AP42 Section:	4.4
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Title:	Author's responses to Comments AWMA Journal Submission, "Empirical Model to Predict Styrene Emissions from Fiber - Reinforced Plastics" C Nunez November 1998

MEMORANDUM

DATE: November 19, 1998

FROM: Carlos Nunez, EPA APPCD
Mark Bahner, RTI

TO: Dr. Petros Koutrakis, Harvard School of Public Health

SUBJECT: Authors' Responses to Reviewers' Comments A&WMA Journal Submission: "Empirical Model to Predict Styrene Emissions from Fiber-Reinforced Plastics."

REVIEWER A

The reviewer includes a summary statement, "Statistical review also recommended." Based on this statement, and a statement suggesting ANOVA analysis in the reviewer's "Significant Concern #3", it appears that the reviewer is not aware that the proposed model is not statistically-derived. We have added text to the paper to emphasize this fact.

Since neither the proposed model or AP-42 is statistically-derived, standard regression measures (e.g., R^2) are not necessarily a good measure of model performance. Similarly, ANOVA analysis is not appropriate for non-statistical models. However, we agree that quantitative measures of model performance are necessary. Therefore, we have significantly revised the paper to add these quantitative performance measures.

We have eliminated 3 figures (Figure 6, "Composite Fabricators Association Phase I gel coating results versus EPA Model and AP-42"; Figure 7, "Composite Fabricators Association Phase I resin sprayup results versus results versus EPA Model and AP-42"; and Figure 8: "EPA/RTI and CFA filled resin results versus EPA model"). We have replaced these figures with a Table 7, "Comparison of Selected Testing Results With Predictions of the EPA Model and AP-42." Table 7 includes quantitative measures of the performance of both the EPA Model and AP-42. These performance measures are "bias" and "mean squared error". We have also added text to explain and interpret the data in Table 7.

Significant Concerns

1) The reviewer makes good points in items a), b) and c). However, as the reviewer notes, we presented this example for simplicity sake alone. Further, we do indeed have more data than the two "points" described (we have data that indicates what the slope of the line should be for thicknesses less than 40 mils). Finally, although the model is presented as an "empirical" model, the shapes of many of the modification factor lines can actually

be predicted with some confidence, based on first principles alone. The thickness modification factor is one such example. (See our response to Significant Concern #3.)

Although we don't feel it's absolutely necessary, we have modified the "Example Calculations" section to address the reviewer's concern. See revised "Example Calculations" text, and revised Table 5.

2) Due to limitations on the paper length, it is not possible to include graphs for each modification factor. However, we have modified Table 3 as suggested by the reviewer.

3) Although it may appear that the fitting of modification factor equations with linear, quadratic, or multiple linear equations is arbitrary, there are many instances where the shape of the curve fit was determined by knowledge or anticipation of values outside of the range of existing data.

For example, it is known that the modification factor for styrene content (or any other parameter) can never be less than zero. A linear best-fit equation through the styrene content data would result in modification factor predictions that were less than zero for positive styrene contents; therefore, a linear modification factor is inappropriate for styrene content (as was pointed out in the paper).

Similarly, we know the thickness modification factors must have steeper slopes as thickness approaches zero, and near-horizontal slopes as thickness approaches infinity. This is why the thickness modification factor is modeled with multiple linear equations. (Note: A third linear equation was added to make the thickness modification factor by truly horizontal at infinite thickness.)

It is a legitimate criticism that, for instance, the effect of thickness could be modeled with a smooth curve, rather than multiple linear equations. However, we do not believe the model accuracy is significantly compromised by multiple linear (versus smooth polynomial) equations. We do not believe the model needs to be changed in this respect.

The reviewer also comments on lack of ANOVA analysis. However, as discussed previously, ANOVA analysis is not appropriate for the new model or AP-42, since neither is statistically derived. However, we have added a Table 7 that analyzes the performance of both the new model and AP-42.

4) The reviewer comments that we used only one study to choose our distance-to-mold modification factor equations for gel coating and resin sprayup, and that we gave no explanation for this choice. However, we did in fact explain why we did not choose to use the other tests. We noted that during the CFA testing with various mold sizes (including "optimization" testing), spray gun pressure was also changed, in addition to distance from mold. This was why we did not use those CFA data. We also noted that during the CFA distance-from-mold sprayup testing, only peak concentration was measured, rather than total emissions. That was why we did not use those data. So we did in fact explain why

we excluded these data, and used only the NMMA data. However, we have added a sentence in the paper to essentially repeat and emphasize this point.

The reviewer also comments that it would be easier to interpret the distance-to-mold figure if it was broken into two separate figures. While we agree that this would make the figure slightly easier to interpret, we don't feel it is necessary to add to the paper length by adding an additional figure, simply to make the figure slightly easier to interpret.

5) The reviewer points out that, in comparing the new model with AP-42, it is most valuable if a completely new data set (not used to develop this model or AP-42) is used. We agree; however such completely new data is difficult to find.

Table 7 (which we added to the paper) includes analysis of both models' performance in predicting results of the EPA/RTI Filled Resin Study and the NMMA Boat Manufacturing study. Both of these studies had only minor impact on the new model development, and therefore are a reasonably close approximation to new data sets. To get completely new data would require additional expensive testing.

Minor Recommendations

1) We have modified the implications statement and abstract per the reviewers comments.

2) We have included a notation on Table 2 about whether tests were laboratory studies, pilot studies, field/full scale studies under controlled conditions, or field studies under actual conditions.

3) We believe that the methodology in AP-42 *is* faulty, although we completely agree with the reviewer that the AP-42 developers did the best they could with the data they had at the time.

AP-42 uses the simple quoting of a range, which is not as useful as attempting to evaluate the effects of various parameters within that range. For example, the CFA resin sprayup test program had 20 runs, with emissions in those runs ranging from 17.1% AS to 38.0% AS. A model that simply said, "resin sprayup emissions range from 17.1% AS to 38.0% AS" is not very useful, because the range is so large, and no help is given as to how to judge where one's own results might lie within that range. Therefore, we continue to believe the multiparameter model is inherently better than the range approach provided in AP-42.

4) We have revised the variable naming scheme.

5) We have added some additional discussion. However, page limitations preclude detailed discussion.

6) We have revised the description of "dry-material-off-mold", as suggested by the reviewer.

7) We've removed the figures (formerly Figures 6, 7, and 8) that caused the reviewer's confusion.

8) We did not state that "lbs styrene released/lb resin used" is the best basis of comparison; we merely suggested that it was probably a better basis than %AS. The reviewer is correct that "lb styrene released/item produced" would be even better...as long as the same amount of resin was used each time (i.e., for the same size parts). However, the part size variation within the FRP industry is enormous (from shower stalls to yacht hulls, for example). Therefore, "lb styrene released/item produced" would not be feasible for the entire FRP industry.

9) The former Figures 6 and 7 have been completely removed from the paper, so this comment is no longer relevant.

REVIEWER B

A. We've added the seventh study in Table 3, so the text and table are now in agreement.

B. Although the conversion table is fairly basic, we will leave it in, unless the A&WMA editors wish to remove it.

C. We have changed Tables 5 and 6, so they are now consistent with Figure 2. We have also added text to explain why it is logical to see the non-linear emission reduction at for velocities below 38 fpm.

D. The former Figures 6 and 7 have been completely removed from the paper, so this comment is no longer relevant.

E. We have included an example calculation (using the new model) in Table 5. We've added a reference to the AP-42 values for this process in a footnote to Table 5, and have included a comparison of the values in the text.