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AP42 Section:	4.4
Related:	6
Title:	Comments on proposed changes to AP-42 Section for Fiber Reinforced Plastics C Nunez July 1998

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
AIR POLLUTION PREVENTION AND CONTROL DIVISION
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

DATE: July17, 1998

SUBJECT: Comments on Proposed Changes to AP-42 Section for Fiber-Reinforced Plastics

FROM: Carlos Nuñez
NRMRL/APPCD, MD-61

TO: Ron Ryan
OAQPS/EMAD, MD-14

This memorandum is in response to your March 18 request for comments on two reports (1. CFA Emission Models for the Reinforced Plastics Industries, and 2. Baseline Characterization of Emissions from Fiberglass Boat Manufacturing), and a spreadsheet placed on the CHIEF web site. These documents were posted as part of your efforts to revise the AP-42 section for fiber-reinforced plastics. You requested comments on the materials "...while we begin drafting a replacement AP-42 section based largely on the two reports." I believe that both Madeleine Strum from OAQPS and Leonardo Ceron from Region IV concur with these comments.

General Comments

1) In most cases, the EPA/ORD model better represents "best available data" than the proposed CFA model. Therefore, the EPA/ORD model should also be presented in AP-42. (And if only one model is presented, it should be the EPA/ORD model.)

2) In many cases, the EPA/ORD model can also be used for boat manufacturing applications. I am concerned that the data contained within the National Marine Manufacturers Association (NMMA) report might be inappropriately used as a de-facto "model" for other boat manufacturing applications.

3) In general, EPA should use documents and employ computer tools that have undergone EPA peer review, in preference to those that have not.

These three general comments are further discussed on the following pages.

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1. In Most Cases, the ORD Model Better Represents "Best Available Data" than the Proposed CFA Model. Therefore, the EPA/ORD Model Should Also Be Presented in AP-42.

The proposed CFA model condenses many parameters known to affect styrene emissions, (such as thickness, gel time, and temperature) into a single continuous variable, styrene content. Although this simplifies inputs to the model, it necessarily reduces the accuracy of the model, because the model does not reflect the effects of these other parameters. Users should obtain the increased accuracy that comes from accounting for all parameters known to effect FRP fabrication emissions.

I also believe the ORD model is better than the proposed CFA model because the CFA model includes the subjective and ambiguous term, "controlled spraying." 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).

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). The ORD model includes this important phenomenon.

The ORD model accurately predicts emissions at the known "boundary" condition of zero styrene content, whereas the proposed CFA model does not. For example, it is certain that styrene emissions, expressed as a percentage of total resin applied, must approach zero as styrene content approaches zero. It is also certain that styrene emissions can never be negative. The ORD model is compatible with these known facts; the proposed CFA model violates both these known facts.

For example, Figure 1 compares the predictions of the ORD model (using primarily default "baseline" values) versus the CFA model (with "uncontrolled" and "controlled" spraying), for resin sprayup with neat styrene contents of 0 to 50%. While the two models are in relative agreement for resin styrene contents above 30%, the CFA model drastically underpredicts emissions at lower styrene contents. In fact, the proposed CFA model for resin sprayup predicts negative emissions for any neat styrene content less than approximately 25%. This flaw in the CFA model will become very important in the coming years, as resin manufacturers continue to lower the styrene content of their resins.

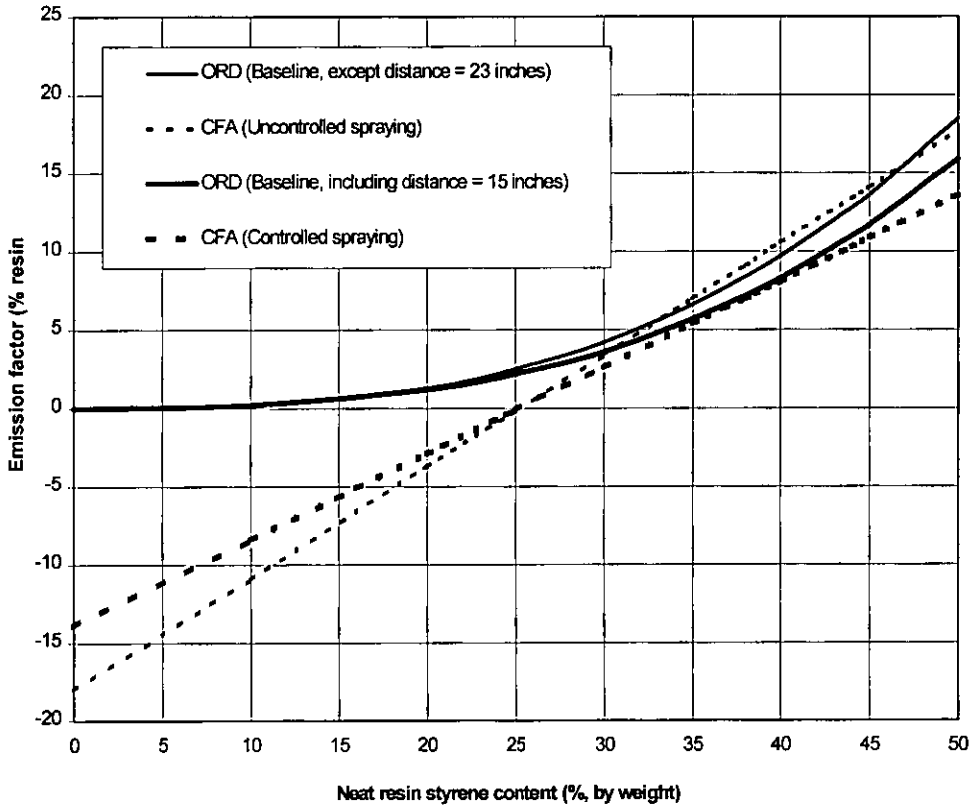

Figure 1. Comparison between ORD model and CFA one-factor model for sprayup with non-vapor-suppressed resin.

In fact, gel coat manufacturers have already developed gel coats with styrene contents well below 30 percent (as low as 10-15%). ORD/RTI measured emissions when spraying a gel coat containing 25% styrene (at Reichhold, in June 1995). The 9-run average results with a 25.4% styrene gel coat and 38.7% gel coat are compared with the CFA and ORD model predictions in Figure 2.

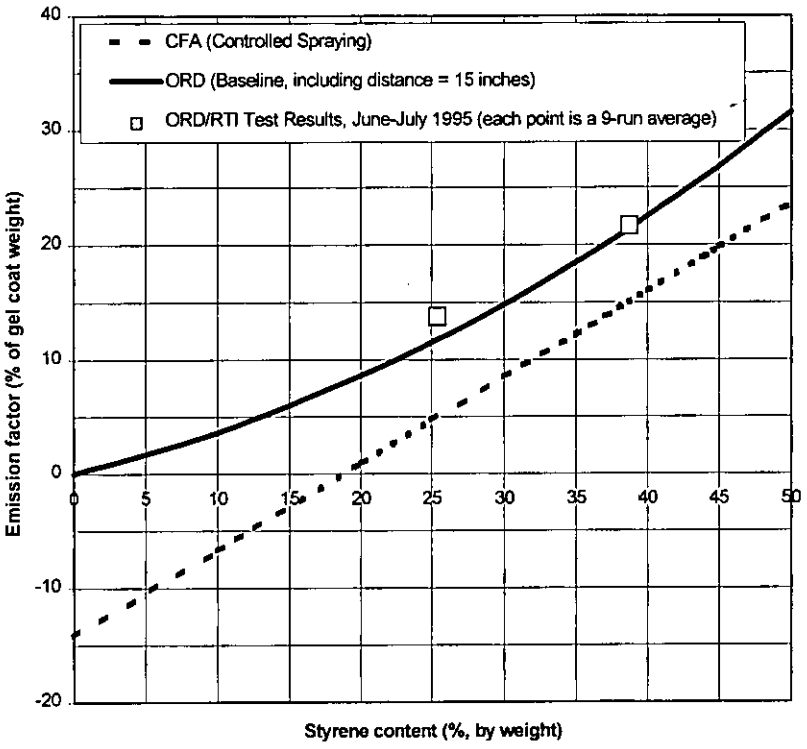

Figure 2. Comparison of ORD/RTI gel coating test results with ORD and CFA one-factor model predictions.

The comparison between ORD gel coating test results and the ORD and CFA modeling predictions is further summarized in Table 1. Figure 2 and Table 1 show that the CFA model underpredicts emissions by 31% and 64% for the two gel coats.[1] In contrast, the ORD model underpredicts by only 1% and 14%. The reasons for the large amounts of underprediction found in the CFA model are related to the two flaws discussed above: 1) the problem of assigning a fixed reduction factor for "controlled" spraying, and 2) the fact that the CFA model becomes increasingly inaccurate as styrene contents are lowered below 30%.

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[1] Page 32 of the document "CFA Emission Models for the Reinforced Plastics Industries" contains the statement that the results of the RTI/ORD study in June-July 1995 show "...Near-perfect agreement for the spray application of gelcoat (21.7% versus CFA's factor of 20.2% for 38.7% styrene content gelcoat)". However, the quoted RTI testing was conducted under conditions that were labeled as "CONTROLLED SPRAYING". If the "controlled spraying" emission reduction factor is used from the CFA model, the predicted emission factor is 15.0%, as shown in Table 1. So in this case, the CFA model actually underpredicts the test results by 31%. Further, no mention is made of the fact that the CFA model underpredicts the RTI results for the 25.4% gel coat by 64%...a very substantial margin. Therefore, we disagree with the document's assessment that, "The results of the RTI emission study strongly verify the accuracy of the CFA emission models."

Table 1. Comparison between ORD and CFA models for ORD gel coat testing of June 1995

Gel Coat Styrene Content	Emission Factor (% of gel coat, by weight)			Error (%)*	
	Test Result	ORD Model	CFA Model**	ORD Model	CFA Model
38.7%	21.7	21.4	15.0	-1	-31
25.4%	13.7	11.8	5.0	-14	-64

* Error (%) = 100 x (Model Prediction-Test Result)/Test Result

** Testing was conducted using "controlled spraying", so a "controlled spraying factor" is used.

It should be noted that ORD has developed a user-friendly model interface that includes "baseline" or "default" values for all parameters. If the user so desired, "styrene content" could be the only variable changed, leaving all other parameters at "baseline" values. This is reflected in the curves in Figure 1 and 2 labeled "ORD (Baseline, Including Distance = 15 Inches)". So the ORD interface allows the user to use the ORD model as a "one factor" model, if desired. However, using the ORD model in this "one factor" mode will create the *same inaccuracy* caused by "condensing" variables that occurs in the proposed CFA one factor model.

Based on these known, significant flaws in the proposed CFA model, I believe that, at minimum, the EPA/ORD model should also be included in AP-42. And if only one model is presented, it should be the ORD model.

2. NMMA Test Results may be Inappropriately Used as a Defacto Model, and In Many Cases, the ORD Model is Reasonable for Boat Manufacturing

I believe 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 as a defacto "model", and may be inappropriately used for other boat manufacturing situations. The following are three specific concerns:

a) The resin sprayup testing at U.S. Marine was performed by a spray gun operator who is the corporate trainer for U.S. Marine Corporation. It was observed that there was very little overspray (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), emissions would be higher.

b) Air velocities over the mold during NMMA testing at U.S. Marine were well below 40 feet per minute. I do not believe these low velocities are 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.

c) Although the boat mold sizes and shapes in the testing were chosen to represent a significant portion of the boat industry, they obviously don't reflect the entire range of

boat mold sizes and shapes. Likewise, the lamination thicknesses, gel times, air temperatures, etc. used during testing can't possibly represent the range of possibilities at all boat manufacturing facilities. For example, as I understand, there is concern in Region IV that boat emissions may be higher (than measured in the Washington testing) in the higher ambient temperatures that occur in the Southeast.

I am concerned that if the AP-42 section contains only a copy of the boat testing results, without any instructions as to whether or how the results should be used, the report might be considered as a de-facto "model" for boat-building. However, because of the concerns listed above (including the fact that EPA did not peer review this document), I believe that using the boat testing results as a de-facto "model" is not appropriate for every boat manufacturing situation.

Research Triangle Institute (RTI) evaluated the ORD model for the NMMA test results at U.S. Marine. Several of the input parameters for the ORD model were either not recorded, or were not summarized for this testing; therefore RTI used judgement to estimate these values. Important input estimates are presented below:

- After taking notes and reviewing videotapes of NMMA spray runs, RTI estimated average distances from the spray gun to the mold to be: 20 inches for spraying the CFA molds, 26 inches during 18' deck spraying, 27 inches during 18' hull spraying, and 36 inches during spraying of 28 foot hulls.

- NMMA did not record the dry material off the mold, as a percentage of total material sprayed. Therefore, RTI estimated the amount of dry material off the mold as a percentage of total material sprayed, based on RTI measurements of material off the mold for the 4 foot by 6 foot panel used in parallel testing, and visual observations of overspray after the NMMA spraying. The dry material-off- the-mold values for the 4 foot by 6 foot panel ranged from 4% to 7.5%. RTI estimated values of 1% dry material off the mold for the two hull sizes, and 4.82-7.5% of dry material off the mold for the deck. RTI estimated 20% dry material off the mold for the CFA mold runs conducted by an inexperienced spray gun operator.

- The input value for "air velocity over the mold" was 16 fpm, which represents the average of all NMMA and EPA velocity measurements near the mold.

- The lamination schedule for the boat molds at U.S. Marine was as shown in Table 3. "Thickness" is an input to the ORD model. The value for thickness that should be used in the ORD model input is the thickness for each individual lamination session. For example, the 18 foot hull is laminated with a 90 mil skin coat, followed by successive laminations of 60 mils, 40 mils, 60 mils, and 40 mils. The average lamination thickness for these five layers is 58 mils, and this is the value RTI used as a model input. — why not 5 separate? would this be acceptable on permit?

Table 3. Lamination Schedule for Testing at U.S. Marine

Part	Lamination schedule	Average thickness
18' deck	60 mil chop skin coat @ 2% catalyst, cured, then 150 mil chop lamination @ 2% catalyst	105 mils
18 foot hull	90 mil chop skin coat @ 2% catalyst, cured, then 60 mil chop + 40 mil mat + 60 mil chop + 40 mil mat, all @ 1.5% catalyst	58 mils
28 foot deck	90 mil chop skin coat @ 2% catalyst, cured, then 60 mil chop + 40 mil mat + 60 mil chop + 40 mil mat 60 mil chop + 40 mil mat, all @ 1.5% catalyst	56 mils
CFA molds	40 mil chop lamination @ 2% catalyst	40 mils

Figure 3 shows the results of ORD model predictions versus NMMA test results. All ORD predictions for gel coating were within ± 9% of measured values. For the boat molds (i.e., 18' deck, 18' hull, 28' hull), all predictions for resin sprayup were within ±12% of measured values. The two predictions for flow coating of the 18' hull were within ±11% of measured values.

The ORD model predictions were least accurate for flow coating of the deck, and for the CFA mold runs that were conducted by the inexperienced spray gun operator. In both these cases, the ORD model predictions were significantly lower than the measured results.

Overall, Figure 3 shows very good correlation between model predictions and NMMA test measurements for resin sprayup of the boat molds. This indicates that, at least for resin sprayup, the ORD model is a useful tool for predicting boat manufacturing emissions. And the issues I've mentioned make it difficult to generalize the NMMA test results to various other boat manufacturing situations. Therefore, people attempting to estimate boat manufacturing emissions should have access to the ORD model, as well as the NMMA test results.

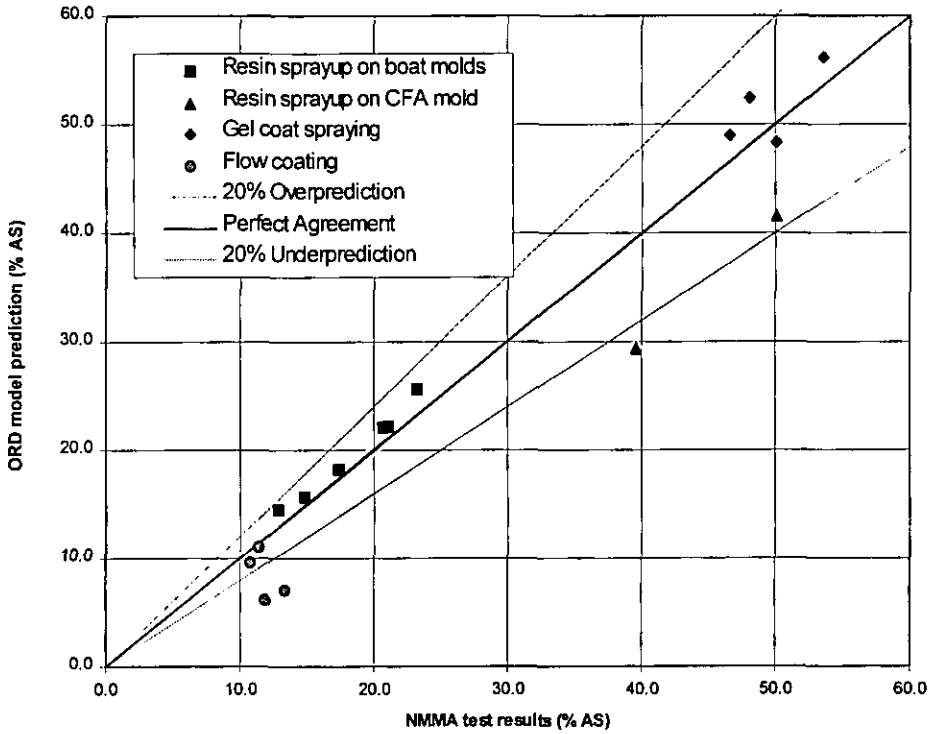

Figure 3. Comparison of NMMA test results with ORD model predictions.

3. In General, EPA Should Use Documents and Computer Tools That Have Undergone EPA Peer Review In Preference to Those That Have Not.

One very important reason for using the ORD model in preference to the CFA one-factor model is that the ORD model[2] has undergone EPA peer review. Both the CFA model and the NMMA test report have not undergone EPA peer review. This is important, because without EPA peer review, EPA has no mechanism for changing problems it knows exist within industry models or documents. For example, an obvious flaw in the proposed CFA model is that the emission factors can go negative at low styrene contents (point discussed previously). Madeleine Strum has repeatedly pointed out this important issue. Similarly, she has told industry that their model should recognize the fact that styrene suppressants lose effectiveness with highly filled resins, as was also discussed previously. However, industries have no obligation to address EPA-identified problems, unless documents and computer tools are submitted for formal EPA peer review.

cc: Leonardo Ceron, Region IV
Madeleine Strum, OAQPS (MD-13)

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[2] The paper that describes the ORD model has undergone EPA peer review, and has also been submitted to a peer-reviewed journal. The ORD model interface (i.e., the computer tool) has also undergone EPA peer review.