III.

Ozone Formation from Aerosol Coating Emissions

As stated in the previous Chapter, the proposed amendments present a new approach to regulate the emissions from aerosol coating products. Using the concepts of reactivity, staff is proposing to replace the January 1, 2002, volatile organic compound (VOC) content limits with reactivity limits that achieve an equivalent air quality result. To do this, it is necessary to quantify the ozone reduction that would be associated with the VOC limits and set reactivity limits that achieve that ozone reduction target. In this way the proposed reactivity limits should ensure an equal air quality benefit.

To set reactivity-based limits, information on the amounts and types of reactive organic compounds emitted, as well as aerosol coating product sales are needed. These data are readily available from the 1997 Aerosol Coating Survey (ARB, 1998b). These same data were used as the basis for setting the January 1, 2002, VOC limits. In this Chapter, we provide a summary of the data on the VOC emissions and sales of aerosol coatings. In addition, the product category reactivities, VOC reductions and the corresponding ozone reduction commitments are shown on a category-by-category basis.

A. Emissions from Aerosol Coating Products Contribute to the Formation of Ozone in the Troposphere

The use of aerosol coating products results in VOC emissions which originate from the propellants and solvents contained in them (Dunn, 1993; Fortmann *et al.,* 1998). Once in the air, these compounds, in the presence of sunlight, react with nitrogen oxides to form ozone. Hence, we have been regulating VOC emissions from aerosol coatings as part of our ozone control strategy.

When aerosol coatings are used outdoors or in well ventilated areas, the VOCs have a direct route to ambient air after they have vaporized. The propellants used in aerosol coatings, such as isobutane, propane, and dimethyl ether, are gases at room temperature. These gases are emitted when an aerosol coating is sprayed and are immediately available for transport to the atmosphere. The solvents used in aerosol coatings evaporate during the application and drying processes of the paint. Typically, a solvent-blend of fast evaporating and slow to medium evaporating solvents is used in the formulation, to provide the correct drying time for the paint film. The evaporation of the solvents takes place in two stages, with the initial loss of solvent (up to 80 percent) being dependent on the vapor pressure of the fast evaporating solvent. After the initial loss of solvent, the polymer film is formed. The remaining solvent loss is caused by a slower diffusion-controlled process (ICAG, 1987). The nonvolatile portion of the coating remains in the cured coating film and, under normal use conditions, is not emitted to the atmosphere.

B. Air Resources Board Emissions Survey

The emission inventory was developed for aerosol coatings based on a survey questionnaire sent out to 313 potential responsible parties and manufacturers of aerosol coatings. Among other information, manufacturers and responsible parties supplied information on product formulation and product sales. Data were received from 137 responsible parties and 53 manufacturers. These data accounted for at least 90 percent of the sales of aerosol paint in California during 1997. A further discussion of survey development and the information supplied is contained in the "Initial Statement of Reasons for the Proposed Amendments to the Regulations for Reducing Volatile Organic Compound Emissions from Aerosol Coatings, Antiperspirants and Deodorants, and Consumer Products" (ARB, 1998a).

C. Summary of the Data from the 1997 Aerosol Coatings Survey

To interpret the data in the following tables, we begin by defining some reactivity-related terms. It is also important to note the distinction we are making between VOC and reactive organic compound (ROC). "VOC," as defined in the mass-based regulation does not include the exempted compounds such as acetone. In our reactivity-based regulation, we are proposing to use the term "ROC" to clarify that all VOCs, including exempt compounds such as acetone, are considered for evaluating products' reactivities. This distinction explains the difference between VOC and ROC emissions reported in Table III-1.

Reactivity related terms used in the following tables:

- $SWA\text{-}MIR_{prod}$ is the sales-weighted average maximum incremental reactivity (MIR) of the products reported in an aerosol coating category.

- $SWA\text{-}MIR_{VOC}$ is the sales-weighted average maximum incremental reactivity of the products ($SWA\text{-}MIR_{prod}$) divided by the sales-weighted average VOC content of the product category, as explained in Chapter IV. The $SWA\text{-}MIR_{VOC}$ is used to calculate the equivalent ozone reduction. The tpd VOC reduction commitment is based on reductions of VOCs (not including acetone).

- Total Ozone Formation is the potential amount of ozone (reported here in tpd) formed from emissions of the VOCs in the aerosol coating category.

- Unadjusted Equivalent Ozone Reduction is the equivalent ozone reduction expected to be achieved from the tpd VOC reduction commitment. The unadjusted ozone reduction is calculated by multiplying the tpd VOC reduction by the $SWA\text{-}MIR_{VOC.}$

- Adjusted $SWA\text{-}MIR_{VOC}$ is the $SWA\text{-}MIR_{VOC}$ adjusted for mechanistic uncertainty of ingredient MIR values.

- Adjusted Equivalent Ozone Reduction is the ozone reduction calculated by multiplying the tpd VOC reduction commitment by the adjusted $SWA\text{-}MIR_{VOC}$. This is the amount of ozone reduction that needs to be achieved by the proposed reactivity limit.

Table III-1 summarizes product sales and VOC and ROC emissions calculated from the survey data. As shown from Table III-1, sales from all coating categories were about 34.3 tpd, with VOC emissions of 19 tpd. Adjusting for survey coverage (which is an approximate 10 percent adjustment), VOC emissions were estimated to be 21 tpd in California in 1997. Data shown in Tables 1and 2 are based on actual reported emissions. Total ROC emissions were reported as 26.5 tpd. Based on the survey data, the six "general" aerosol coating categories account for approximately 77 percent of the total ROC emissions and 78 percent of the total amount of ozone formed from aerosol coating emissions in California in 1997. The remaining 23 percent of ROC emissions and 22 percent of total ozone formed can be attributed to the combined emissions from the 29 "specialty" aerosol coating categories. Among all categories, nonflat ("glossy") coatings are 43 percent of the ROC emissions and represent almost 46 percent of the total ozone formation.

Table III-2 summarizes our estimates of VOC emission reductions and the corresponding ozone reduction (i.e. unadjusted equivalent ozone reduction) that would have occurred upon implementation of the VOC standards adopted by the Board on November 19, 1998. As detailed in Chapter IV, not all VOC have been thoroughly studied. In these instances, uncertainty factors are applied to the ingredient MIR values prior to determining what the "ozone reduction target" should be. After accounting for MIR value uncertainty, the adjusted $SWA\text{-}MIR_{VOC}$ is multiplied by the VOC reduction commitment (in tpd). This ozone reduction target is shown in Table III-2 as "adjusted equivalent ozone reduction." Nevertheless, these adjustments are rather insignificant (up to 10 percent), suggesting that the compounds used in aerosol coating products are reasonably well studied (see also Chapter IV).

As shown in Table III-2, the VOC standards would have achieved reductions of 3.1 tpd from VOC emissions totaling 19 tpd. The total VOC emissions and VOC emission reductions shown in Tables III-1 and 2 are different from those reported in the October 2, 1998, staff report (ARB, 1998a). Upon further quality checks of the data, data entry errors were found in the ground traffic and marking coating category. After correcting the data, the VOC emissions and VOC reductions from the ground traffic and marking category are 1.7 tpd and 0.28 tpd, respectively. Previously we reported emissions of 2.83 tpd and a reduction of 0.74 tpd.

TABLE III-1
SUMMARY OF DATA FROM THE 1997 AEROSOL COATING SURVEY

Aerosol Coating Category	California Sales (tons per day)	VOC Emissions (tons per day)	ROC Emissions (tons per day)	SWA-MIR_{prod} (g O_3/g product)	Total Ozone Formation (tons per day)
General Categories					
Clear Coatings	1.59	0.96	1.36	1.66	2.64
Flat Paint Products	3.04	1.54	2.36	1.52	4.62
Fluorescent Coatings	0.36	0.24	0.25	1.63	0.59
Metallic Coatings	2.33	1.65	1.88	2.09	4.87
Nonflat Paint Products	15.13	8.13	12.09	1.62	24.51
Primers	3.56	1.82	2.59	1.33	4.73
Specialty Categories					
Art Fixatives or Sealants	0.33	0.23	0.28	1.56	0.51
Auto Body Primers	0.50	0.25	0.37	1.69	0.85
Auto Bumper and Trim	0.35	0.30	0.32	1.59	0.56
Exact Match Finishes: Engine Enamel	0.38	0.18	0.32	1.52	0.58
Exact Match Finishes: Automotive	0.72	0.39	0.64	1.68	1.21
Ground/Traffic/Marking	3.20	1.70	1.81	1.35	4.32
High Temperature Coatings	0.70	0.48	0.60	2.04	1.43
Vinyl/Fabric/Leather/ Polycarbonate	0.33	0.25	0.31	1.67	0.55
All Other Coating Categories	1.74	0.89	1.36	N/A	1.66
Totals	34.25	18.99	26.54	N/A	53.63

N/A : not applicable

TABLE III-2
SUMMARY OF VOC EMISSIONS AND TARGET OZONE REDUCTIONS

Aerosol Coating Category	VOC Reduction (tons per day)	Unadjusted [a]SWA-MIR_{VOC} (g O_3/g VOC)	Adjusted [a]SWA-MIR_{VOC} (g O_3/g VOC)	Unadjusted Equivalent Ozone Reduction (tons per day)	Adjusted Equivalent Ozone Reduction (tons per day)
General Categories					
Clear Coatings	0.17	2.75	3.00	0.47	0.52
Flat Paint Products	0.33	3.00	3.21	0.99	1.06
Fluorescent Coatings	0.03	2.45	2.63	0.07	0.07
Metallic Coatings	0.21	2.95	3.07	0.62	0.66
Nonflat Paint Products	1.37	3.01	3.26	4.12	4.46
Primers	0.41	2.60	2.77	1.07	1.13
Specialty Categories					
Art Fixatives or Sealants	0.04	2.24	2.35	0.09	0.10
Auto Body Primers	0.04	3.35	3.62	0.13	0.13
Auto Bumper and Trim	0.04	1.89	1.97	0.07	0.08
Exact Match Finishes: Engine Enamel	0.01	3.13	3.42	0.03	0.04
Exact Match Finishes: Automotive	0.04	3.11	3.17	0.12	0.14
Ground/Traffic/Marking	0.28	2.54	2.78	0.71	0.78
High Temperature Coatings	0.07	3.01	3.15	0.21	0.22
Vinyl/Fabric/Leather/ Polycarbonate	0.03	2.27	2.34	0.07	0.08
All Other Coating Categories*	0.03	N/A	N/A	0.04	0.06
Totals	3.11	N/A	N/A	8.82	9.56

[a]SWA-MIR_{VOC} = SWA-MIR_{prod} / SWA-VOC
N/A : not applicable

REFERENCES

Air Resources Board. (1998a), Initial Statement of Reasons for the Proposed Amendments to the Regulations for Reducing Volatile Organic Compound Emission from Aerosol Coatings, Antiperspirants and Deodorants, and Consumer Products. October 2, 1998.

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