

V. AMBIENT AIR QUALITY AND EMISSIONS

California's extreme air quality problems require unique strategies for meeting federal and State ambient air quality standards. In this chapter, we provide an overview of these air quality problems and the need for significant emission reductions from all sources of air pollution. We also describe the need for the regulation of automotive coatings and provide a summary of the emissions from the coating categories proposed for regulation.

A. AMBIENT AIR QUALITY AND THE NEED FOR EMISSION REDUCTIONS

VOC emissions contribute to the formation of ozone, and fine particulate matter (PM). PM pollution consists of very small liquid and solid particles in the air. PM includes particles smaller than 10 microns in size (PM₁₀), and particles smaller than 2.5 microns in size (PM_{2.5}). Ozone formation in the lower atmosphere results from a series of chemical reactions between VOCs and nitrogen oxides in the presence of sunlight. PM₁₀ and PM_{2.5} pollution result from both direct and indirect emissions. Direct sources of PM₁₀ and PM_{2.5} include emissions from fuel combustion and wind erosion of soil. Indirect PM₁₀ and PM_{2.5} result from the chemical reaction of VOCs, nitrogen oxides, sulfur oxides and other chemicals in the atmosphere. Federal and State ambient air quality standards for these contaminants have been established to protect California's population from the harmful effects of ozone and PM.

1. Ozone

VOCs and nitrogen oxides (NO_x) react in the presence of sunlight to form ozone. The rate of ozone generation is related closely to the amount and reactivity of VOC emissions as well as the amount of NO_x emissions available in the atmosphere (U.S. EPA, 1996; Seinfeld and Pandis, 1998). Ozone is a colorless gas and the chief component of urban smog. It is one of the State's more persistent air quality problems. As shown in Figure V-1, the population-weighted average exposure to ozone concentrations above the 1-hour State ambient air quality standard (of 0.09 ppm) in the South Coast Air Basin has been declining. However, despite this decline and nearly 25 years of regulatory efforts, ozone continues to be an important environmental and health concern.

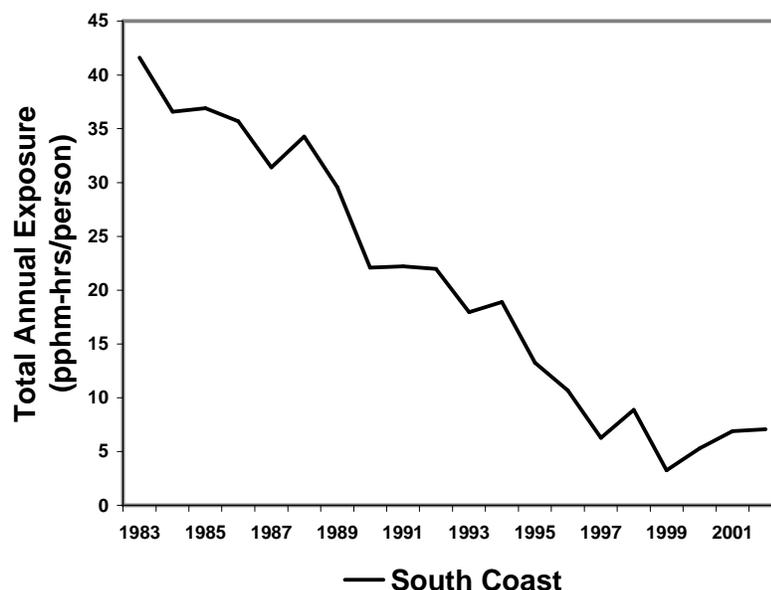
It has been well documented that ozone adversely affects the respiratory functions of humans and animals. Human health studies show that short-term exposure to ozone injures the lung (ARB, 2000b, 1997; U.S. EPA, 1996). In some animal studies, permanent structural changes with long-term exposures to ozone concentrations considerably above ambient levels were noted; these changes remain even after periods of exposure to clean air (U.S. EPA, 1996). Ozone is a strong irritant that can cause constriction of the airways, forcing the respiratory system to work harder in order to provide oxygen to the body. Ozone is a powerful oxidant that can damage the respiratory tract, causing inflammation and irritation, and induces symptoms such as coughing, chest tightness, shortness of breath, and worsening of asthma symptoms

(U.S. EPA, 1996). Ozone in sufficient doses increases the permeability of lung cells, rendering them more susceptible to toxins and microorganisms.

The greatest risk is to those who are more active outdoors during smoggy periods, such as children, athletes, and outdoor workers. Exposure to levels of ozone above the current ambient air quality standard leads to lung inflammation and lung tissue damage, and a reduction in the amount of air inhaled into the lungs. Recent evidence has, for the first time, linked the onset of asthma to exposure to elevated ozone levels in exercising children (McConnell et al., 2002).

One requirement of The Children’s Environmental Health Protection Act is that the ARB, in consultation with OEHHA, review all of California’s health-based ambient air quality standards by December 31, 2000 (Senate Bill 25, Escutia, 1999). The purpose of the review was to determine whether the standards adequately protect public health, especially the health of infants and children. The findings are summarized in the report, "Adequacy of California Ambient Air Quality Standards: Children’s Environmental Health Protection Act" (ARB, 2000b). This report found that the standards for particulate matter, ozone, and nitrogen dioxide are inadequate to protect public health. The standards for particulate matter (PM₁₀ and sulfates) were found to have the highest priority for revision. At the December 9, 2000, Public Meeting, the Board approved the report and urged staff to work as expeditiously as possible to present them with recommendations due to the serious impact of these pollutants on the health of Californians. In March 2005, the State adopted a new 8-hour standard for ozone, and retained the existing 1-hour ozone standard.

**Figure V-1
Population-Weighted Exposure to Ozone Concentrations
Above the State Ambient Air Quality Standard**



Not only does ozone adversely affect human and animal health, but it also affects vegetation throughout most of California resulting in reduced yield and quality in agricultural crops, disfiguration or unsatisfactory growth in ornamental vegetation, and damage to native plants. During the summer, ozone levels are often highest in the urban centers in southern California, the San Joaquin Valley, and Sacramento Valley, which are adjacent to the principal production areas in the State's multibillion-dollar agricultural industry. ARB studies indicate that ozone pollution damage to crops is estimated to cost agriculture over 300 million dollars annually (ARB, 1987). Similarly, the U.S. EPA estimates national agricultural losses to exceed 1 billion dollars annually (U.S. EPA, 1996). Elevated levels of ozone also cause damage to materials such as rubber, paints, fabric, and plastics.

In 1997, the U.S. EPA promulgated a new 8-hour ozone ambient air quality standard (U.S. EPA, 1997). On April 15, 2004, U.S. EPA designated nonattainment areas for the new 8-hour ozone standard effective June 15, 2004 (U.S. EPA, 2004a, 2004b). In California, many of these areas are already designated nonattainment for the federal 1-hour standard. New nonattainment areas include a number of rural Sierra foothill counties and additional parts of the Sacramento Valley. This action starts the transition from the 1-hour standard to the 8-hour standard. The federal 1-hour standard was revoked in June 2005.

SIPs showing how each area will meet the federal 8-hour standard are due by 2007. In order to maintain progress towards clean air, the Clean Air Act prohibits backsliding on the control program. Since the federal 8-hour standard is more health-protective than the federal 1-hour standard, ARB expects that California will need to reduce emissions beyond the existing 1-hour SIP targets. All major urban areas in California continue to violate the federal and State ozone standards, and need additional emission reductions in ozone precursors – such as VOCs – to attain these health-based standards.

2. Fine Particulate Matter

PM is prevalent in the urban atmosphere (see, for example, Pandis *et al.*, 1992), and ambient PM, especially PM_{2.5} is known to have negative impacts on human health (Schwartz *et al.*, 1996; Moolgavkar and Leubeck, 1996). Like ozone, PM can be formed via atmospheric oxidation of organic compounds (Finlayson-Pitts and Pitts, 2000). According to the results from several recent studies, photochemically derived PM (i.e. secondary organic aerosol) could contribute up to 80 percent of the fine particle burden observed in severe air pollution episodes (Pandis *et al.*, 1992; Turpin and Huntzicker, 1991, 1995). In urban PM, these secondary organic aerosols (SOA) could produce effects such as visibility degradation and toxicity (see, for example Atkinson and Arey, 1994).

The relative contribution of primary versus secondary PM also varies by region and by season. While only limited information is available on how much of the measured PM_{2.5} organic carbon component is SOAs, available studies suggest that in the South Coast on an annual average basis, SOAs may constitute six to 16 percent of PM_{2.5}. In urban areas of the San Joaquin Valley during the winter, SOAs may contribute up to an average of eight percent of PM_{2.5} (ARB 2005c).

Significant advances have been made in the theoretical and the experimental studies of the formation of SOAs (Pankow, 1994a, 1994b; Odum *et al.*, 1996; Seinfeld and Pandis, 1998; Harner and Bidleman, 1998; Kleindienst, *et al.*, 1999; Yu *et al.*, 1999). In addition, modeling techniques to determine the amount of ozone, as well as the amount of aerosol formed from a VOC have been established (Bowman *et al.*, 1995), and the concept similar to maximum incremental reactivity is being applied to quantitatively assess the aerosol formation potential of a VOC (i.e. incremental aerosol reactivity) (Griffin *et al.*, 1999). Based on the results of these studies, we now know that there is a mechanistic linkage between the ozone formation and SOA formation of a VOC.

Although most organic compounds contribute to ozone formation (Carter, 2000), SOA is usually formed from photooxidation of organic compounds with carbon numbers equal to seven or more (Grosjean and Seinfeld, 1989; Wang *et al.*, 1992). This observation is consistent with the fact that both reactivity and a product's volatility need to be considered for evaluating the aerosol formation potential of a VOC (Odum *et al.*, 1997). It has also been shown that aromatic compounds are more likely to participate in the formation of SOA than are alkenes (Grosjean, 1992; Pandis *et al.*, 1992). Only chemicals which react fast enough in the atmosphere will generate sufficient amounts of low volatility products for forming aerosols.

The federal and State ambient air quality standards for ozone and PM are shown in Table V-1.

Pollutant	Averaging Time	State Standard	National Standard
Ozone	1 hour	0.09 ppm (180 µg/m ³)	-----
	8 hour	0.070 ppm (137 µg/m ³)	0.08 ppm (157 µg/m ³)
PM ₁₀	24 hour Annual Annual Arithmetic Mean	50 µg/m ³ 20 µg/m ³	150 µg/m ³ 50 µg/m ³
PM _{2.5}	24 hour Annual Annual Arithmetic Mean	----- 12 µg/m ³	65 µg/m ³ 15 µg/m ³

The U.S. EPA adopted standards for PM_{2.5} in addition to the PM₁₀ standards (U.S. EPA, 1997). PM_{2.5} consists of directly emitted particulate matter, and secondary particulate matter such as nitrates, sulfates and condensables that are formed in the atmosphere from precursors such as NO_x, ammonia, SO_x and complex hydrocarbons. Because PM_{2.5} is a subset of PM₁₀, these precursors contribute to PM₁₀ pollution as well. In 2002, California established an annual average PM_{2.5} standard of 12 µg/m³, which is more health-protective than the federal standard (15 µg/m³).

U.S. EPA set a February 15, 2004 deadline for states to provide their PM_{2.5} nonattainment designation recommendations based on ambient monitoring data from 2000 through 2002. ARB submitted the data and recommendations on February 11, 2004. (ARB 2004) U.S. EPA finalized the PM_{2.5} designations in January 2005. Nonattainment areas for the federal PM_{2.5} standard include the South Coast Air Basin and the San Joaquin Valley Air Basin. The PM_{2.5} SIPs are due by April 2008.

The vast majority of California's population who live in urban areas breathe unhealthy air. Figures V-2, V-3, and V-4 show that unhealthy levels of ozone, PM₁₀, and PM_{2.5} respectively, are not limited to urban areas, but can be found in nearly every county in California. As shown in these maps for 2004, 46 counties are currently designated as nonattainment (or nonattainment-transitional, which is a subcategory of nonattainment) for the State ozone standard, while 54 counties are designated as nonattainment for the State PM₁₀ standard (ARB, 2004). Over 99 percent of California's population lives in areas designated as nonattainment for the State ozone and PM₁₀ standards, a clear indication of the magnitude of the air quality problems in California. (ARB, 2005a)

The California Clean Air Act requires districts that have been designated nonattainment for the State ambient air quality standards for ozone, carbon monoxide, sulfur dioxide, or nitrogen dioxide to prepare and submit plans for attaining and maintaining the standards (see Health and Safety Code § 40910 *et seq.*). In addition, the federal Clean Air Act requires that districts designated nonattainment for the federal ambient air quality standards prepare SIPs to demonstrate attainment with the federal standards. In some of these districts, substantial additional emission reductions will be necessary if attainment is to be achieved. In developing their plans, each district determines which measures are necessary to include, as well as the specific details of each included measure.

The plans from various districts underscore the increasing role of pollution from area-wide sources, including consumer products, architectural coatings, and automotive coatings. As emissions from facilities and vehicles are reduced, the area-wide sources become a larger part of the inventory, and are included as a more significant area for potential reductions of VOC emissions. It is estimated that without additional automotive coatings regulations, the inventory for automotive coatings emissions will increase due to population growth.

Figure V-2

2004
Area Designations for State
Ambient Air Quality Standards
OZONE



Figure V-3

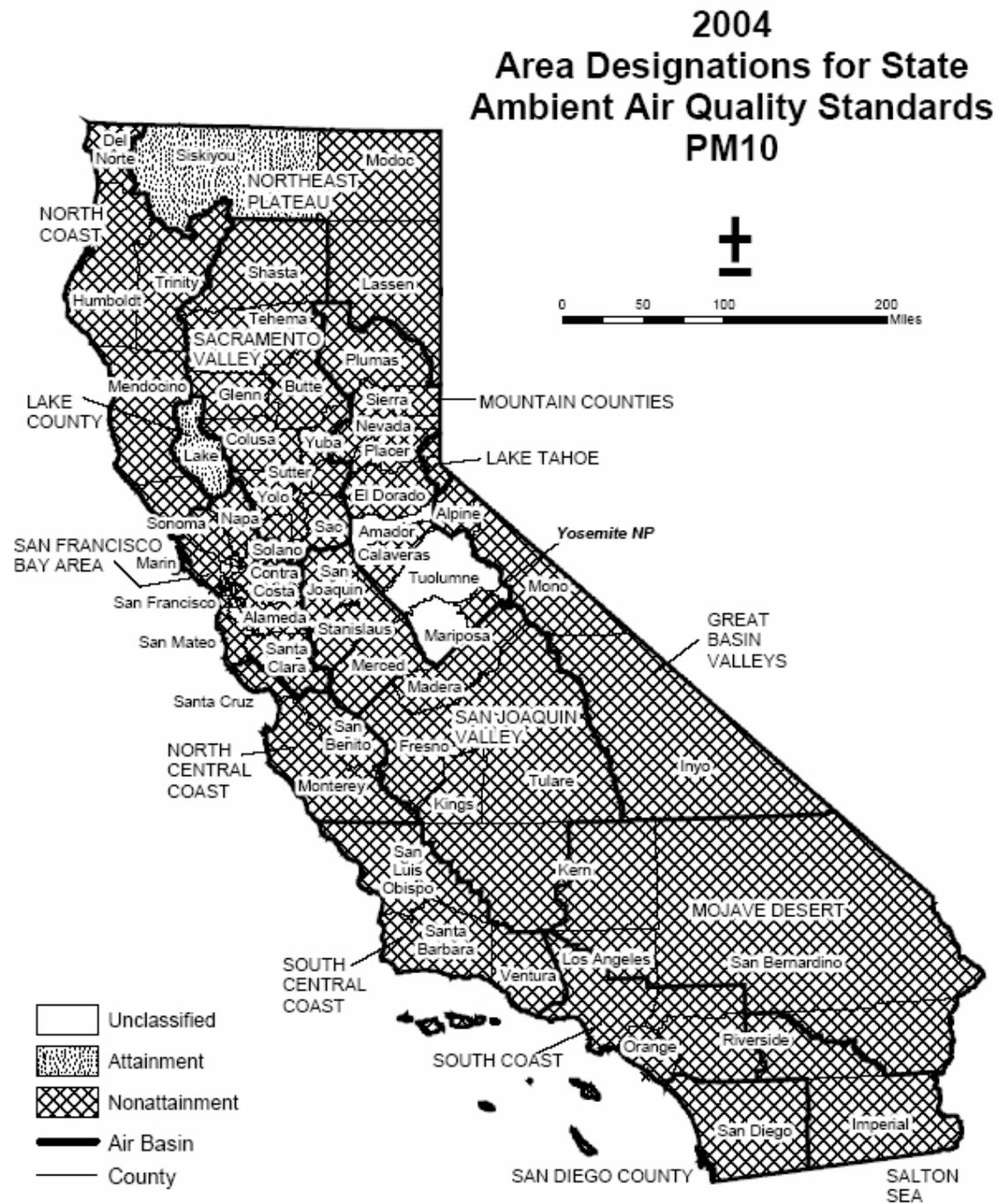
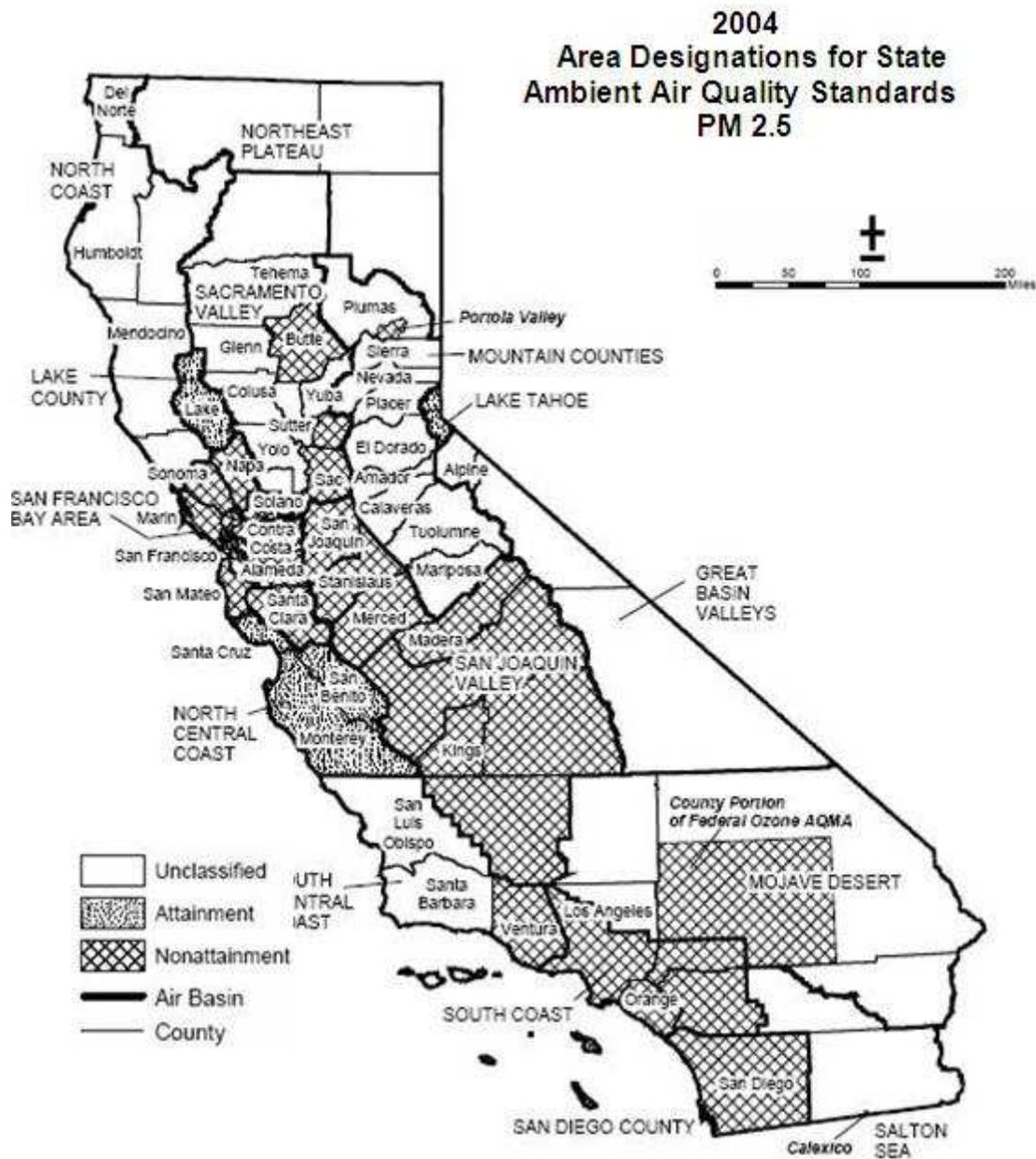


Figure V-4



B. ESTIMATED EMISSIONS FROM AUTOMOTIVE COATINGS

Emissions from automotive coatings are estimated from the survey of automotive coatings that the ARB conducted in 2002. In June 2002, the ARB mailed survey questionnaires to companies that potentially sold automotive coatings products in California in 2001. A total of 17 companies submitted data. The survey collected data on the VOC contents of products, which were then used to estimate VOC emissions from automotive coatings. Estimated emissions from automotive coatings were 7,631 tons per year or approximately 20.7 tpd in 2001, based on the survey data. These quantities do not include emissions from solvents used for surface preparation and cleanup because the 2002 Survey did not collect this data. Table V-2 summarizes key findings from the 2002 Survey data.

The survey also collected information on speciation of VOCs. The quantity of VOC ingredients reported in the survey is close to the quantity of VOC emissions calculated using sales and VOC content data. This indicates a good correlation between the speciated ingredient data and the data that are used to calculate VOC emissions.

Total volume (gallons)	3,685,636
Volume of water-based/solvent-based coatings (percent)	1/99
Estimated emissions (tpd)	20.7
Volume per capita (gallons)	0.11
Emissions per capita (pounds)	0.44

Total VOC emissions from stationary sources (including area-wide sources) in California were estimated to be about 1,336 tpd in 2001. VOC emissions from automotive coatings are estimated to be about 20.7 tpd based on ARB 2002 Survey data (ARB, 2005b). This represents about two percent of the VOC emissions from stationary sources.

Table V-3 presents the estimated emissions and emission reductions by category based on the coating information provided in the 2002 Survey. The emissions estimate accounts for the total volume of products sold. Because the 2002 Survey did not collect data on solvent usage for surface preparation and cleanup, we are unable to quantify the emission reduction from the 25 g/l VOC limit for solvents. However, the emission reduction from the 25 g/l VOC limit has already been accounted for in the SCAQMD under Rule 1171. Although not quantified, extending the 25 g/l VOC limit for solvents statewide would achieve emission reductions outside of the SCAQMD.

Table V-3 - Estimated Emissions and Emission Reductions from Automotive Coatings			
	Estimated Emission Baseline (tpd)	Estimated Emission Reductions (tpd)	Percent Reduction
Adhesion Promoter	0.03	0.02	78
Clear Coating	2.70	1.61	60
Color Coating	12.85	8.78	68
Multi-color Coating	0.00	0.00	0
Pretreatment Coating	0.36	0.21	59
Primer	1.78	1.01	56
Single-stage Coating	2.87	1.68	58
Temporary Protective Coating	<0.01	<0.01	43
Truck Bed Liner Coating	<0.01	<0.01	0
Underbody Coating	0.01	<0.01	53
Uniform Finish Coating	0.08	0.05	63
Any Other Coating Type	0.00	0.00	0
Total	20.7	13.4	65

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