 100 milliliter cup gel time test. Note that this does not refer to the gel time on the part, which is typically longer than the 100 ml cup gel time.

Application rate (lb/min). This is the application rate (in pounds per minute) of either the gel coat or the resin (in resin sprayup). In the data used to generate this model, "application rate" refers to the amount of neat resin exiting the gun, per minute.

Air temperature (°F). This is the air temperature where fabrication is occurring.

Air velocity over the mold (ft/min). This is the average air velocity in the area between the spray gun and the mold. Air velocity over the mold can be measured with a hot wire or vane anemometer. For lamination inside a spray booth, air velocity can sometimes be calculated (approximated) using the spray booth flow rate, and the cross-sectional areas of the booth and part.

6. After all parameters appropriate to your fabrication process have been added, click on the button labeled "Calculate". This will cause the values for "Overall modification factor" and "Calculated emission (% AS)" to be displayed in the bottom-right-hand corner of the screen. The "Calculated emission (%AS)", represents the calculated emission factor (as a percentage of available styrene), under the conditions at your facility.

7. If you wish to see the individual modification factors calculated for each individual input to the model, go to the icons at the top, left-hand corner of the page. Find the icon with the small blue header, titled "list modification factors". Using the left mouse button to click on this icon will display a "list of modification factors", with each modification factor as it applies to the process conditions you have input. After this list of modification factors has been displayed, the list must be closed before further inputs or calculations can be performed with the model.

8. It is possible to print the list of modification factors, or the inputs and calculated results of the model. Simply click on the "print" icon, or use the "File/Print" option.

9. It is also possible to save the results of a calculation session, or to open the results of previously-saved files. The files are saved with the extension ".FRP".

10. At the end of the session, use your click your left mouse button on the icon titled "close", or use the File/Exit sequence.

RESEARCH TRIANGLE INSTITUTE

Center for Environmental Analysis

MEMORANDUM

DATE: November 11, 1997

TO:	Geddes Ramsey,	EPA/APPCD, MD-61, w/enclosures (3)
	Carlos Nuñez,	EPA/APPCD, MD-61, w/enclosure (1)
	Madeleine Strum,	EPA/OAQPS, w/enclosure
	Ron Ryan,	EPA/OAQPS, w/enclosure

FROM: Mark Bahner MAB

SUBJECT: Styrene Emission Factor Model Paper.
EPA Cooperative Agreement No. 824257; RTI Project 92U-6497-08.

Enclosed are copies of the subject paper. I have included extra copies in my transmittal to Geddes, assuming that the extra copies would be used for EPA editorial review.

The paper has been revised to address review comments by Madeleine Strum and Ron Ryan of EPA/OAQPS. As both these reviewers recommended, the model's predictive capabilities were evaluated for NMMA/RTI testing at U.S. Marine, and the model was revised as a result of this review.

As the paper has not completed the EPA/APPCD review cycle, I have stamped copies of the paper as "Draft".

If you have any questions or comments, please call me at 541-6016, or contact me by E-mail at bahner@rti.org.

3040 Cornwallis Road • Post Office Box 12194 • Research Triangle Park, North Carolina 27709-2194 USA
Telephone 919 541-5882 • Fax 919 541-7155

DRAFT

Empirical Model to Predict Styrene Emissions from Fiber-Reinforced Plastics Fabrication Processes

by

Carlos M. Nuñez and Geddes H. Ramsey
U.S. Environmental Protection Agency
National Risk Management Research Laboratory
Air Pollution Prevention and Control Division
Research Triangle Park, NC 27711

and

Mark A. Bahner and C. Andrew Clayton
Research Triangle Institute
P.O. Box 12194
Research Triangle Park, NC 27709

ABSTRACT

This paper describes an empirical model designed to predict styrene emissions from selected fiber-reinforced plastics (FRP) manufacturing processes. The model promotes an understanding of the relevant variables impacting styrene emissions in FRP processes and helps identify future areas of FRP pollution prevention (P2) research. In most instances, the model has been shown to be more accurate than the commonly-used model, *i.e.*, EPA's Compilation of Emission Factors for Industrial Processes or AP-42.

IMPLICATIONS

The mathematical model described herein can be used to predict styrene emissions from fiber-reinforced plastics (FRP) manufacturing processes. The model promotes an understanding of variables affecting styrene emissions and can, therefore, help identify future areas of FRP pollution prevention (P2) research. The model has been shown to be more accurate than AP-42 in predicting emissions from open mold spraying processes.

INTRODUCTION

The Air Pollution Prevention and Control Division (APPCD) of the Environmental Protection Agency's (EPA) National Risk Management Research Laboratory (NRMRL) is conducting research to reduce styrene emissions from open mold processes in the fiber-reinforced plastics (FRP) manufacturing industry. Open mold spraying processes are commonly used by the FRP manufacturing industry. These processes are used to manufacture boats, bathtubs, shower stalls, truck caps, body panels for recreational vehicles and trucks, swimming pools, etc. When polyester resins or gel coats are applied to open molds, styrene is emitted by evaporation. Based on Toxic Release Inventory reports [1], modified by the results of recent testing, we estimate annual styrene emissions from U.S. FRP manufacturing industries (including boat building) to be approximately 25,000 tons (2.3×10^{11} g), and we estimate that more than 50% of these emissions can be attributed to spraying of open molds.

Maximum Achievable Control Technology (MACT) standards for the reinforced plastic composites and boat building source categories are currently scheduled to be promulgated by November 2000. Pollution prevention (P2) techniques, such as changes in equipment and resin formulations may be used to reduce styrene emissions from some FRP products manufactured with open mold processes. The need to more accurately estimate styrene emissions, the factors influencing those emissions, and the standards development process have warranted the investigation of P2 opportunities for the FRP industry.

Currently, the most commonly used method for estimating styrene emissions from FRP manufacturing facilities is AP-42 (U.S. EPA, 1988), the EPA's Office of Air Quality Planning and Standards (OAQPS) manual for estimating air emissions from manufacturing processes (see Table 1).[2] In AP-42, emissions of styrene are presented in terms of an emission factor range for each FRP manufacturing process (gel coating, spray lay-up, hand lay-up, pultrusion, etc.). The emission factors are presented as a percentage of available monomer. If the monomer is styrene, the emission factors are as a percentage of available styrene (AS).

Table 1. AP-42 Emission Factors (Table 4.12-2 of AP-42).

Emission Factors for Uncontrolled Polyester Resin Product Fabrication Processes (a)

(100 x mass of VOC emitted / mass of monomer input)

Process	Resin NVS	Resin VS(b)	Emission Factor Rating(h)	Gel Coat NVS	Gel Coat VS(b)	Emission Factor Rating(h)
Hand layup	5 - 10	2 - 7	C	26 -35	8 - 25	D
Spray layup	9 - 13	3 - 9	B	26 - 35	8 - 25	B
Continuous lamination	4 - 7	1 - 5	B	(c)	(c)	
Pultrusion (d)	4 - 7	1 - 5	D	(c)	(c)	
Filament winding (e)	5 - 10	2 - 7	D	(c)	(c)	
Marble casting	1 - 3	1 - 2	B	(f)	(f)	
Closed molding (g)	1 - 3	1 - 2	D	(c)	(c)	

(a) Ranges represent the variability of processes and sensitivity of emissions to process parameters. Single value factors should be selected with caution. NVS = nonvapor - suppressed resin. VS = vapor-suppressed resin.

(b) Factors are 30-70% of those for nonvapor-suppressed resins.

(c) Gel coat is not normally used in this process.

(d) Resin factors for the continuous lamination process are assumed to apply.

(e) Resin factors for the hand layup process are assumed to apply.

(f) Factors unavailable. However, when cast parts are subsequently sprayed with gel coat, hand and spray layup gel coat factors are assumed to apply.

(g) Resin factors for marble casting, a semiclosed process, are assumed to apply.

(h) AP-42 emission factors are assigned quality ratings (see AP-42 Introduction). These ratings are:

A = Excellent
B = Above average
C = Average
D = Below average
E = Poor

Typical Resin Styrene - Percentages

Resin Application	Resin Styrene Content (a) (wt. %)
Hand layup	43
Spray layup	43
Continuous lamination	40
Filament winding	40
Marble casting	32
Closed molding	35
Gel coat	35

May vary at least ± 5 percentage points.

Recent tests conducted by EPA and others (see Table 2) indicate that styrene emissions from FRP processes may be higher than those published in AP-42. In addition, the AP-42 emission factor ranges are not correlated with conditions known or believed to affect emissions. For example, the emission factor range for spray layup with a styrene vapor suppressant ranges from 3 to 9% of available styrene, but no advice is given on what conditions would produce values in the upper or lower portions of this range.

EPA's APPCD, in cooperation with Research Triangle Institute (RTI), has engaged in the development of an empirical model to provide better styrene emission estimates for selected open-molding FRP fabricating processes. The model takes into account changes in parameters that are known to affect styrene emissions. This aids in understanding the relevance of variables impacting styrene emissions in FRP processes, and helps to identify future areas for FRP P2 research. Recommendations for potential future research and model development are presented in this paper.

Table 2. Comparison of AP-42 Resin Sprayup and Gel Coating Emission Factors with Recent Test Results

Emission Factor Source	Gel Coat Sprayup (NVS) %	Ratio to AP-42 Midpoint	Resin Sprayup NVS %	Ratio to AP-42 Midpoint	Resin Sprayup (VS) %	Ratio to AP-42 Midpoint
AP-42 Emission Factor (Reference 2).	26 - 35	1.0	9 - 13	1.0	3 - 9	1.0
EPA/Southern Research Institute (SRI) testing at Eljer Plumbingware (now Carolina Classics), June 1993, with EPA Method 25A (Reference 3).	48	1.6	--	--	20 / 12(a)	2.7 / 2.0
EPA/Radian (RTP) testing at Venetian Marble, VA (Reference 4).	68	2.2	--	--	--	--
EPA/Radian testing at General Marble, NC (Reference 5).	97	3.2	--	--	--	--
Radian testing, gel coat spraying of side-wall panels for trailers and recreational vehicles (Reference 6).	42 / 29(b)	1.4 / 1.0	--	--	--	--
Composite Fabricators Association (CFA)/Dow Phase I testing in Freeport, TX, September-December 1995, average values for all experimental runs (Reference 7).	51	1.7	25	2.3	--	--
EPA/RTI pollution prevention testing at Reichhold Chemicals in June, 1995, (Reference 8).	63 / 54(c)	2.0 / 1.7	27 / 18(c)	2.5 / 1.6	11	1.8
Testing at Lasco Bathware in Yelm, Washington, August 1996 (Reference 9).	53 / 45(d)	1.7 / 1.5	--	--	20	3.3
Testing at Lasco Bathware in Moapa, Nevada, June 1996 (Reference 10).	33 / 49(d)	1.1 / 1.6	--	--	16	2.7
NMMA testing at U.S. Marine, in April 1997, average values for all boat mold runs (Reference 11).	51	1.7	18	1.7	--	--

Notes:

-- Process or condition not tested.

(a) 20% = first layup, 12% = second layup.

(b) 42% = baseline gel coat, 29% = high performance gel coat with fast gel time. Robotic spray guns inside a total enclosure.

(c) Values are for normal spraying and controlled spraying, respectively.

(d) Values are for gel coat and barrier coat, respectively.

DESCRIPTION OF MODEL

Algebraic Form

An empirical model has been developed to predict emissions from open-molding FRP fabrication processes. The model chosen is:

$$\xi_m = \xi_b \cdot \Gamma_i!$$

where:

ξ_m = Emissions, as a percentage of the styrene in the gel coat or resin.

ξ_b = Baseline emissions, i.e., emissions from a process under fixed, "typical" conditions.

Γ_i = Modification factors, i.e., changes to baseline emissions caused by changes in parameters that are known to affect styrene emissions (gel time, styrene content, thickness, etc.).

$\Gamma_i!$ = Product of all applicable modification factors.

To simplify this modeling approach, baseline emission values were calculated for each process. The baseline emission values were calculate under fixed, "typical" conditions. If all the conditions at a particular plant were equal to baseline conditions, each of the modification factors would be given a value of 1.0, and the predicted emissions would equal the baseline value. In addition, emission curves are generated for each modification factor and the overall emission factor is then represented by the product of each curve. At present, the model assumes no multiple-factor interactions (i.e., the equation for one modification factor changing with another modification factor).

Studies Used as Model Inputs

Many emission studies were evaluated and used as model inputs. Table 3 lists model parameters, including baseline emission factors and modification factors, and styrene emission studies used as model inputs.

Baseline Values

Baseline emission values, and the conditions under which they were established, are shown in Table 4. Baseline values for gel coating, and resin sprayup are derived from EPA/RTI testing. This testing was chosen to establish baseline values because the amount of dried material off the mold (a key modeling parameter) was measured during the testing.

Table 3. Emission Studies Used as Model Inputs.

Model Parameter	Emission Studies Used as Input to Model					
	1	2	3	4	5	6
Baseline Emission Factors						
Resin sprayup		✓				
Gel coat spraying		✓				
Hand layup (with bucket/paint roller)	✓					
Flow coating			✓			
Pressure-fed rolling			✓			
Modification factors						
Styrene content for sprayup	✓	✓		✓		
Styrene content for hand layup, pressure-fed rolling, flow coating	✓					
Styrene content for gel coat spraying	✓	✓				
Distance from spray gun to mold	✓		✓			
Dry material off the mold, as a percentage of total material sprayed		✓				
Laminate/gel coat thickness	✓	✓				
Cup gel time	✓					
Application rate	✓					
Air temperature						✓
Air velocity (above 40 fpm)	✓	✓				
Air velocity (below 40 fpm)					✓	
Styrene suppressant		✓		✓		

Emission studies:

1. CFA/Dow Phase I (CFA 1996)[7]
2. EPA ORD/RTI Pollution Prevention (EPA, 1997)[8]
3. CFA/Dow Phase II (Not yet published)[7]
4. EPA ORD/RTI Filled Resin (RTI 1996b)[11]
5. Pultrusion Industry Council Phase II (SPI, 1995)[12]
6. Dow Filament Winding (Dow, 1997)[13]

Table 4. Chosen Baseline Values and Baseline Conditions

Process	Gel Coating	Resin Sprayup	Hand Layup	Flow Coater (with chop)	Pressure-Fed Roller
Baseline emission value (%AS)	54.8 (a)	18.9 (b)	12.3 (c)	11.3 (d)	12.6 (e)
Styrene content, neat (%, by weight)	38	38	38	38	38
Styrene suppressant	No	No	No	No	No
Distance from spray gun to mold (inches)	23	23	N/A (f)	23	N/A
Dried material off of mold, as a percentage of total material sprayed (%)	6	6	N/A	N/A	N/A
Thickness (0.001 in.)	20	70	70	70	70
Gel time (minutes)	15	15	15	15	15
Application rate (lb/min)	2	4	N/A	N/A	N/A
Air temperature (°F)	75	75	75	75	75
Air velocity (ft/min)	100	100	100	100	100

(a) Reflects measured value of 56.0, adjusted to baseline conditions.

(b) Reflects measured value of 17.5, adjusted to baseline conditions.

(c) Reflects measured value of 14.6, adjusted to baseline conditions.

(d) Reflects measured value of 11.5, adjusted to baseline conditions.

(e) Reflects measured value of 12.9, adjusted to baseline conditions.

(f) N/A = Not Applicable

A key assumption in use of baseline values from limited numbers of studies is that all types of resins (e.g. orthophthallic, dicyclopentadiene [DCPD], vinyl ester, etc.) have the same level of emissions for a given styrene content. This assumption may not be valid, as will be discussed later in this paper.

Example Calculations

The following example, based on the resin sprayup thickness modification factor, illustrates how various modification factors were developed:

1) CFA testing in October 1995, indicated an average emission factor of approximately 26% AS for a laminate thickness of 40 mils (40 thousandths of an inch), and an emission factor of approximately 24% AS for a laminate thickness of 80 mils.

2) A laminate thickness of 70 mils was chosen as the "baseline" thickness. (The choice of 70 mils is somewhat arbitrary, but is believed to represent a typical thickness for a single application layer within the FRP industry.) Using linear interpolation between the two laminate thicknesses of the CFA testing, the emissions for a laminate thickness of 70 mils would be 24.5%.

3) If the resin sprayup emission factor for 80 mils is 24% AS, and the emission factor for the baseline 70 mils is 24.5% AS, the modification factor for 80 mils is 24/24.5, or 0.98. Similarly, the modification factor for 40 mils is 26/24.5, or 1.06.

4) The equation for a straight line passing through a modification factor of 0.98 at 80 mils and 1.06 at 40 mils is $y = 1.14 - 0.002x$, where x= laminate thickness in mils.

A sample calculation for emissions from an unfilled resin system, with a neat resin styrene content of 46%, a thickness of 160 mils, a temperature of 72°F, and all other conditions equal to the unfilled resin "baseline" conditions, is presented in Table 5.

Review of Selected Modification Factors

A total of 10 modification factors are included in the complete model. Equations for modification factors were determined from test results. The equations are shown in Table 6.

Background data used to generate the (neat) styrene content modification factor are shown in Figure 1. A second order (quadratic) equation has been fitted through the data. This type of curve is probably more accurate than a linear regression in describing emissions behavior at low styrene contents (below 33% styrene). A linear regression fitted through the data would

Table 5. Example Calculation (Sprayup with an Unfilled Resin).

Parameter	Value	Modification Factor: Equation[a]	Modification Factor: Calculated Value
Styrene content (% by weight, neat[b])	46	$0.000614x^2 + 0.003x$	1.43
Styrene suppressant (YES/NO)	NO	IF NO: 1.00; IF YES: 0.64	1.00
Distance from spray gun to mold (inches)	15	$0.69 + 0.0205x$	1.00
Dried material off mold/total material sprayed (%)	6	$0.0028x^2 - 0.006x + 0.93$	1.00
Laminate/gel coat thickness (mils, i.e., thousandths of an inch)[c]	160	IF $x>40$: $1.14 - 0.002x$; IF $x\leq40$: $3.34 - 0.0583x$	0.82
Cup gel time (min)	15	$0.97 + 0.002x$	1.00
Application rate (lb/min)	3	IF $x<4$: $1.276 - 0.092x$ IF $x\geq4$: 0.908	1.00
Air temperature (°F)	72	$0.180 + 0.011x$	0.97
Air velocity (ft/min)	100	IF $x<38$: $0.64 + 0.0148x$; IF $x\geq38$: $0.96 + 000405x$	1.00
Baseline value (%AS)			7.5
Overall modification factor			1.14
Calculated emissions (%AS)			20.0

[a] In equations, "x" denotes the value for the applicable parameter.

[b] "Neat" refers to the styrene content (%, by weight) before filler is added.

[c] "Laminate thickness" refers to the thickness for a single "spraying session", which might include 2-4 "passes" with the spray gun.

Table 6. Modification Factors for Styrene Emission Factor Prediction Model

Parameter	Units for "x"	Modification Factor Equation for Gel Coating	Modification Factor Equation for Resin Sprayup	Modification Factor Equation for Hand Layup, Pressure-Fed Roller, Flow Coater
Neat resin styrene content	%	$0.55 + 0.011x + 0.00005x^2$	$0.003x + 0.000614x^2$	$0.24 + 0.02x$
Styrene suppressant	YES/NO	Not applicable	IF NO: 1.00; IF YES: $0.64 + 0.005y$ (See Note 1)	IF NO: 1.00; IF YES: $0.50 + 0.005y$ (See Note 1)
Distance from spray gun to mold	inches	$0.87 + 0.0088x$	$0.69 + 0.0205x$	1
Dry material off of mold/total material sprayed	%	$0.862 + 0.023x$	$0.90 + 0.0007x + 0.0025x^2$	1
Thickness (see Note 2)	mils	IF $x<40$: $1.55 - 0.0273x$; IF $x\geq40$: $0.492 - 0.0009x$	IF $x>40$: $1.14 - 0.002x$; IF $x\leq40$: $3.34 - 0.0583x$	IF $x>40$: $1.63 - 0.009x$; IF $x\leq40$: $3.34 - 0.0583x$
"Cup" gel time	min	$0.97 + 0.002x$	$0.97 + 0.002x$	$0.79 + 0.014x$
Application rate	lb/min	1	IF $x<4$: $1.406 - 0.102x$ IF $x\geq4$: 1.0	Not applicable
Air temperature	°F	$0.18 + 0.011x$	$0.18 + 0.011x$	$0.18 + 0.011x$
Air velocity over mold	ft/min	IF $x<38$: $0.64 + 0.0148x$; IF $x\geq38$: $0.96 + 0.000405x$	IF $x<38$: $0.64 + 0.0148x$; IF $x\geq38$: $0.96 + 0.000405x$	IF $x<38$: $0.64 + 0.0148x$; IF $x\geq38$: $0.96 + 0.000405x$

Notes:

(1) In modification factor for resin spraying with styrene suppressant, "y" represents amount of filler (by weight), in the resin, as applied. For example, sprayup of a styrene-suppressed resin with 50% filler (by weight, as applied) would have styrene suppressant modification factor of 0.89.

(2) "Thickness" refers to the thickness for one "spraying session", which might include 2-4 "passes" with the spray gun.

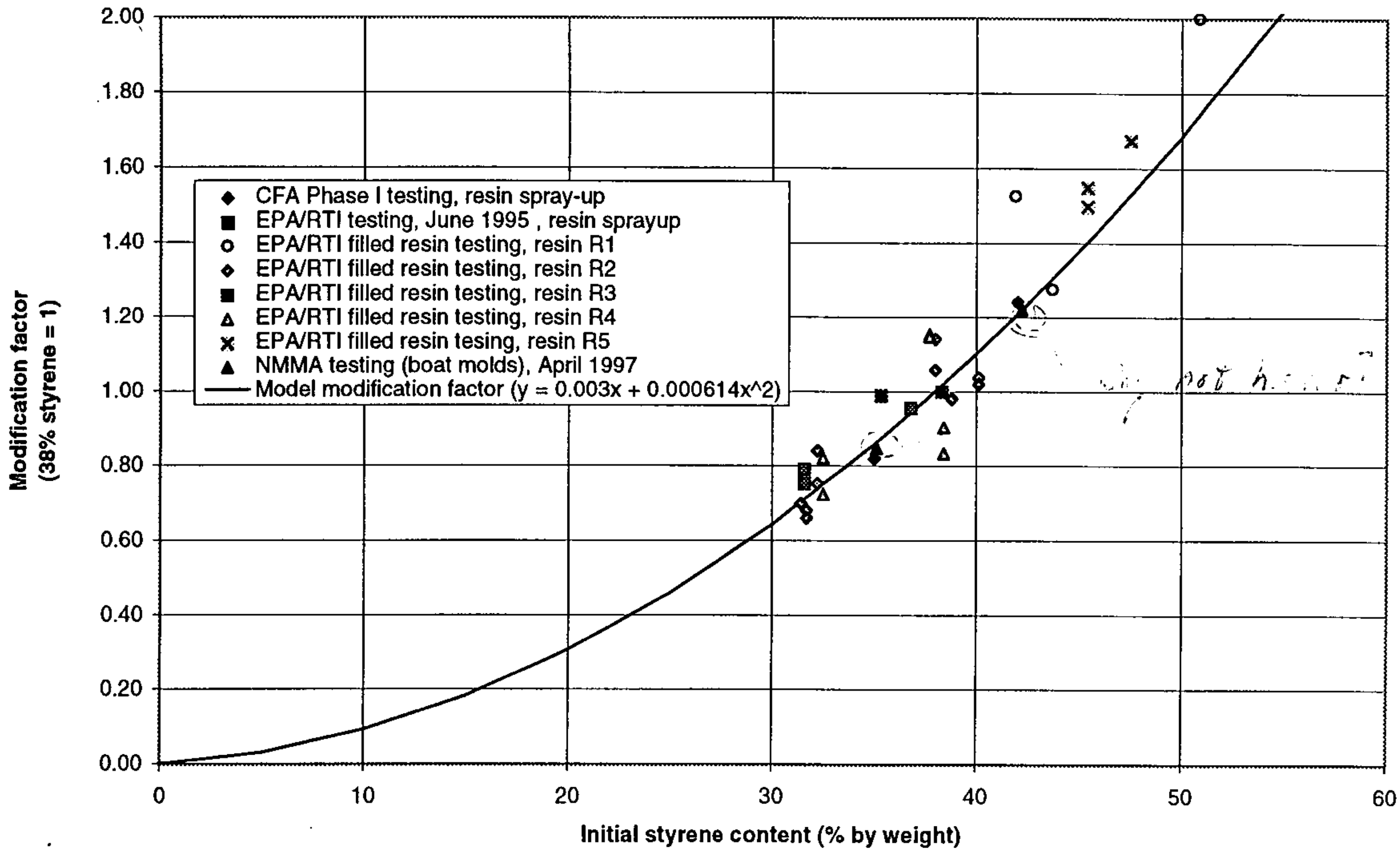

Figure 1. Modification factor for intial styrene content during resin sprayup.

result in prediction of negative emissions at very low styrene contents, which is obviously a physical impossibility. Figure 1 illustrates that styrene content is predicted to have a large effect on emissions in resin sprayup. For example, the modification factor for a styrene content of 38% is 1.0, but the modification factor for an neat styrene content of 42% is 1.21; in other words, emissions (expressed as a percentage of available styrene) are predicted to increase by 21% when styrene content is raised from 38% to 42%.

Background data used to generate the styrene content modification factor for gel coat spraying are shown in Figure 2. When compared with the resin sprayup data in Figure 1, it can be seen that the available gel coat data in Figure 2 are limited. It can also be seen that the predicted effect of styrene content on gel coat emissions is much less; i.e., the slope of the curve in Figure 2 is much more shallow than in Figure 1.

The predicted effect of air velocity over the mold is depicted in Figure 3. It can be seen that air velocity over the mold has little effect on emissions for air velocities in the range from 50 to 200 f/min. This result is based on testing conducted by EPA and RTI, under a cooperative agreement, and CFA.

Figure 3 shows that reductions in air velocity (for air velocities below approximately 40 ft/min) are predicted to produce reductions in emissions. For air velocities near zero (i.e., no air exchange, as could be found in an enclosed space), the predicted emission reduction is up to 36 % (i.e., a modification factor of 0.64), relative to emissions at 100 ft/min. Data for air velocities below 40 ft/min are available from testing on a pultrusion process by the SPI/PIC, and from RTI bench-scale testing (measuring curing emissions from paint lids). Model predictions for air velocities below 40 ft/min are based on taking the central values for all SPI/PIC and RTI bench-scale testing. Figure 3 shows that the model predictions below 40 ft/min have a great deal of uncertainty, because of the wide variation in results in the RTI bench-scale testing, and between the RTI and SPI/PIC results. Further, neither of these tests represented resin sprayup or gel coating processes; it may therefore be inappropriate to extend the results to sprayup or gel coating. For example, most spray guns in the FRP industry are air-assisted (i.e., use an air stream to direct the resin to the mold). This air-assist creates its own air velocity across the mold.

Operator spraying technique appears to have a significant effect on emissions from gel coat and resin spraying. There are many ways to objectively measure operator spraying technique, in order to correlate operator technique with emissions. In June and July of 1995, EPA and RTI conducted testing that demonstrated that emissions could be correlated with transfer efficiency. In this testing, transfer efficiency was defined as the amount of wet material on the mold immediately after spraying stopped, divided by the total amount of material sprayed. However, these measurements of transfer efficiency would be very difficult to make with large molds in a production situation, since the mold would have to be sitting on a high-accuracy, high-capacity scale. During the 1995 testing, the amount of dried material off of the mold was also measured. When the ratio of dried material off of the mold is divided by the total amount of material sprayed, this ratio also appears to correlate with emissions. This dry-material-off-mold

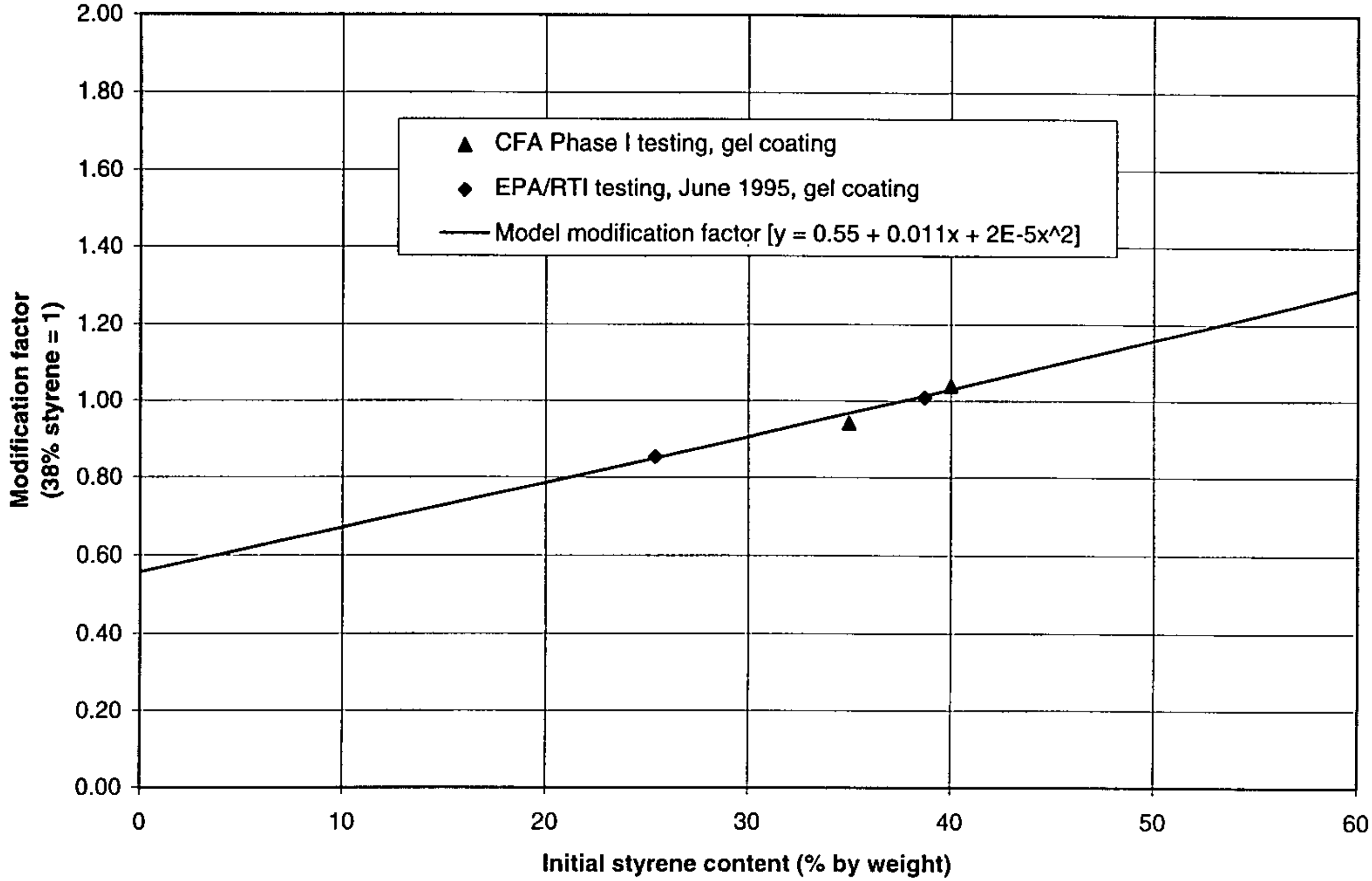

Figure 2. Background data for initial styrene content modification factor for gel coat spraying.

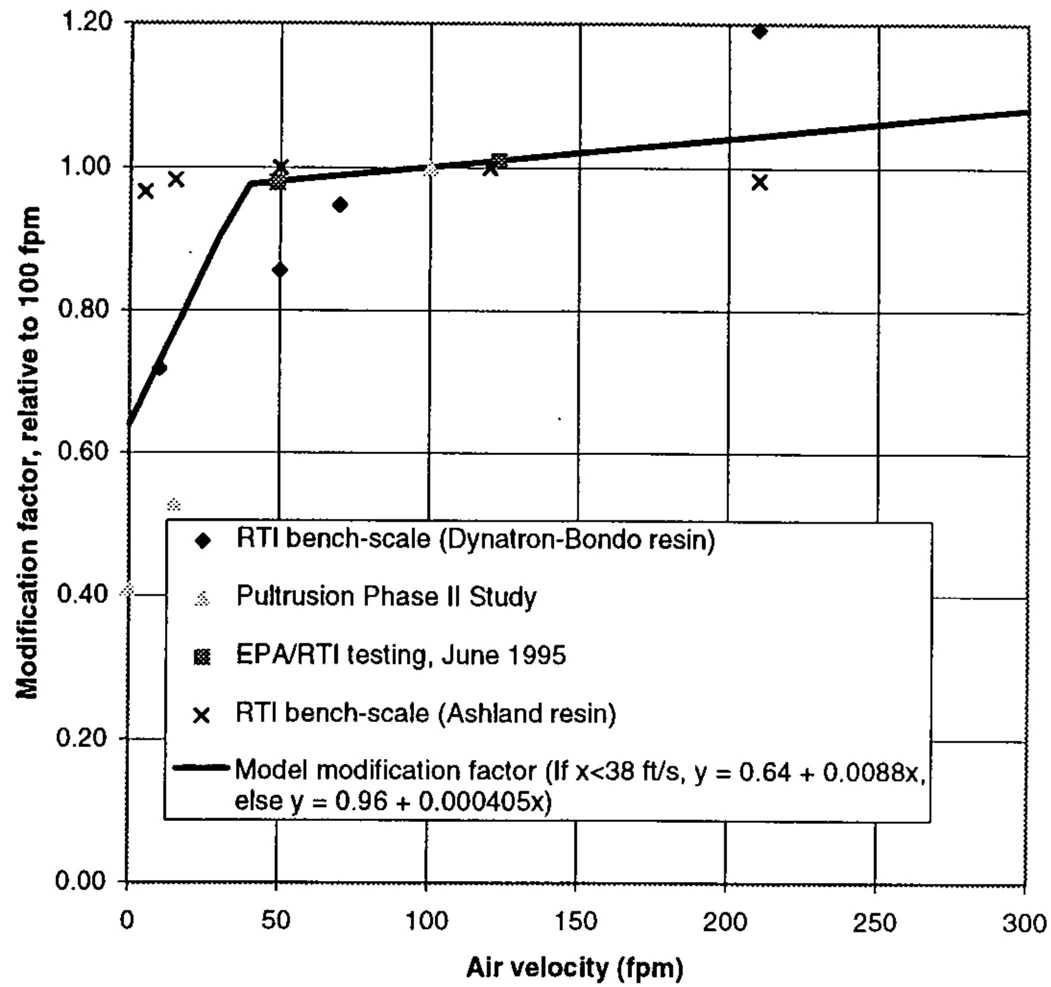

Figure 3. Background data for air velocity modification factor.

ratio was used as a model input, because the amount of dried material off of the mold is a much easier measurement to make than the amount of wet material on the mold.

Figure 4 depicts available data for the dry-material-off-mold resin sprayup modification factor. The data are from the testing that EPA and RTI conducted in 1995. During EPA and RTI "controlled" spraying, the mass of dry material off of the mold averaged 5.7% of the total material sprayed. For the one "normal resin" sprayup run, the mass of dried material off of the mold represented 15.7% of the total material sprayed. Both these data points are represented in Figure 4.

At present, there has been no attempt to measure the amount of dried material falling off the mold for large female parts, such as boat hulls. However, it can probably be assumed that the fraction of material falling off the mold during "controlled" spraying of a large female mold would be significantly less than was measured during the EPA/RTI 1995 testing, which was conducted on a relatively small (25 ft^2) male mold. Further, emissions from the "controlled" spraying of large female molds were measured by both CFA and NMMA. These emissions were not substantially lower than the emissions measured during the EPA/RTI 1995 testing. Therefore, Figure 4 shows the model assumption that the modification factor for dry-material-off-the-mold is a curve that reaches a minimum at approximately 10 percent lower than the value measured during EPA/RTI "controlled" spraying tests in 1995.

Figure 5 depicts available data for the dry-material-off- mold gel coat spraying modification factor. During EPA and RTI controlled gel coat spraying, the average emission factor was 54.2%AS when the dried material off of the mold averaged 6.4% of the total material sprayed. During the EPA and RTI normal spraying, the average emission factor was 62.5%AS when the dried material off of the mold averaged 13.1% of the total material sprayed. These data are plotted in Figure 5.

Another objective parameter reflecting operator spraying technique that appears to have an effect on emissions is the distance from the spray gun to the mold. Figure 6 depicts available data for the distance-from-spray-gun-to-mold modification factor.

The data in Figure 6 come from two sources. One source is testing conducted by the CFA in 1996. Tests were conducted with a variety of mold sizes and shapes. Tests were conducted with "controlled" spraying, in which the spray gun was held approximately 12 inches from the mold, and maintained perpendicular to the mold surface. Spraying was also conducted with "uncontrolled" spraying, in which the spray gun was held approximately 18-20 inches from the mold surface, and allowed to have an angle of up to 45 degrees from the mold surface. Based on these distances and angles, we have assumed an average distance from the spray gun to the mold surface of approximately 23 inches in analyzing the CFA data. This represents an assumption that approximately ½ of the total time was spent spraying perpendicularly from a distance of 19 inches, and ½ of the total time was spent spraying at a 45 degree angle from 19 inches (which produces a distance of 27 inches). However, during these controlled/uncontrolled spraying comparisons, spray gun pressure was also varied, with higher pressures used during the

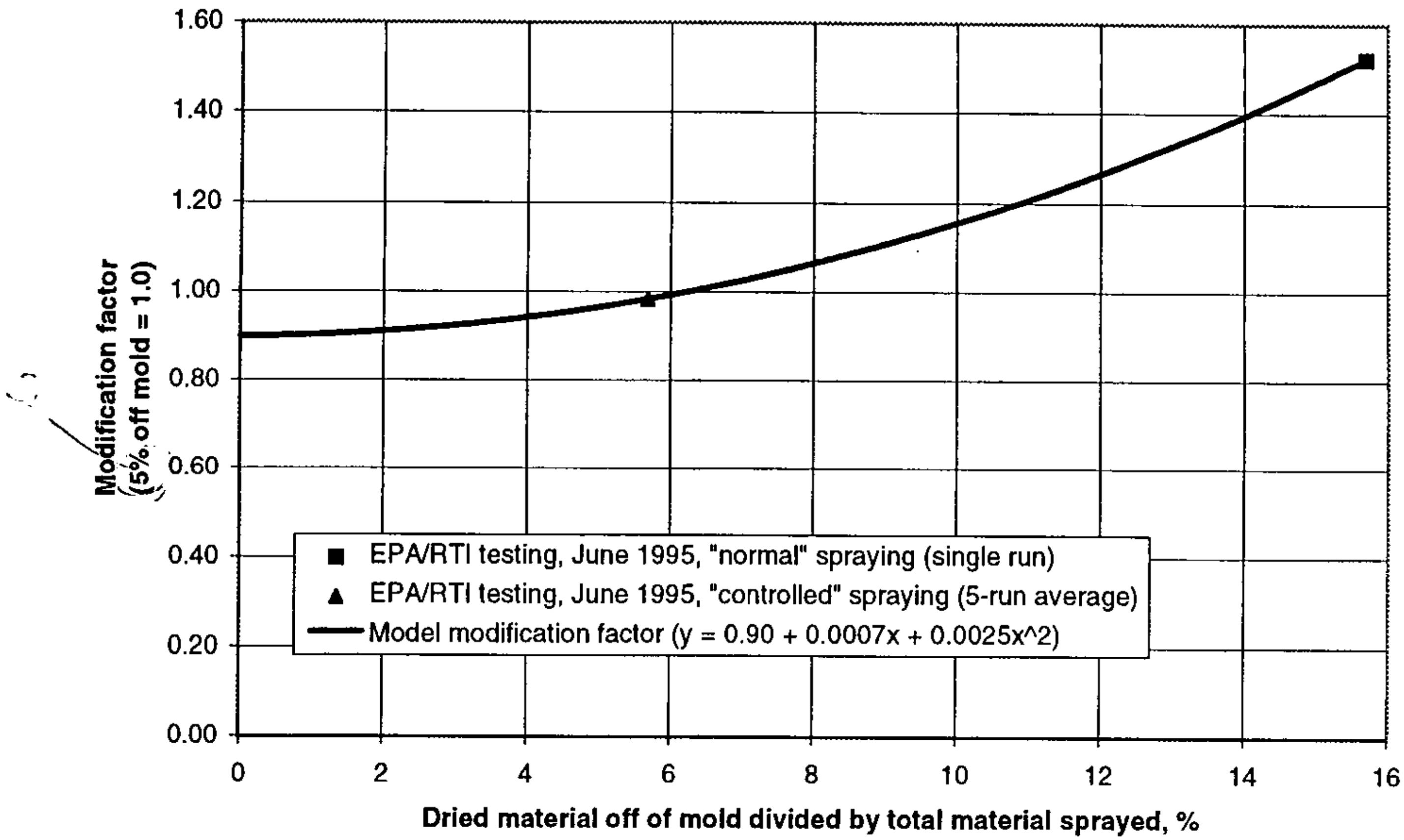

Figure 4. Background data for "dried material off the mold" for resin sprayup.

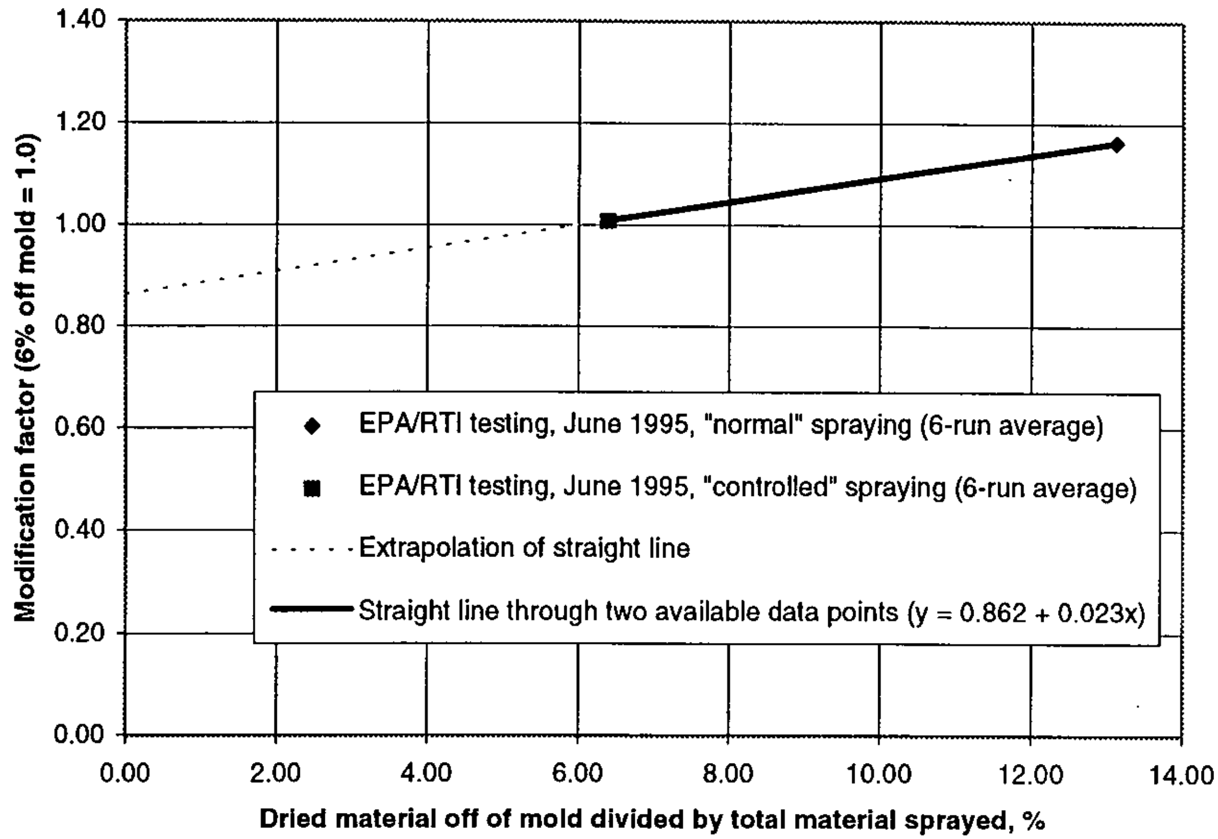

Figure 5. Background data for "dried material off mold" modification factor for gel coat spraying.

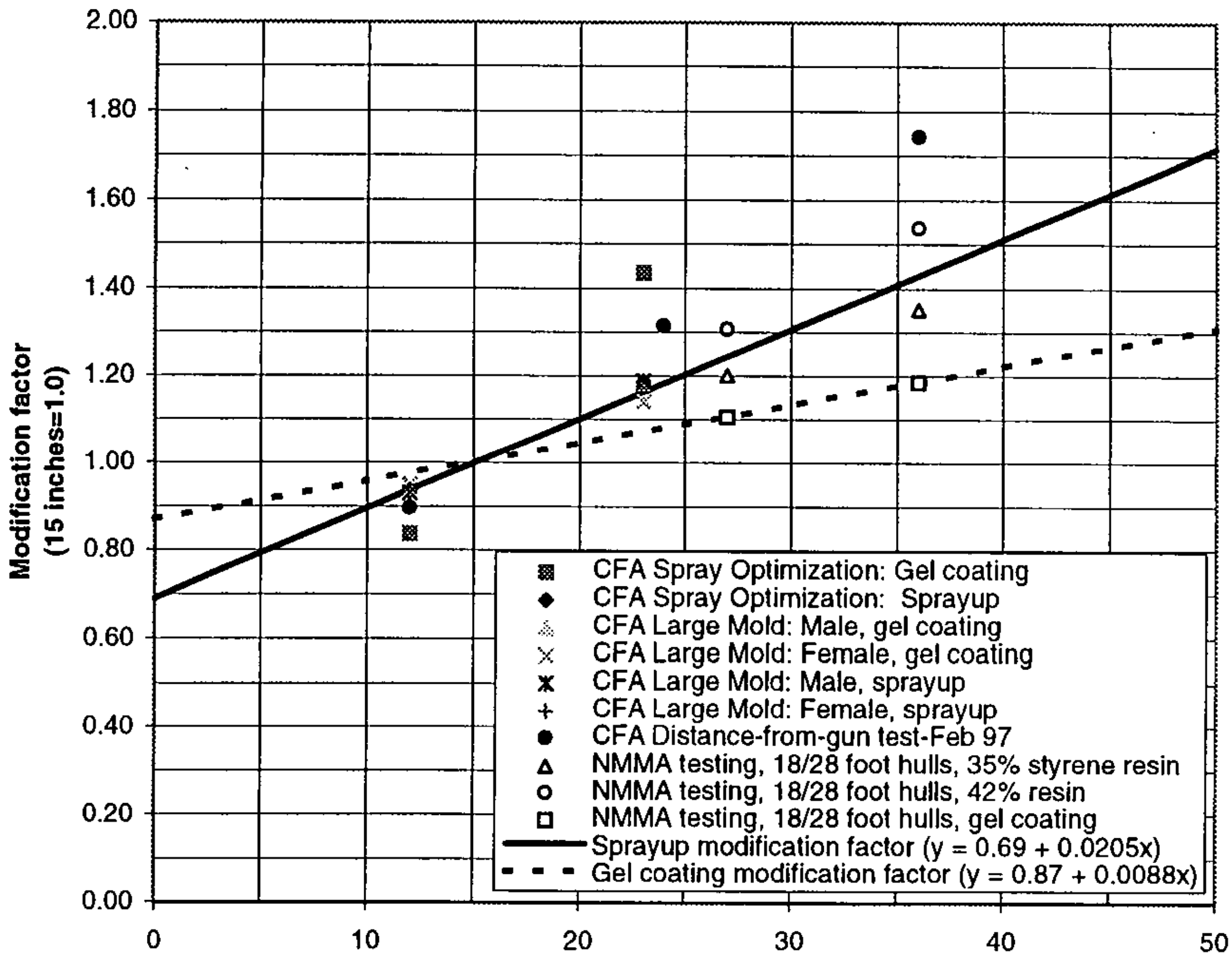

Figure 6. Modification factor for distance from spray gun tip to mold.

"uncontrolled" testing. Therefore, the effects of distance alone are probably less than depicted by comparing "controlled" versus "uncontrolled" results. Another source of data in Figure 6 is testing conducted by the CFA in February 1997. In this testing, a gun was held in a stationary position perpendicular to a mold, at fixed distances of 12, 24 and 36 inches from the mold. Peak exhaust concentrations were measured at each of these distances. Although peak exhaust concentrations during spraying do not necessarily correlate with spraying emissions, the data from the February 1997 testing are included in Figure 6, because this testing carefully controlled distance from the spray gun to the mold.

A final set of data in Figure 6 are based on results of NMMA testing of emissions from laminating 18-foot and 28-foot hulls. When laminating the 28-foot hull, the spray gun was, on average, at a greater distance from the mold than during spraying of the 18-foot hull; this greater distance produced higher emissions. The model modification factors for distance-from-the-mold are based on analysis of NMMA data. The gel coat modification factor is based on a straight line through the NMMA gel coating data;

The CFA optimization testing in 1996 also showed that spray gun tip pressure/tip size has an effect on emissions. The CFA testing showed that, for any given tip size, increasing tip pressure increases emissions. However, no attempt has been made to include a spray gun tip pressure/tip size modification factor in this model. Spray gun pressure/tip size has been left out of this model for simplicity, and because the effects of optimizing spray gun pressure/tip size were found to interact with controlled spraying technique. For example, during the resin sprayup optimization testing, controlled spraying was found to reduce emissions (expressed in % AS) by 21% relative to baseline conditions, and optimizing spray gun pressure was found to reduce emissions by 9% relative to baseline conditions. However, when controlled spraying and optimized spray gun pressure were both used, the emission reduction was still approximately 21%; equivalent to the reduction produced by controlled spraying alone.

Modification Factors with Largest Impact

The complete model has 10 modification factors. Some of these modification factors become very significant only in limited cases. For example, the air temperature modification factor changes by approximately 1% for every 1°F above or below the baseline of 75°F. Therefore, if plant conditions were maintained within ± 5°F of 75°F, there would be little need to consider air temperature. However, most FRP facilities do not have air conditioning, and summertime temperatures can be above 95 °F; these temperatures significantly increase the predicted emissions. Other modification factors are important for only certain processes. For example, thickness has a very significant effect on the percentage of available styrene emitted for gel coating, but has much less significance at the typical thicknesses (70 mils or greater) found in resin sprayup.

In many cases, the number of inputs to the model can be limited to the 4 or 5 factors with the largest impact on emission predictions, rather than using all 11 inputs. Figures 7 and 8 depict the 5 factors with the greatest impact for gel coating and resin sprayup, respectively, based on

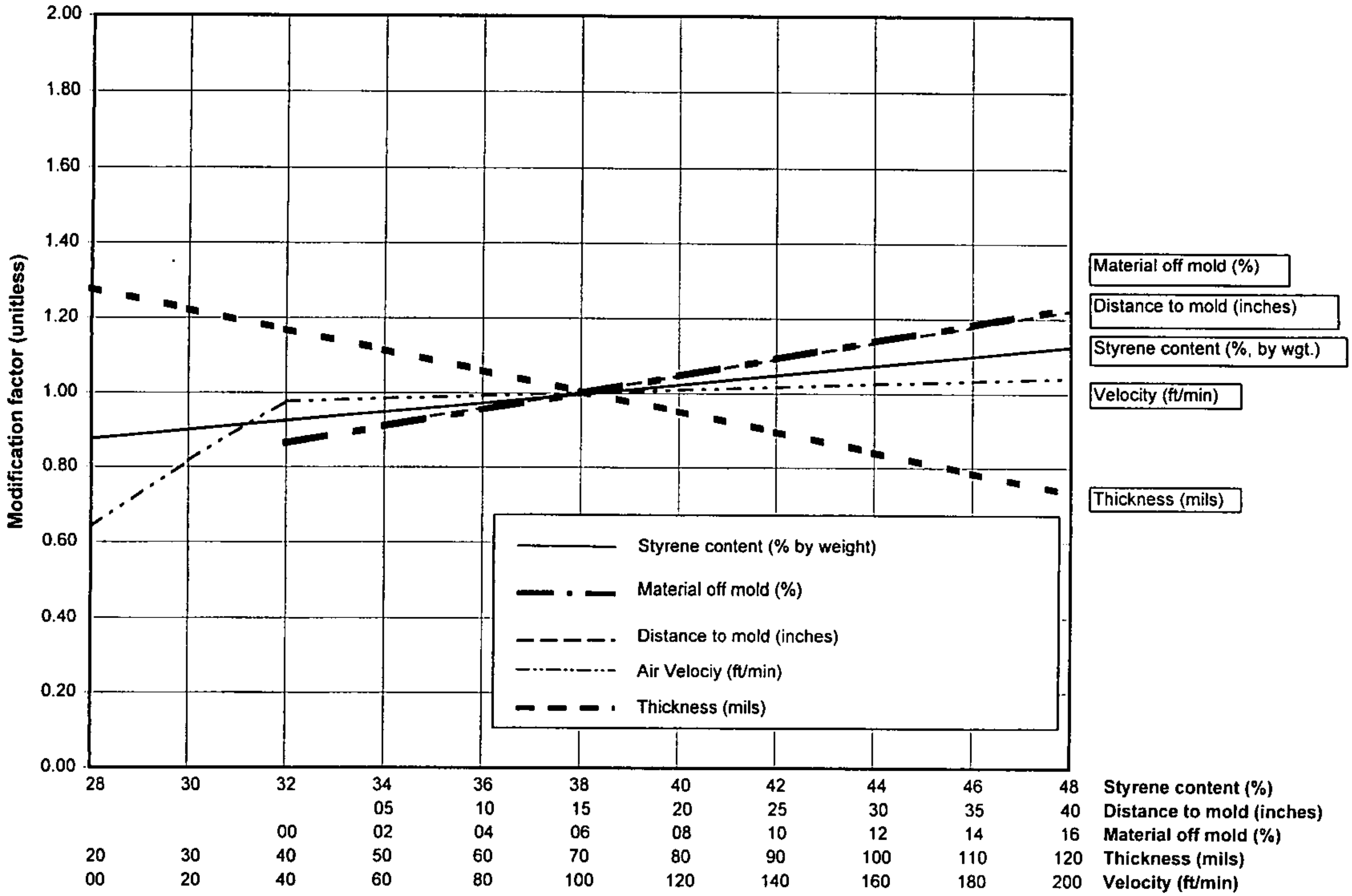

Figure 7. Important modification factors for gel coating.

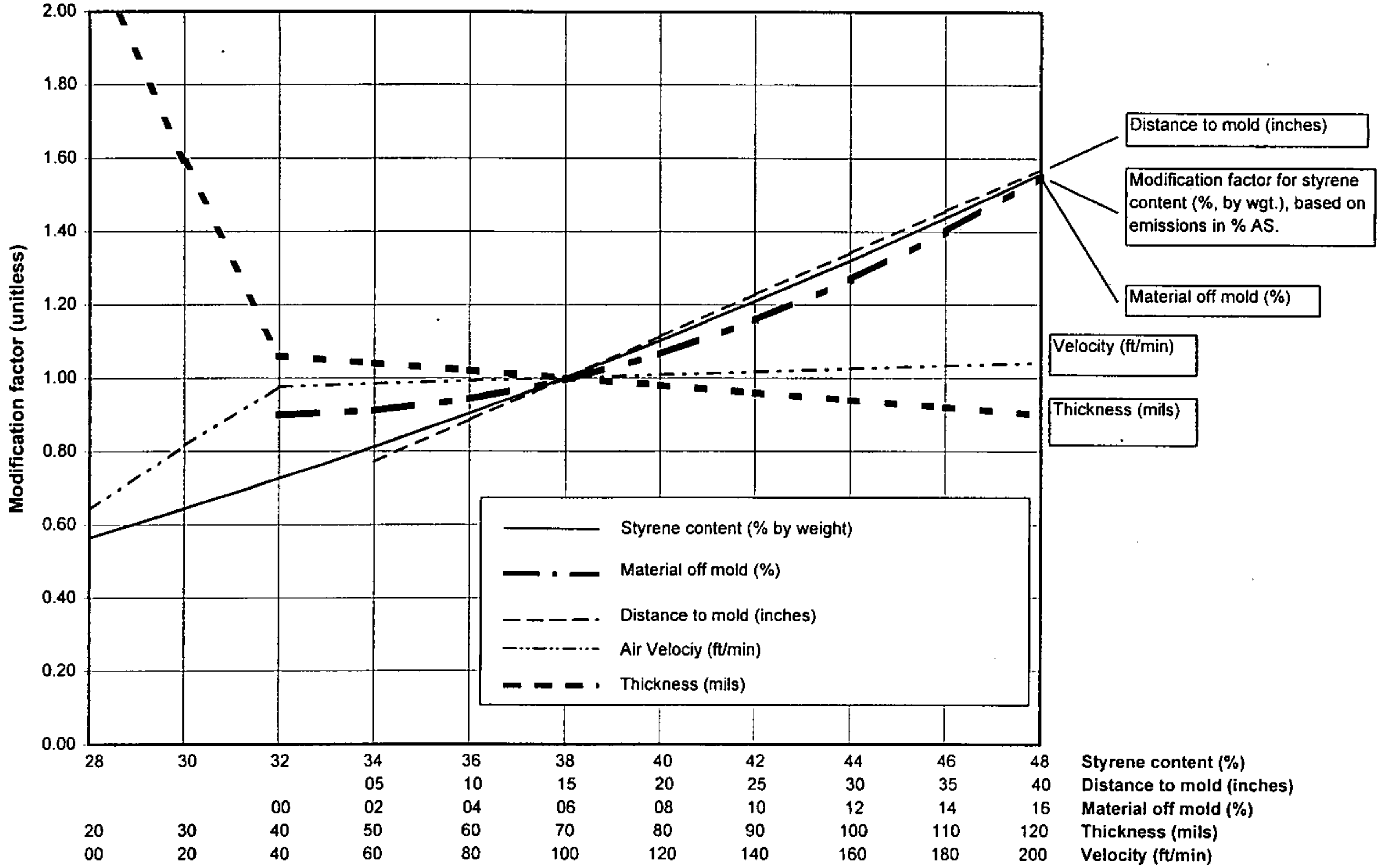

Figure 8. Important modification factors for resin sprayup.

typical conditions found at FRP facilities. It should be understood that the decision about what constitutes *typical* conditions is a judgement. For example, there are some FRP plants where temperatures above 85°F are in fact typical. The x-axes in Figures 7 and 8 have the chosen baseline conditions in the center of the graph, and approximate minimum and maximum conditions on the left and right sides of the graph, respectively. (The decision about what constitutes minimum and maximum conditions is also a judgement.) For example, the scale for velocity has a midpoint at 100 fpm (the baseline velocity). The minimum and maximum values for velocity are 0 and 200 fpm, respectively; 200 fpm represents the maximum velocity that might be found in a spray booth or forced ventilation situation.

Figure 7 shows that one significant method for reducing gel coat spraying emissions is to decrease the amount of overspray (i.e., the amount of material not landing on the mold). As shown in Figure 7 (and in Figure 5), the model predicts that gel coat spraying emissions, expressed as a percentage of available styrene, can be reduced by approximately 14% (i.e. the modification factor can be lowered to 0.86), if the amount of dried material off of the mold can be reduced from 6% of total material sprayed to 0% of total material sprayed. Another potential way to reduce gel coating emissions is to decrease the air velocity over the mold to near zero. This produces a predicted reduction of approximately 36% (i.e. a modification factor of approximately 0.64), relative to a velocity of 100 ft/min over the mold. However, such reductions in air velocity over the mold are unlikely to be achieved in open spraying situations, because operator exposures to styrene would probably increase to unacceptably high levels. In order to produce the very low air velocities over the mold necessary to reduce emissions, sophisticated air handling techniques or spraying enclosures would be required.

The resin sprayup modification factors in Figure 8 show that styrene content has a significant effect on emissions, expressed as a percentage of available styrene emitted. This is illustrated by the fact that the styrene content curve in Figure 8 is very steep, compared to other curves. In fact, in the region at the center of the curve (representing baseline conditions) the only curve which has a steeper downward slope than the styrene content curve is the distance-to-mold curve. Therefore, reducing resin styrene content is an extremely important pollution prevention measure for resin sprayup.

COMPARISON OF THE NEW EMPIRICAL MODEL WITH THE AP-42 "MODEL"

CFA Phase I Testing

Figures 9 and 10 compare model predictions with AP-42 predictions for gel coat spraying and resin sprayup, respectively, for the CFA phase I testing. In both cases, the value for "dry-material-off-the-mold" was not measured by CFA. The analysis in Figures 9 and 10 is based on the assumption that the values for "dry-material-off-the-mold" are equal to the "baseline" model values of 6% (for gel coating and resin sprayup). These values are essentially equal to the values obtained for "controlled" spraying during the EPA/RTI testing at Reichhold, in June 1995.

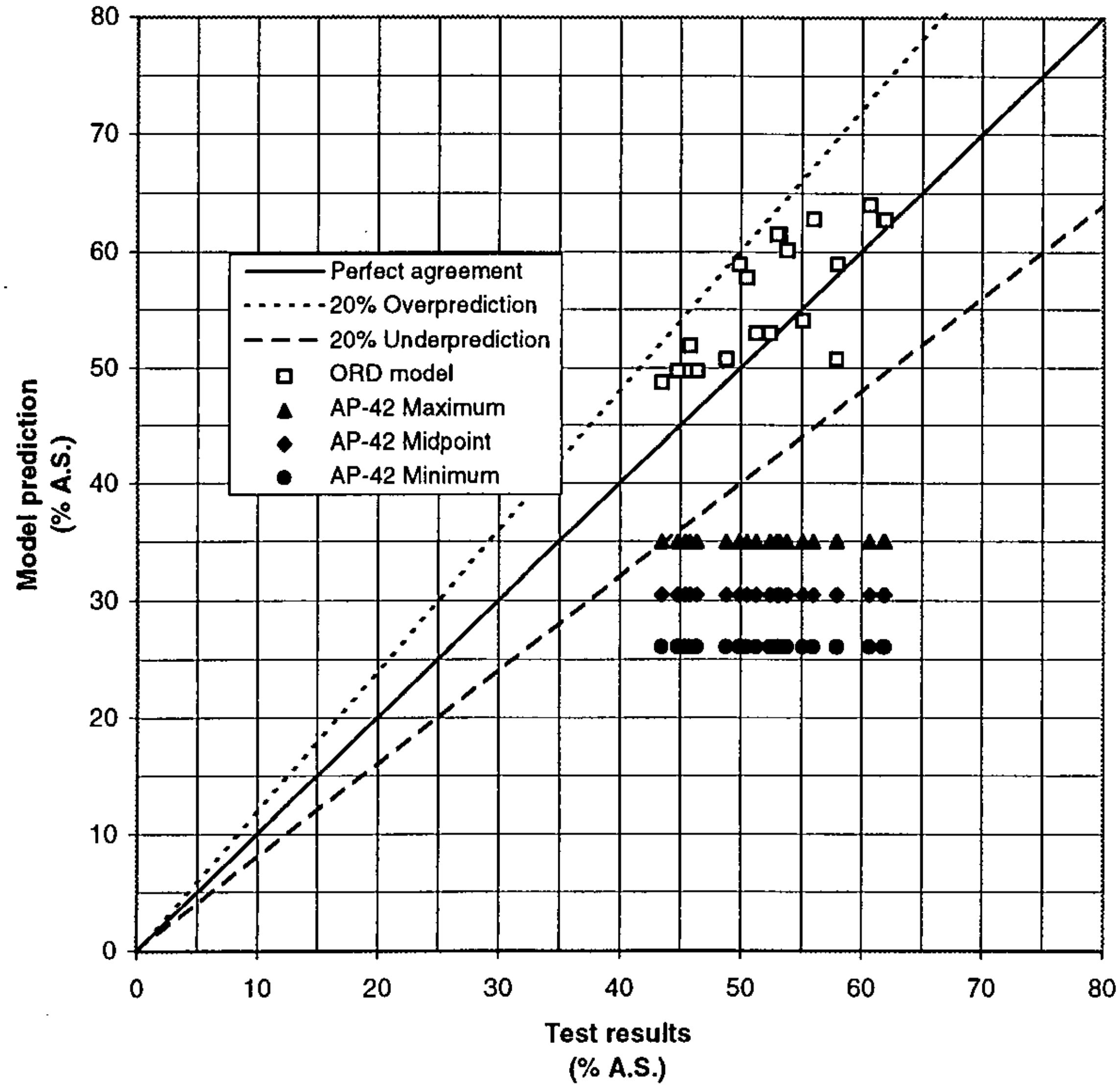

Figure 9. Composite Fabricators Association Phase I gel coating results versus RTI Model and AP-42.

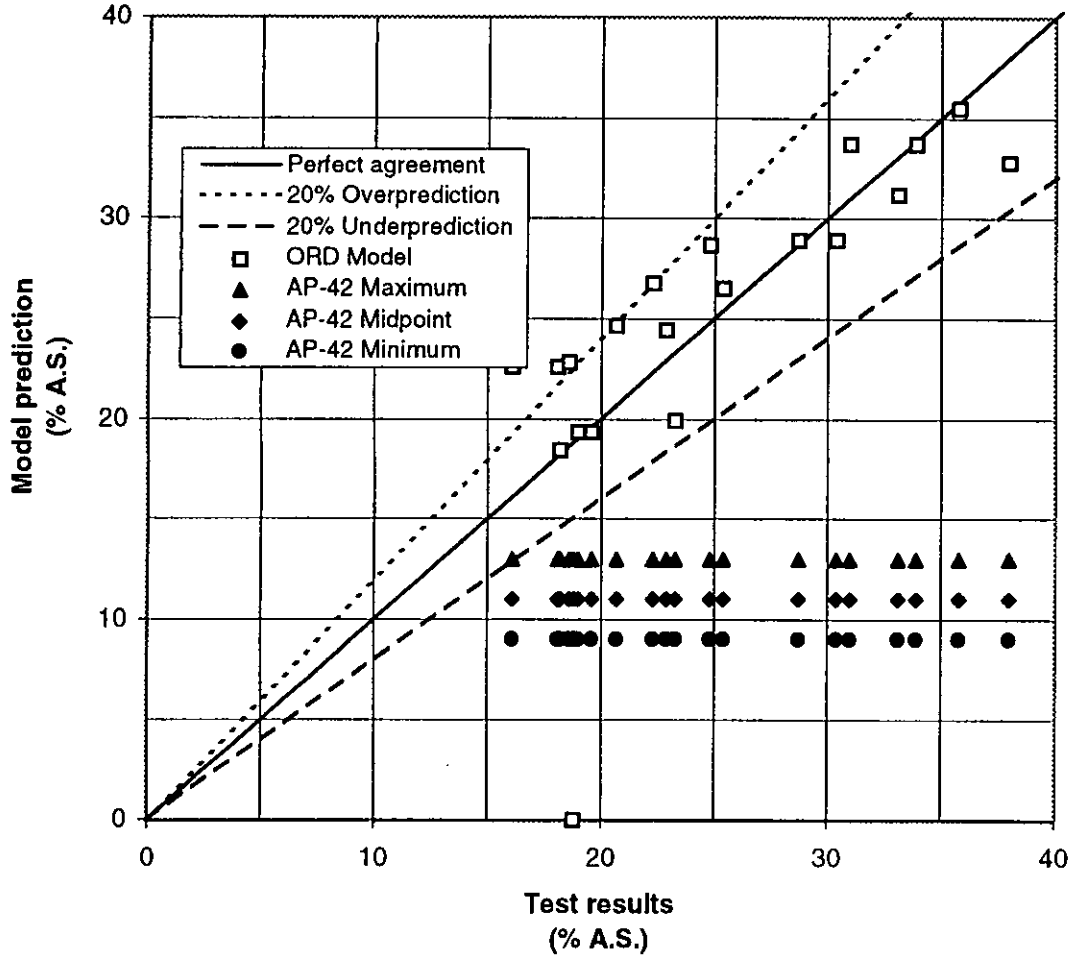

Figure 10. Composite Fabricators Association Phase I resin sprayup results versus RTI Model and AP-42.

Figures 9 and 10 indicate that the model is significantly more accurate than AP-42 in predicting emission test results. However, this is not surprising, because many of the modification factors in the model were based on CFA phase I testing. Also, the modification factors for dry-material-off-the-mold were assumed to be 1.0 (i.e., the amount of dry material off the mold was assumed to be 6%) in the analysis. The model predictions would increase or decrease if the amounts of dry material of the mold were higher or lower than these values.

RTI Filled Resin Testing

Figure 11 compares model predictions with results from RTI's filled resin testing in 1996. Here the model predicts less accurately than for the CFA phase I testing. However, the model is still more accurate than AP-42 (which predicts an emission factor of 3-9% AS for styrene suppressed resin sprayup). Figure 11 shows good agreement between the model and the test results for all resins except two: 1) the orthophthallic resin with suppressant (R1, shown as a solid triangle), and 2) a DCPD resin with suppressant (R5, shown as a solid diamond).

A significant assumption of the model is that all resins with identical neat styrene contents have identical emissions. Conversely, the model assumes that resins with identical emissions must have identical neat styrene contents. However, if the filled resin test results are plotted versus neat styrene content, as shown in Figure 12, it can be seen that the orthophthallic and DCPD resins have significantly different neat styrene contents for equivalent emission levels. For example, for an emission rate of 12% AS, the DCPD resin has a neat styrene content of 30-35%, but the orthophthallic resin styrene content is 42-45% at the same emission rate. Conversely, for a neat styrene content of 40%, the linear regression line for the DCPD (#2) resin shows an emission factor of approximately 17% of available styrene. However, if the linear regression line for the orthophthallic resin (#1) is extrapolated down to a neat styrene content of 40%, the resulting emission factor is only approximately 9% of available styrene.

IMPLICATIONS OF USING A MODEL THAT PREDICTS EMISSIONS IN PERCENTAGE OF AVAILABLE STYRENE

One goal for developing this model was to identify and quantify the P2 benefits obtained by modifications of various parameters in open-mold FRP fabrication. All of the data presented in this paper are presented in %AS, because these are the units presented in AP-42, which is currently the most familiar model for predicting emissions from FRP fabrication. However, presentation of model results in terms of %AS tends to mask the true benefits of reductions in the styrene content of resin or gel coat. This phenomenon is demonstrated in Figure 13, which illustrates how the various modification factors for unfilled resin sprayup would change if the model output was expressed in pounds of styrene emitted per pound of resin rather than as a percentage of available styrene in the resin. It can be seen that the only modification factor that changes is the modification factor for styrene content. The modification factor for styrene content, which is already a significant factor, becomes even more significant (i.e., the slope of the curve is even steeper) when emissions are expressed in pounds of styrene emitted per pound of resin used.

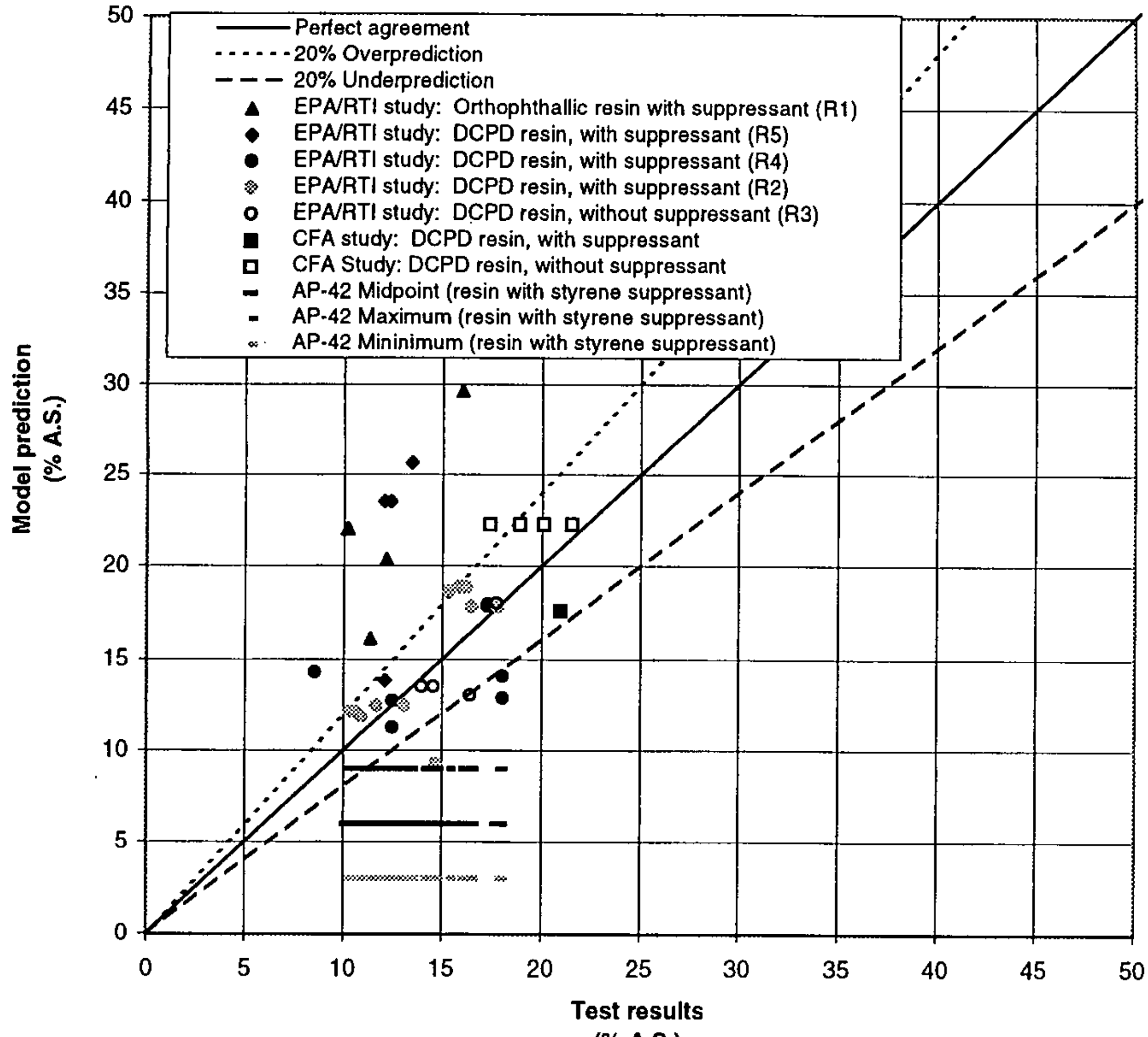

Figure 11. EPA/RTI and CFA filled resin results versus ORD model.

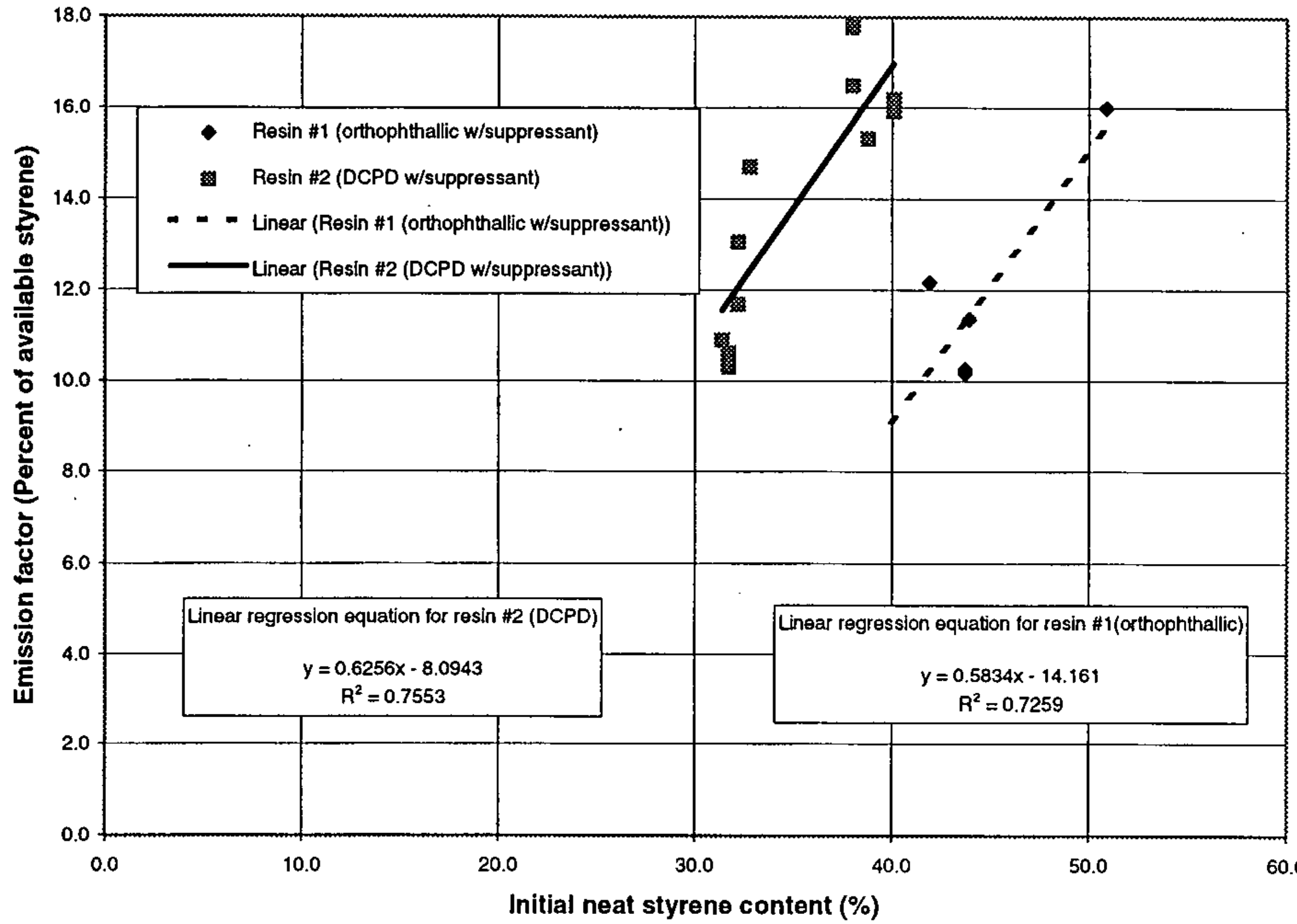

Figure 12. EPA/RTI filled resin results.

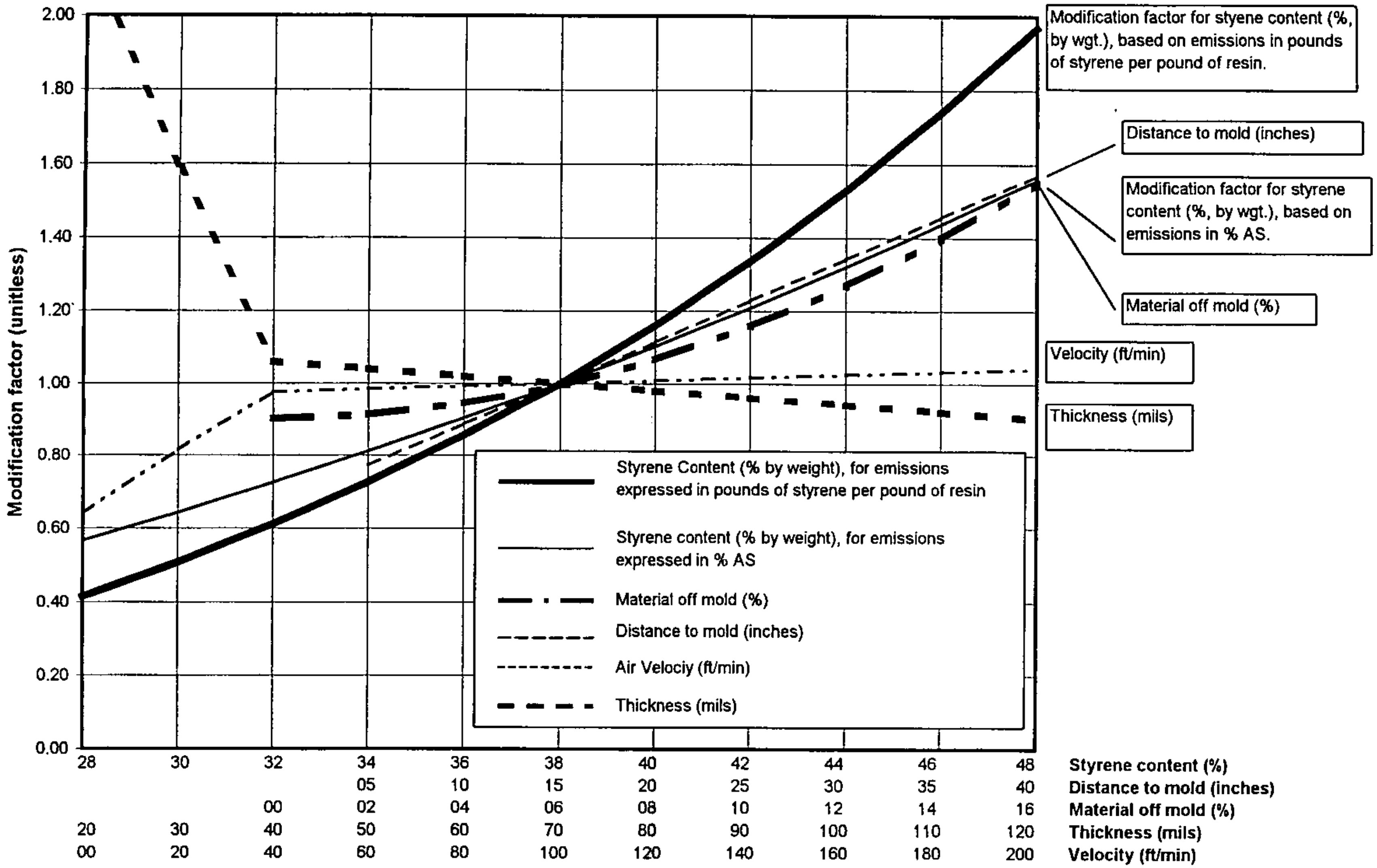

Figure 13. Important modification factors for resin sprayup.

SUGGESTED FUTURE RESEARCH FOR MODEL DEVELOPMENT AND VALIDATION

Filled resin testing conducted under a cooperative agreement between EPA's APPCD and RTI seemed to indicate that two different resins (in this case, DCPD resin versus orthophthallic resin) could have the same neat styrene content, but could produce substantially different emissions. However, these test results were not incorporated into the model; the model continues to assume that two resins with equal styrene contents have equal emissions, if all other conditions are the same. Further comparison tests between resins with equal styrene contents (such as orthophthallic and DCPD resins with equal styrene contents) are recommended. This testing will determine the validity of the model assumption that different resins with equal styrene contents have equal emissions, if all other conditions are equal.

This model tries to predict emissions based on resin variables such as styrene content and the presence or absence of a styrene suppressant. However, it would be advantageous to have a simple test of resin emissions under fixed conditions as an input to the model, if resins with equal styrene contents do not produce equal emissions.

Transfer efficiency, a measure of the operator's spraying technique, was originally a factor in this model. It was removed and replaced with *distance from the spray gun to the mold* and *dried material off of the mold, as a percentage of total material sprayed.* These two parameters eliminate the need for wet transfer efficiency measurements, which would be very difficult for large molds, or in production situations. However, further testing is needed to verify the accuracy of the current modification factor curves for "distance from spray gun to mold" and "dried material off the mold."

CONVERSION TABLE

To convert from	**to**	**multiply by:**
Inches (in)	Meter (m)	0.025
Feet (ft)	Meter (m)	0.3048
Square feet (ft^2)	Square meters (m^2)	0.0929
Feet/minute (ft/min)	Meter/minute (m/sec)	0.00508
Pound (lb)	Kilogram (Kg)	0.454
Pound/minute (lb/min)	Kilogram/sec (Kg/sec)	0.00757
Fahrenheit (°F)	Celsius (°C)	(°F - 32) / 1.8

ACKNOWLEDGMENTS

Trade organizations, including the Composite Fabricators Association, National Marine Manufacturers Association, and the Society for the Plastics Industry/Composites Institute conducted much of the testing used to develop this model.

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Emission Factor and Inventory Group
Emissions Monitoring and Analysis Division (MD-14)
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711
FAX Number: (919) 541-0684

FAX TRANSMISSION

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NAME	PHONE NUMBER
Cheryl A. Golich	504-340-0001
COMPANY/OFFICE	FAX NUMBER
Harbour Ventures Inc	504-348-4766

From:

NAME	PHONE NUMBER
Ron Ryan	919-541-4330

COMMENTS: – CFA model request

Attached are 3 pages (2 files - chap4-4.txt & CFA_mod1.txt) describing background; 2 pages showing the spreadsheet hard copy & the formulas it uses; & 4 pages (19, 20, 21 & 24) from the CFA report (shows "Engineering Environmental" as the header). The spreadsheet is available in Lotus, Excel, & Quattro versions on our web site, all in one "ZIP" file. PKZIP or WINZIP will extract these files. The documents are in PDF format, & Adobe software (like PKZIP) is freely available to read PDF files.

Number of Pages (including cover sheet): 10

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File: chap4_4.txt

March 16, 1998

Section 4.4 of AP-42 has been removed from this web site as of today because the emission factors presented in that section appear to underpredict styrene emissions from most polyester resin operations. A number of individual site tests and studies performed over the past few years have lead to this conclusion. The user is referred to the "Policies and Procedures" page on this web site, where EPA has posted two reports which document and analyze much of the recent data. The first report is entitled "Baseline Characterization of Emissions from Fiberglass Boat Manufacturing". The second report is entitled "CFA Emission Models for the Reinforced Plastics Industries". The USEPA is requesting comments on the two reports while we begin drafting a replacement AP-42 section based largely on the two reports. Meanwhile, the USEPA's Office of Research and Development (ORD) and Research Triangle Institute (RTI) are continuing their efforts to bring all of the available data together into a consistent, explanatory model, and we hope to post those results on the CHIEF web site when they become available. The CFA is also planning additional testing to quantify the effects of combining various control techniques.

Comments on this material can be addressed to:

Ron Ryan
U.S. EPA (MD-14)
RTP, NC 27711
Phone - (919) 541-4330
FAX - (919) 541-0684
EMAIL - ryan.ron@epamail.epa.gov

File: CFA_modl.TXT

March 17, 1998

The USEPA's Emission Factors and Inventory Group (EFIG) is making available today for review, comment, and use an emissions characterization report entitled "CFA Emission Models for the Reinforced Plastics Industries", dated February 28, 1998 and prepared by Dr. Robert Haberlein of Engineering Environmental on behalf of the Composite Fabricators Association (CFA), the International Cast Polymer Association, and the Composites Institute. The report describes the development of a set of four emission estimating equations or models that can be used to predict the styrene emissions from open molding processes used by the reinforced plastics industry. This material is related to existing AP-42 section 4.4, "Polyester Resin Plastic Products Fabrication". It is also related to a report prepared by the National Marine Manufacturers Association (NMMA) entitled "Baseline Characterization of Emissions from Fiberglass Boat Manufacturing", which was posted on USEPA's CHIEF web site (www.epa.gov/ttn/chief/ap42etc.html) on January 6, 1998.

The CFA and NMMA testing results and reports are generally consistent, and they support the suspicion that the existing AP-42 section may underpredict styrene emissions from most polyester resin operations. For these reasons we are removing the existing AP-42 section from the CHIEF web site today and requesting comments on the two reports while we begin drafting a replacement AP-42 section which will be based largely on the two reports. Meanwhile, the USEPA's Office of Research and Development (ORD) and Research Triangle Institute (RTI) are continuing their efforts to bring all of the available data together into a consistent, explanatory model, and we hope to post those results on the CHIEF web site when they become available. The CFA is also planning additional testing to quantify the effects of combining various control techniques.

Although the CFA report presents both multi-variable and single variable equations for predicting emissions from each of four open molding processes, EFIG agrees with the report's conclusion that the single-variable (% styrene in the resin) equations account for almost all of the variation due to parameters that can be reasonably monitored in a production setting. The recommended one-variable equations and associated control factors are summarized as eqns. 12, 15, 18, and 21 on pages 20 and 21 of the report. Table 2.16 on page 24 of the report provides a table of results from these equations for a number of given input assumptions. The equations have also been packaged into a spreadsheet model to facilitate users generating emission factors for their own scenarios. The spreadsheet model is available from this web site in three formats: QuattroPro, Excel, and Lotus.

Users should note that the equations in the CFA report and the spreadsheet models produce emission factors in units of "% neat resin". These factors are expressed as decimals and should be multiplied directly by the pounds of neat resin consumed to yield pounds of styrene emissions. There is no need to divide by 100. Also note that these units differ from the old AP-42 units and the NMMA report units, which are "% of available styrene".

Users should be aware that although the NMMA, CFA, and RTI work has made great advances in quantifying the effects of many different parameters on emissions, the impacts of one of the most significant parameters, the degree of overspray, remains difficult to quantify in a simple manner. The percentage of styrene in the resin which escapes to the atmosphere appears to be much greater for the resin which is sprayed off the edge of the mold as compared to the resin which lands on the mold. Thus, facilities which have a larger proportion of oversprayed material than the operations tested can expect to have higher percentages of the styrene emitted.

The USEPA thanks the CFA, their members, Dr. Haberlein, Larry Craigie of Dow Chemical, RTI, and others who contributed to the development and analysis of the data presented in this report.

Comments on this material can be addressed to:
Ron Ryan
U.S. EPA (MD-14)
RTP, NC 27711
Phone - (919) 541-4330
FAX - (919) 541-0684
EMAIL - ryan.ron@epamail.epa.gov

SHT A

1 # CFA Emission Model for the Reinforced Plastics Industries - 1 Variable

2 February 28, 1998

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
3–6		Current Monomer Content (%)	New Monomer Content (%)	Monomer Factor (%)		Vapor Suppressant Factor (%)		Controlled Spraying Factor (%)	or	Non-Atom Equipment Factor (%)	Add-on Control Factor (%)	% of Add-on Control (%)	Current Emission Factor (lb/ton)	New Emission Factor (lb/ton)	New Emission Factor (% resin)
7–8	APPLICATION METHOD														
9															
10	Manual Resin	44.0%	38.0%	76.5%	n	100%		n/a		n/a	95%	0%	146	112	5.6%
11															
12															
13	Mechanical Resin	44.0%	38.0%	68.1%	y	62%	n	100%	n	100%	95%	0%	268	113	5.7%
14															
15															
16	Gelcoat Spray	44.0%	38.0%	76.2%		n/a	n	100%		n/a	95%	0%	522	$\boxed{397}$	19.9%
17															
18															
19	Filament Resin	44.0%	38.0%	81.9%	n	100%		n/a		n/a	95%	0%	182	149	7.5%

SHEET
COLUMN
ROW

A:D10: (0.286*C10-0.0529)/(0.286*B10-0.0529)

A:D13: (0.714*C13-0.18)/(0.714*B13-0.18)

A:D16: (1.036*C16-0.195)/(1.036*B16-0.195)

A:D19: (0.2746*C19-0.0298)/(0.2746*B19-0.0298)

A:F10: @IF(E10="Y",((0.04476*C$10+0.01289)/(0.286*C$10-0.0529)),1)

A:F13: @IF(E13="Y",0.62,1)

A:F19: @IF(E19="Y",0.65,1)

A:H13: @IF(G13="Y"#AND#I13="N",0.77,1)

A:H16: @IF(G16="Y",0.73,1)

A:J13: @IF(I13="Y"#AND#G13="N",0.51,1)

A:M10: (0.286*B10-0.0529)*2000

A:M13: (0.714*B13-0.18)*2000

A:M16: 2000*(1.036*B16-0.195)

A:M19: (0.2746*B19-0.0298)*2000

A:N10: +M10*D10*F10*((1-L10)+L10*(1-K10))

A:N13: +M13*D13*F13*H13*J13*((1-L13)+L13*(1-K13))

A:N16: +M16*D16*H16*((1-L16)+L16*(1-K16)) = "NEW EMISSION FACTOR FOR GELCOAT SPRAY"

A:N19: +M19*D19*F19*((1-L19)+L19*(1-K19)) (cell on spreadsheet)

A:O10: +N10/2000

A:O13: +N13/2000

A:O16: +N16/2000

A:O19: +N19/2000

Table 2.16 - Emission Factors for the CFA Emission Models

CFA EMISSION FACTORS

(Styrene Emission Rates listed as % of Neat Resin Weight as applied)

	Manual Resin Application		Mechanical Resin Application						Gelcoat Application		Filament Winding	
	Bucket & Tool		Uncontrolled Spray		Controlled Spray		Non-Atomized Application		Uncontrolled Spray	Controlled Spray		
Styrene Content % wt	Non-Vapor Suppressed	Vapor-Suppressed	Non-Vapor Suppressed	Vapor-Suppressed	Non-Vapor Suppressed	Vapor-Suppressed	Non-Vapor Suppressed	Vapor-Suppressed			Non-Vapor Suppressed	Vapor-Suppressed
33%	4.1%	2.8%	5.6%	3.4%	4.3%	*	**	*	14.7%	10.7%	6.1%	4.0%
34%	4.4%	2.8%	6.3%	3.9%	4.8%	*	**	*	15.7%	11.5%	6.4%	4.1%
35%	4.7%	2.9%	7.0%	4.3%	5.4%	*	**	*	16.8%	12.2%	6.6%	4.3%
36%	5.0%	2.9%	7.7%	4.8%	5.9%	*	**	*	17.8%	13.0%	6.9%	4.5%
37%	5.3%	2.9%	8.4%	5.2%	6.5%	*	**	*	18.8%	13.7%	7.2%	4.7%
38%	5.6%	3.0%	9.1%	5.7%	7.0%	to	**	to	19.9%	14.5%	7.5%	4.8%
39%	5.9%	3.0%	9.8%	6.1%	7.6%	be	**	be	20.9%	15.3%	7.7%	5.0%
40%	6.2%	3.1%	10.6%	6.5%	8.1%	determined	**	determined	21.9%	16.0%	8.0%	5.2%
41%	6.4%	3.1%	11.3%	7.0%	8.7%	by	**	by	23.0%	16.8%	8.3%	5.4%
42%	6.7%	3.2%	12.0%	7.4%	9.2%	05/15/98	6.1%	05/15/98	24.0%	17.5%	8.6%	5.6%
43%	7.0%	3.2%	12.7%	7.9%	9.8%	*	6.5%	*	25.0%	18.3%	8.8%	5.7%
44%	7.3%	3.3%	13.4%	8.3%	10.3%	*	6.8%	*	26.1%	19.0%	9.1%	5.9%
45%	7.6%	3.3%	14.1%	8.8%	10.9%	*	7.2%	*	27.1%	19.8%	9.4%	6.1%
46%	7.9%	3.3%	14.8%	9.2%	11.4%	*	7.6%	*	28.2%	20.6%	9.7%	6.3%
47%	8.2%	3.4%	15.6%	9.6%	12.0%	*	**	*	29.2%	21.3%	9.9%	6.5%
48%	8.4%	3.4%	16.3%	10.1%	12.5%	*	**	*	30.2%	22.1%	10.2%	6.6%
49%	8.7%	3.5%	17.0%	10.5%	13.1%	*	**	*	31.3%	22.8%	10.5%	6.8%
50%	9.0%	3.5%	17.7%	11.0%	13.6%	*	**	*	32.3%	23.6%	10.8%	7.0%

prepared on 1/15/98 - emission rates based on revised 12/8/97 CFA Matrix Models
** outside the tested range

Suppressant Control Factor

The calculation of the suppressant control factor for filament winding, which is the emission factor for resin with suppressant divided by the emission factor for resin without suppressant, is shown in **Table 2.15** on the previous page. Ten data sets (suppressed and non-suppressed) are compared to investigate the effect of suppressant on emissions at two different styrene monomer content. No obvious relationship is observed between the styrene monomer content and suppressant effect for this data. The suppressant factor varies widely from 0.39 to 0.92, with an average value of **0.65**.

2.6 - CFA Emission Models

The results of the CFA emission testing discussed in the previous sections are now converted into algebraic expressions, henceforth referred to as "Emission Models." A separate CFA Emission Model is developed for manual resin application (hand lay-up), mechanical resin application (spray lay-up), and gelcoat spraying. Each Emission Model estimates the styrene emission rate for the corresponding process. The manual resin application (hand lay-up), mechanical resin application (spray lay-up) and gelcoat spraying models are based upon the responses to the chief process variables measured in the Phase I CFA testing and the effects of the emission reduction techniques measured in the Phase II CFA testing. No distinction between the emission rates from filled and unfilled resin systems was observed during the CFA testing, so the effect of filler was not incorporated into any model. Resin fillers appear to merely extend the amount of resin used to manufacture a part, and do not significantly affect an emission rate based upon the consumption of neat (unfilled) resin or available styrene monomer.

The results of the Dow study of filament winding emissions also discussed in the previous section are converted into an algebraic expression, henceforth referred to as the "Filament Winding Model." This model is based upon the experimental responses to the chief process variables and the effects of resin suppressant measured in the Dow testing.

Both the multi-variable and the single variable models are presented below for completeness. As discussed earlier, the multi-variable models are not suitable for regulatory purposes. However, the one-variable (styrene content) models are suitable and have acceptable scatter for the purpose of characterizing styrene emissions across an entire industry such as reinforced plastics. The CFA Emission Models for non-suppressed resins and gel coat are plotted in **Figure 2.1** at the end of this section. The CFA Emission Models for vapor-suppressed resins are shown in **Figure 2.2**. The emission factors are also listed in a handy tabular format in **Table 2.16**.

2.6.1 - Manual Resin Application (Hand Lay-up) Model

The general emission model for manual resin application (hand lay-up) is:

$$\textit{Emission Rate} = \textit{Resin Usage} \times \textit{Emission Factor} \times \textit{Suppressant Factor} \qquad \text{[eq 10]}$$

The four-variable emission model is:

$$\begin{aligned}\textit{Emission Rate} = \textit{Resin Usage} \times (&-0.46365 \times \textit{thickness} + 0.00265 \times \%\textit{styrene} \\ &+ 0.00068 \times \textit{gel time} + 0.00003 \times \textit{air flow} - 0.0320)\end{aligned} \qquad \text{[eq 11]}$$

And the one-variable emission model, which is also one of the CFA matrix elements, is:

$$\begin{aligned}\textit{Emission Rate} &= \textit{Resin Usage} \times (0.00286 \times \%\ \textit{styrene} - 0.0529) \\ &\quad \times \left[1.00 \text{ <or> } \frac{0.0004476 \times \%\ \textit{styrene} + 0.01289}{0.00286 \times \%\ \textit{styrene} - 0.0529}\right]\end{aligned} \qquad \text{[eq 12]}$$

2.6.2 - Mechanical Resin Application (Spray Lay-up) Model

The general emission model for mechanical resin application (spray lay-up) for both filled and unfilled resins is:

$$\begin{aligned}\textit{Emission Rate} = \textit{Resin Usage} &\times \textit{Emission Factor} \times \textit{Suppressant Factor} \\ &\times [\textit{Controlled Spray Factor} \text{ <or> } \textit{Non-Spray Factor}]\end{aligned} \qquad \text{[eq 13]}$$

The five-variable emission model is:

$$\begin{aligned}\textit{Emission Rate} = \textit{Resin Usage} \times (&-0.19881 \times \textit{thickness} + 0.00827 \times \%\ \textit{styrene} \\ &+ 0.00038 \times \textit{gel time} - 0.00854 \times \textit{resin flow} \\ &+ 0.00003 \times \textit{air flow} - 0.1941) \times [1.00 \text{ <or> } 0.62] \\ &\times [1.00 \text{ <or> } 0.77] \text{ <or> } [1.00 \text{ <or> } 0.51]\end{aligned} \qquad \text{[eq 14]}$$

And the one-variable emission model, which is also one of the CFA matrix elements, is:

$$\begin{aligned}\textit{Emission Rate} = \textit{Resin Usage} &\times (0.00714 \times \%\ \textit{styrene} - 0.180) \times [1.00 \text{ <or> } 0.62] \\ &\times [1.00 \text{ <or> } 0.77] \text{ <or> } [1.00 \text{ <or> } 0.51]\end{aligned} \qquad \text{[eq 15]}$$

2.6.3 - Gelcoat Spraying Model

The general emission model for gelcoat spraying is:

$$\textit{Emission Rate} = \textit{Resin Usage} \times \textit{Emission Factor} \times \textit{Controlled Spray Factor} \qquad \text{[eq 16]}$$

The five-variable emission model is:

$$\begin{aligned}\textit{Emission Rate} = \; & \textit{Resin Usage} \times (-5.34119 \times \textit{thickness} + 0.00897 \times \%\ \textit{styrene} \\ & + 0.00083 \times \textit{gel time} - 0.00018 \times \textit{resin flow} \\ & + 0.00004 \times \textit{air flow} - 0.0476) \times [1.00 < \textit{or} > 0.73] \qquad \text{[eq 17]}\end{aligned}$$

And the one-variable emission model, which is also one of the CFA matrix elements, is:

$$\begin{aligned}\textit{Emission Rate} = \; & \textit{Resin Usage} \times (0.01036 \times \%\ \textit{styrene} - 0.1950) \\ & \times [1.00 < \textit{or} > 0.73] \qquad \text{[eq 18]}\end{aligned}$$

2.6.4 - Filament Winding Model

The general emission model for filament winding is:

$$\textit{Emission Rate} = \textit{Resin Usage} \times \textit{Emission Factor} \times \textit{Suppressant Factor} \qquad \text{[eq 19]}$$

The four-variable emission model (including suppressant as a variable) is:

$$\begin{aligned}\textit{Emission Rate} = \; & \textit{Resin Usage} \times ((0.002532 \times \%\ \textit{styrene}) - (0.00013 \times \textit{temp}) \\ & + (0.000773 \times \textit{size}) - 0.02716)) \times [1.00 < \textit{or} > 0.65] \qquad \text{[eq 20]}\end{aligned}$$

And the one-variable emission model, which is also one of the CFA matrix elements, is:

$$\begin{aligned}\textit{Emission Rate} = \; & \textit{Resin Usage} \times ((0.002746 \times \%\ \textit{styrene}) - 0.02980) \\ & \times [1.00 < \textit{or} > 0.65] \qquad \text{[eq 21]}\end{aligned}$$

ENGINEERING ENVIRONMENTAL
CONSULTING SERVICES
Robert A. Haberlein, Ph.D., QEP
robhab@erols.com

TWO FISK CIRCLE
ANNAPOLIS, MD 21401
(410) 268-7367
(410) 267-8174 FAX

E-MAIL TRANSMITTAL

one (1) page including this sheet with attachment

June 28, 1999

phone: (919) 541-1156
email: cnunez@engineer.aeerl.epa.gov

Mr. Carlos M. Nunez
U.S. EPA
NRML/APPCD/ECPD
MD-61
Research Triangle Park, NC 27711

Dear Carlos,

I recently received a copy of Mr. Mark Bahner's March 22 memo addressed to you containing the RTI criticisms of the revised emission model developed by the CFA, which has been named the Unified Emission Factors (UEF). The CFA asked me to respond to the contents of the Bahner memo. This response is attached hereto as a PDF file.

I encourage you to carefully consider the observations contained in this response, because most of Mr. Bahner's comments are more appropriately directed to problems contained in the ORD FRP Model. As we have discussed before, there is widespread dissatisfaction with the ORD FRP Model as a practical tool - both inside and outside EPA. There are also several technical problems with the FRP Model that will not go away simply because the EPA does not have the budget to address them. In fact, I believe that these problems may climax after the publication of your article in the Journal of Air & Waste Management.

There are simply too many problems with the FRP Model as a regulatory model for the regulated and regulatory communities to ignore.

I am very interested in your reactions and thoughts. I am glad we will have an opportunity to meet next Wednesday to discuss these issues in person.

Sincerely,

Robert A. Haberlein, Ph.D., QEP

cc: CFA - J. Schweitzer & June 30 meeting attendees

Response to the March 22, 1999 RTI Comments on the CFA UEF

June 25, 1999

In General

Many of comment and criticisms contained in the March 22 memo do not really pertain to the relative merits of the two models, because they fail to grasp the fundamental differences between the stated purpose of the Composite Fabricators Association (CFA) Unified Emissions Factors (UEF) and the stated purpose of the Office of Research and Development (ORD) FRP Model.

The CFA UEF was designed to be a practical regulatory tool. With this in mind, CFA considered several different modeling approaches, including a multi-factor model very similar to the ORD Model. Eventually, CFA decided that a set of different process models based on styrene content alone was the only practical approach for a regulatory model.

According to the information provided by ORD and Research Triangle Institute (RTI), the FRP Model was created as a pollution-prevention research tool, not as a regulatory tool. As such, such practical issues as how to measure key input values and the reasonableness of the key model assumptions were not really important, since the FRP Model would not be used to enforce permitted emission limits or to determine whether a plant was classified as a major or minor source. After all, a research tool should pose unanswered questions and challenge the technical boundaries. But a research tool is usually not practical as a regulatory model.

CFA supports the continued development of research tools such as the FRP Model, so long as the purpose and application of such modeling efforts remain in the realm of research.

Ironically, most of the criticisms expressed in the March 22 memo seem to be more applicable to the FRP Model. In fact, most of the observations made by Mr. Bahner in the memo would be strongly critical if applied to the FRP Model. This situation reminds me of the old saying "...like the pot calling the kettle black."

Response to Specific Criticisms

The March 22 RTI memo specifically listed five criticisms of the CFA UEF. Each criticisms is discussed separately in the following five sections:

1.) A "single factor" model is inherently less accurate than a multi-factor model.

The RTI memo is comparing apples to oranges. The single-factor CFA UEF is not "inherently" less accurate than the multi-factor model FRP Model - the two models are simply different.

The number of input factors does not necessarily indicate the accuracy of a model. Other considerations determine the accuracy. A multi-factor emission model might be able to better characterize a complicated process or phenomenon - but only if the multi-factor model is able to correctly and accurately simulate the process emissions and correctly measure the input factors.

On April 7, 1999, the CFA posted a summary report entitled *"Comparison of Actual Source Test Factors with the Unified Emission Factors for the Open Molding of Composites."* This report is available at the CFA web site (www.cfa-hq.org) in PDF format. Please download this report for a comparison of the CFA UEF with the source test factor data available on that time. The field data showed that the CFA UEF appeared to be a very good conservative predictor of styrene emissions.

You will also learn that the ORD FRP model grossly under predicted the styrene emissions at one plant where adequate source inputs parameters (gun distance, overspray, and part thickness) were accurately measured and source test data was collected. This was probably the worst possible outcome for an emissions model. Coincidentally, the CFA UEF for non-atomized mechanical application agreed exactly with the average of the three test runs at the plant. How can RTI assume that the FRP Model is inherently more accurate in the face of this data?

RTI recommended that the CFA perform some statistical analysis on the CFA UEF:

> *"Two recommended measures of model accuracy are model average bias, and mean squared error (MSE) of the model."*

However, I do not believe that sufficient data exists to make the concept of average bias and mean square error applicable. The Pierson's r^2 statistic, which is a measure of the "goodness-of-fit" to the original data was provided as part of the model derivation, and should be sufficient at present. If a large amount of additional experimental or source test data becomes available, then additional statistical analyses may then be performed to see how this data fits the CFA UEF.

However, further statistical analyses of the FRP Model do seem to be warranted. The assumption of independence is not an issue with the CFA UEF, but it is critically important for the FRP Model. If the FRP Model is to rely on this assumption, then RTI should conduct a test for independence. Perhaps a power of ANOVA analysis could be performed to determine if the amount of available data is sufficient to support any statistical conclusions regarding the multi-factor FRP Model.

2.) Many predictions of the proposed CFA models do not make sense, from a scientific standpoint, outside the range of 33-50% styrene.

CFA generally agrees with the intent of this statement, and wonders why RTI does not see that this criticism applies even more strongly to the FRP Model. The FRP Model contains many serious flaws, which include errors in the fundamental mathematical assumptions that form the basis of the model. For example, the FRP Model assumes that its modification factors are linearly independent. But this assumption, although convenient, does not make any scientific sense, and makes even less sense outside the 33% to 50% range. Many of the FRP Model modification factors were based on a few data points, collected from dissimilar processes, within a much narrower range of styrene monomer contents. In spite of these limitations, the FRP Model allows the extrapolation of these factors way beyond any reasonable range. What is scientifically defensible about this?

According to the RTI memo:

> *"Even a casual review of Figure 1 reveals the artificial shape of the CFA model curves. There are two problems with these curves:*
>
> > *Emission factors (in %AS) for styrene contents at or below 33% are assumed to be equal, or "fixed", as illustrated by the horizontal lines in each curve.*
> >
> > *Emission factors "plateau" at higher styrene contents, producing artificially low results as styrene content approaches 100%."*

First of all, the use of the word phrases "*Even a casual review...*" and "*the artificial shape*" do not seem appropriate. Hopefully, Mr. Bahner's review was more than casual. As for the shape of the model curves - both the CFA UEF and the FRP Model curves are artificial, as are all such mathematical relationships.

RTI is particularly critical towards any compromise for estimating factors below 33% styrene as follows:

> *"...this "compromise" is not based on science. Science indicates that it is far more reasonable to expect that emission factors, in %AS, will be reduced to progressively lower, non-negative values, as styrene content is reduced to zero."*

However, this criticism does not make any sense. The CFA UEF values below 33% are progressively lower non-negative values as %resin, which is clearly noted, and eventually all of the UEF values reach zero at 0% monomer content. Why does RTI feel this is not reasonable?

More troubling is the RTI assertion that "science indicates" anything in this lower range. There is no data below 25% content and very little data below 30%. The CFA UEF text document discusses this in detail. However, RTI has provided no scientific rationale for the FRP Model factors in this range. Where is the evidence, the data, or the science? Yet, the FRP Model will return values that give the "illusion of science" for this range of factors.

> *"The second problem, ("plateauing" emissions) may only have practical significance for resins and gel coats with styrene contents above approximately 45%. However, the plateauing effect produces increasingly inaccurate predictions as styrene content increases above 45%. The predicted emission factors for gel coating, resin sprayup, and flow coating with pure (100%) styrene are 81%, 41%, and 14%, respectively. The values for sprayup and flow coating are especially far from the scientifically-based expectation that use of 100% styrene would produce emission factors of approximately 100%."*

The second point does not make any sense. The CFA UEF emission factors do not "plateau" above 50% as suggested by Bahner, but instead continue to increase at the same rate for materials with styrene contents between 33% and 50%.

The assertion that the CFA UEF (or any reinforced plastics model) should produce a 100% emission factor for a 100% content resin is absurd. A 100% styrene content resin or gelcoat cannot exist, because such a resin or gelcoat would never cure. Note that the same argument applies to a 0% content resin or gelcoat.

The RTI memo then goes on to state that:

> *"The CFA models should be revised so they produce scientifically defensible predictions throughout the entire range, from 0% to 100% styrene."*

This advice is misguided. A useful model should be designed to predict real emission rates from real processes that use real formulations. There is no point in developing a model for imaginary materials that could never exist. The practical upper limit for a resin or gelcoat is probably around 65% styrene and a lower limit may be 15%. Commercial formulations do not exist with monomer contents below 20% or above 60% by weight.

More disturbing, this statement is obviously inconsistent, because the FRP Model cannot produce defensible (or even feasible) predictions throughout the entire range either. For example, the FRP Model does not yield 100% emission factors for 100% styrene content materials. Why is this a problem for the CFA UEF model and not the FRP Model?

In some cases, the FRP Model returns impossible values well above 100%, yet the inputs used to estimate these impossible results were within the models's acceptable input ranges. If these inputs were acceptable, how come the FRP Model result was impossible?

3.) The term "controlled spraying" is ambiguous and unmeasurable, and the "controlled spraying" emission reduction is a single, discrete value.

This criticism is based on two statements by Bahner as follows:

> *"I believe that a far more objective and measurable method to characterize operator spraying technique is to use factors such as "distance from spray gun to mold" and "amount of dry material off the mold". Use of these factors such as "distance from spray gun to mold" and "amount of dry material off the mold" answers all of the questions listed above, because there is no need to attempt to label spraying as "controlled" or "uncontrolled"."*
>
> *"Additionally, in contrast to the CFA models, the amount of predicted emission reduction in the FRP Model is based on two continuous functions; the emission reduction is not a scientifically-questionable step function."*

According to his first statement, Bahner believes that the two parameters, distance-from-spray-gun-to-mold and amount-of-dry material-off-the-mold, are "far more objective and measurable" to characterize operator spraying technique. Note that this statement is presented as a personal belief and not as fact. The approach suggested by Bahner has merit, and would be very desirable.
However, CFA does not believe that these two factors could be used to distinguish between controlled and uncontrolled spraying for two reasons. First, these two inputs would be extremely difficult to measure or monitor at most fiberglass shops. This problem was detailed in earlier correspondence with the ORD and RTI, and to date, no practical solution has been proposed by either ORD or RTI. CFA believes the problem is intractable. Common sense says that a model has no practical value if the inputs cannot be feasibley measured. Second, CFA feels that the modification factors for these two inputs are flawed because the data used to develop the factors was too narrow in scope and range to accurately reflect all likely modeling scenarios. Further, these factors affect the area extent, thickness, and gel time of the evaporative surface, and are probably not independent factors, which violates the FRP Model's most basic assumption.

The second statement is both incorrect and inconsistent. The FRP Model is not based completely on continuous functions either, but incorporates several non-continuous step functions. For example, the FRP Model uses step-functions for the thickness, application rate, and air velocity modification factors. Why are step functions scientifically questionable for the CFA UEF, but not for the FRP Model?

A step function is often used to represent phenomena that have different behavior at different ranges. There would be nothing scientifically-questionable about such a use. Unfortunately, there simply is not enough data for anyone to make a scientific claim about the behavior of very low and very high styrene content materials. This underscores one of the more troubling aspects of the FRP Model - it embeds its step functions within the Windows program. A lay user would probably not understand the basis for the factors. On the other hand, the CFA UEF clearly states that the emission factors below 33% and above 50% are based on conservative assumptions that were made to create a workable model - not real data. The FRP Model does not clearly state this, and thereby gives a false sense of accuracy, which is known as the illusion of science.

4.) The proposed "Unique Vapor-Suppressed Resin Factors for Specific Resin Formulations" appears to be supported only by laboratory testing.

The CFA UEF contains unique vapor-suppressed resin factors developed through actual testing. This approach was first proposed by the EPA (Dr. Madeleine Strum's MACT development group), and is the most scientifically sound and practical method to verify the effect of specific vapor suppressants. By incorporating the Vapor Suppressant Effectiveness test, the effect of vapor suppressant will be measured for each unique blend of resin and suppressant. Why does the RTI have a problem with this approach?

5.) The CFA model does not accurately predict the results of the EPA/RTI gel coating test results of June/July 1995.

The CFA has noted the discrepancy between the RTI test results and the factors predicted by the UEF curves. CFA would like more information on this RTI test, so that CFA can further evaluate the data from this test. Perhaps the problem with the data can be explained by irregularities in the test method or procedures.

According to Bob Lacovara, CFA was originally contacted by Mr. Bahner regarding some problems with this RTI test. Reichhold had convinced RTI that the viscosities of the filled systems had to be uniform, so RTI modified the various levels of filled resins by adding styrene to create uniform viscosities across the sample group. Mr. Bahner reported that there was resin drainage from some of the laminates. Modifying the viscosity by adding styrene had created samples of varying styrene content, caused laminate drainage (usually resulting in poor cure in thin areas), and was not an accepted practice in real application. This may present a serious problem when attempting to resolve the data for both filler effects and styrene content effects, and may explain the unusual test results.

RESEARCH TRIANGLE INSTITUTE

RTI

Center for Environmental Analysis

MEMORANDUM

DATE:	October 15, 1997	
TO:	Madeleine Strum,	EPA/OAQPS/CCPG, MD-13
CC:	Geddes Ramsey,	EPA/ORD/APPCD, MD-61
	Carlos Nuñez,	EPA/ORD/APPCD, MD-61
	Ron Ryan,	EPA/OAQPS/EMAD, MD-14
	Jesse Baskir,	RTI
	Emery Kong,	RTI
FROM:	Mark Bahner, MAB	RTI

SUBJECT: Comments on Composite Fabricators' Association (CFA) Styrene Emission Factor Model, as Presented in the Following Documents, dated September 18, 1997:
1) Presentation on Existing Source MACT for Open Molding , and
2) Derivation and Verification of CFA Emission Models.

As a result of your September 18 meeting with representatives of the Reinforced Plastic Composites (RP/C) source category, you requested EPA Office of Research and Development (ORD) and RTI assistance in evaluating the CFA styrene emission factor model presented in that meeting. You were specifically interested in comments on the appropriateness of CFA's use of straight lines to model emission factors (in $lb_{styrene}/lb_{resin}$), as a function of initial styrene content.

1) Appropriateness of Straight Lines for Emissions versus Styrene Content.

All equations in Table 1 of the CFA report give linear expressions for emissions versus styrene content. For example, the equation for Mechanical Resin Application includes the expression, "(0.00559 x %styrene - 0.1193)". This equation was presumably based on drawing a straight line between CFA phase I test results, which were conducted at 35% styrene and 42% styrene.

Use of a straight line to represent emissions versus styrene content is inappropriate, particularly at low or high styrene contents. For example, the CFA expression for Mechanical Resin Application actually becomes negative with styrene contents below 21%. It is obviously impossible that resins with styrene contents below 21% will actually remove styrene from the atmosphere. Also, extrapolating the proposed straight line for mechanical resin application up to a styrene content of 100% (i.e., pure styrene) yields a predicted emission value of only 0.44 pounds of styrene emitted per pound of resin used, rather than the necessary value of 1.0.

3040 Cornwallis Road • Post Office Box 12194 • Research Triangle Park, North Carolina 27709-2194 USA
Telephone 919 541-5882 • Fax 919 541-7155

The use of a straight line is therefore inappropriate at low or high styrene contents. In order to determine the form of a more appropriate equation, it is possible to examine the boundary conditions for this situation: 1) at 0% styrene, the equation should yield an emission factor of 0.0 $lb_{styrene}/lb_{resin}$, and 2) at 100% styrene, the equation should yield an emission factor of 1.0 $lb_{styrene}/lb_{resin}$.

As previously stated, the straight line proposed by CFA doesn't meet these boundary conditions, so a higher order equation is needed. I suggest the following equation:

$$y = 6.7E^{-7}x^3 + 2.92E^{-5}x^2 + 3.33E^{-4}x$$

where y = Emission factor, $lb_{styrene}/lb_{resin}$
x = Neat resin initial styrene content, % by weight

It is important to note that the proposed equation produces emission predictions that are virtually identical to the CFA straight line at 35 and 42 percent styrene; it is only at higher and lower styrene contents that the proposed equation is more accurate. This is illustrated in the following Table A and Figure A. Table A shows that the CFA and proposed equations both yield essentially the same emission predictions for 35% and 42% styrene. It is only at the very high and low styrene contents that the CFA straight line significantly underestimates emissions. This is further illustrated in Figure A, which shows emission factor predictions of the two models for styrene contents of 0 to 50 percent.

Table A. Comparison of linear versus polynomial models for mechanical resin application of an unfilled resin.

Initial styrene content (% by weight)	Predicted Emission Factor ($lb_{styrene}/lb_{resin}$)		Percent Difference (Referenced to Polynomial Model)
	Polynomial Model	Linear Model	
25	0.037	0.020	-45
35	0.076	0.076	0
42	0.115	0.115	0
50	0.173	0.160	-8
100	0.995	0.440	-56

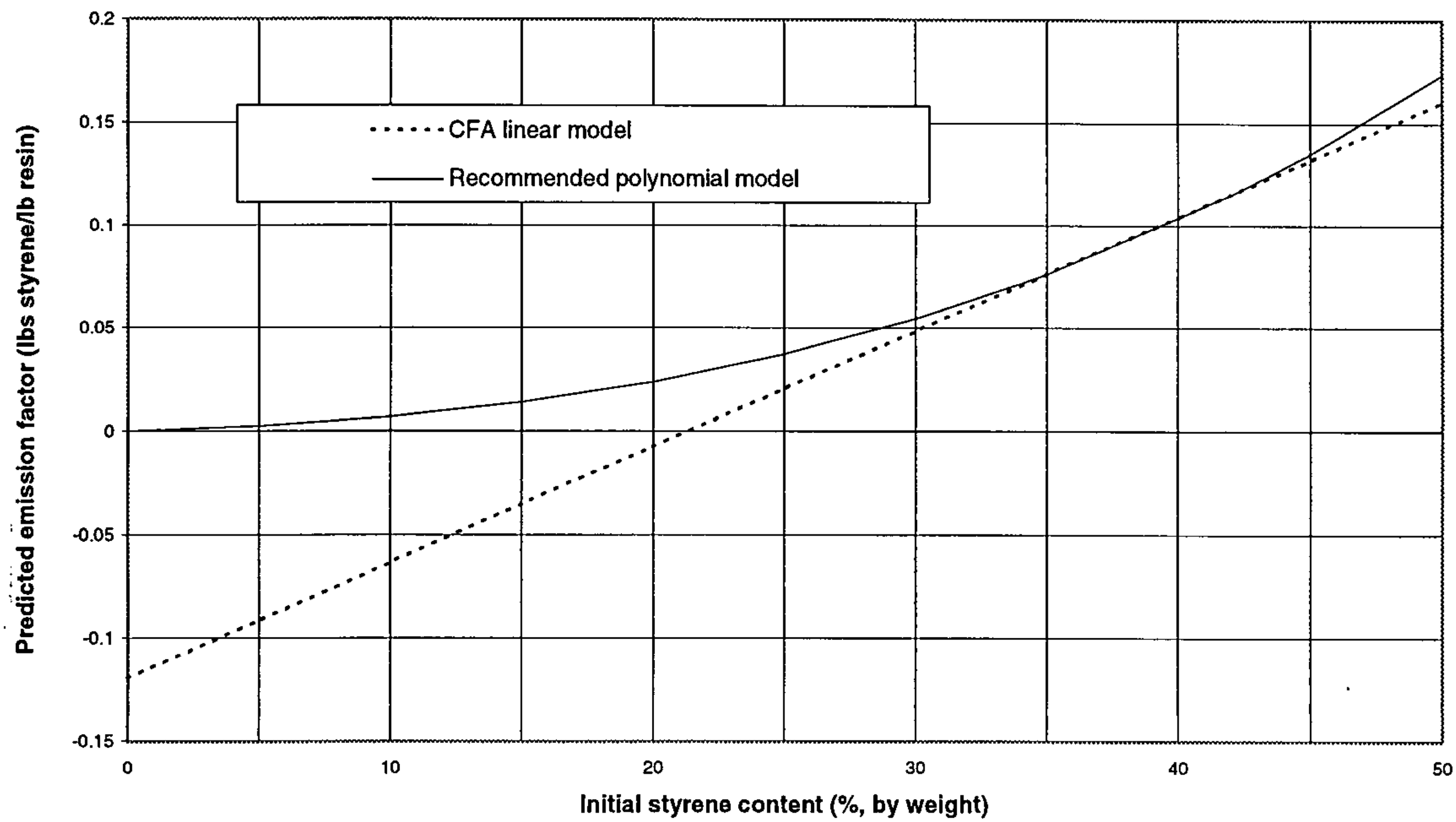

Figure A: Comparison of CFA linear model with suggested polynomial model.

Table B presents the CFA proposed linear equations and my recommended polynomial equations for Manual Resin Application, Mechanical Resin Application, Gel Coat Application, and Filament Application.

Table B. CFA Versus Recommended Equations for Various Application Processes.

Process	CFA (Linear) Equation*	Recommended (Polynomial) Equation*
Manual Resin Application	$y = 0.002747x - 0.0298$	$y = 2.0E^{-6}x^3 - 1.32E^{-4}x^2 + 3.54E^{-3}x$
Mechanical Resin Application	$y = 0.00559x - 0.1193$	$y = 6.7E^{-7}x^3 + 2.92E^{-5}x^2 + 3.33E^{-4}x$
Gel Coat Application	$y = 0.01036x - 0.01950$	$y = 1.0E^{-6}x^3 + 2.13E^{-4}x^2 - 1.47E^{-3}x$
Filament Application	$y = 0.002746x - 0.0298$	$y = 2.0E^{-6}x^3 - 1.54E^{-4}x^2 + 4.67E^{-3}x$

* y = Emission Factor, $lb_{styrene}/lb_{resin}$; x = Initial Styrene Content, % by weight.

It may seem as though the differences in the models have no practical application, since few resins that are currently sprayed have styrene contents below approximately 33% (neat resin, by weight). However, it can be assumed that resin manufacturers will place increasing emphasis on low styrene resins, particularly after proposal of MACT for the FRP/C industry. For example, in 1995 RTI/ORD studied emissions from a newly-developed gel coat by Cook Composites and Polymers that had a styrene content of only 25%. Further, gel coat manufacturers have already developed gel coats with styrene contents of 15% or less. Therefore, the fact that linear extrapolation underestimates emissions at low styrene contents is not just of academic interest.

2. Modification Factor for Suppressants in Mechanical Resin Application Equation

The suppressant factors given in Table 5 are 1.00 and 0.62; CFA is recommending that the 0.62 factor be used when styrene suppressants are used. However, testing by both RTI/ORD and CFA have shown that suppressants provide little or no emission reduction for filled resins. If no further research is conducted on styrene suppressants, I suggest using an equation that produces a value of 0.62 for non-filled applications, with the predicted emissions increasing to a value of 1.00 for a resin with a filler content of 60%. However, I understand that you are working with the industry and other groups in OAQPS to develop a test method to predict how styrene suppressant performance may be affected by other variables (such as initial styrene content, non-spray application, and others). This seems like a good area for research. The results of this research might provide even more accurate estimates of the reductions achieved by suppressants.

3. "Controlled" Spraying Modification Factor in Mechanical Resin Application and Gel Coat Application.

Table 5 gives modification values of 0.77 and 0.73 for use of "controlled" spraying for resin sprayup and gel coating, respectively. This raises two issues: 1) a definition of what constitutes "controlled" spraying, and 2) whether the magnitude of the two factors are appropriate.

I believe that the use of the term "controlled" spraying is extremely ambiguous. The RTI/ORD model, rather than using the terms "controlled" or "uncontrolled", has two objective measurements of spraying technique: 1) distance from the spray gun to the mold, and 2) amount of dried material off of the mold, as a percentage of total material sprayed. I suggest eliminating the subjective term of "controlled" spraying; this term could be replaced by the two objective measurements in the RTI/ORD model. CFA's proposed single value for emission reductions achieved by controlled spraying could then be replaced by equations that relate emissions to distance-from-the-mold and dried-material-off-the-mold.

In the current RTI/ORD model, straight lines are used to relate distance-from-the-mold and dried-material-off-the-mold to emissions. This means, for example, that emissions are predicted to increase continuously with distance from the mold. Clearly, it may be impractical to determine distance-from-the-mold within inches. Therefore, if distance-from-the-mold was included in a regulation, it might be desirable to translate that line into a series of "steps", with appropriate modification factors. For example, a spraying distance of 0-2 feet from the mold might be given one factor, while distances of 2-4 feet and 4-6 feet might be given appropriately higher factors. Use of a straight line would not present this problem for dried-material-off-the-mold; the dried material collected after a certain time would simply be compared with the total material sprayed, and the equation could be used directly.

Because the term "controlled" is so ambiguous, it is difficult to assess the appropriateness of the values of 0.77 and 0.73 for "controlled" spraying of resin and gel coat, respectively. However, RTI/ORD did a careful study of the effects of what RTI labeled as "controlled" and "normal" spraying of gel coat, during testing at Reichhold in 1995. In this testing, a total of 6 runs were conducted with "controlled" gel coat spraying, and 6 runs were conducted with "normal" gel coat spraying. (The spray gun operator was given tapes of spraying at a tub/shower manufacturing facility, and told to duplicate the observed spraying techniques for "normal" spraying.) These tests indicated that "controlled" gel coat spraying produced an emission reduction of approximately 14 percent, when emissions are expressed in $lb_{styrene}/lb_{resin}$. This 14 percent emission reduction represents a "modification factor for controlled spraying" of 0.86, which can be contrasted with the 0.73 factor proposed by CFA for "controlled" gel coat spraying. Again, replacing the subjective word "controlled" with objective, measurable values would eliminate this problem.

4. Non-Atomized Mechanical Resin Application Factor.

Table 5 recommends a single factor of 0.51 for non-atomized application; i.e., the emission reduction achieved by non-atomized application is independent of initial styrene content. However, testing by the National Marine Manufacturers Association (NMMA) and ORD/RTI at the U.S. Marine facility in Washington both indicated that the emission reductions achieved by flow coaters changed with initial styrene content. In both tests, the emission reductions achieved by flow coaters were less for an initial styrene content of 35% than for 42%. The modification factor for non-atomized application should reflect this effect of initial styrene content.

5. Use of a Single Model for Mechanical Application of Filled and Non-Filled Resins.

Page 5 of document #1 recommends that the standard not include separate treatment for filled and unfilled resins. This recommendation is followed in Table 1 of the document; for example, Table 1 has a single emission equation for the effect of styrene content on Mechanical Resin Application emissions.

If one uses the recommended equation in Table 1 to predict emissions for the filled resin used in CFA's phase II testing, which had a neat styrene content of 45.8%, one arrives at a predicted emission factor of 0.137 $lb_{styrene}/lb_{resin}$. This contrasts with the actual test result of 0.092 $lb_{styrene}/lb_{resin}$ (see document 2, page 35). Therefore, the CFA model presented in Table 1 predicts emissions that are nearly 49% higher than the actual CFA filled-resin test results.

This apparent difference between CFA's results with filled and unfilled resins may actually not be the result of the fact that one resin was designed to be "filled", while another was not. ORD/RTI filled resin testing conducted in 1996 seemed to indicate that even two resins that were designed to be "filled" would not have the same emissions with equal styrene contents. These data may therefore call into question the accuracy of *any* single equation for emissions-versus-content.

As recommended below, CFA should evaluate the accuracy of their model in predicting emission factors derived from CFA and ORD/RTI filled resin testing, as well as the recently-completed NMMA and ORD/RTI testing at U.S. Marine in Washington.

6. Agreement Among CFA and EPA/RTI Studies

Page 10 of the subject document #1 states that, "The emission factors derived from the CFA and EPA/RTI studies for gel coat application, atomized spray application, and non-atomized spray application agree to within, respectively, 1.5%, 0.9%, and 3%. This excellent agreement between the results of two completely independent studies supports the validity of the CFA emission models."

I was unable to find the supporting calculations for the agreement values of 1.5%, 0.9%, and 3%. Further, page 31 of document #2 has different values. From the values presented there, differences of 7.4% and 9.5% can be calculated for gel coat application and atomized spray application (using the CFA values as reference values).

More importantly, this analysis does not include comparisons of the CFA model predictions with CFA and EPA/RTI results for filled resins, or NMMA and EPA/RTI results at the U.S. Marine boat manufacturing plant. An analysis of the CFA model's predictions as compared with these results would give a more complete assessment of the predictive capabilities of CFA's proposed model.

7. Quality Assurance Procedures for Dow Filament Winding Testing and CFA Phase II Testing.

Page 10 of document #1 says that the Dow filament winding study "...employed the same QC procedures and analytical techniques as the CFA study." Much of the Phase I CFA testing at Dow Chemical was conducted following EPA requirements for QA Category II. This included submittal and EPA approval of a QA level II Quality Assurance Project Plan. To my knowledge, such a plan was not submitted for the filament winding testing.

Similarly, page 8 of document #1 states that (all) CFA testing at Dow Chemical in Freeport, TX was run in accordance with EPA's Category II quality criteria. This would require submission and EPA approval of a Level II Quality Assurance Project Plan (QAPP). To my knowledge, no such QAPP was submitted for the "optimization study" portion of the CFA Phase I testing, or for any portion of the CFA Phase II testing.