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VOLATILE ORGANIC COMPOUND EMISSION CONTROLS
FOR THE AUTOMOBILE REFINISHING INDUSTRY

by

PEDCo Environmental, Inc.
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Arlington, Texas 76012

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Project Officer
Eileen Glenn

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SUMMARY

This report presents an evaluation of the prospect of controlling VOC emissions from automobile refinishing shops. An industry estimate indicates that the Philadelphia area has approximately 2000 such refinishing shops, and these sources are believed to emit a total of about 2000 tons of volatile organic compounds (VOC) per year. A survey of different yellow pages in the AQCR, however, indicated only 744 automobile refinishers.

Exceptionally large automobile refinishing shops may emit 10 to 20 tons of VOC per year. Although most automobile refinishing is done in conjunction with body repair work that involves repainting only part of a car, body repair shops also routinely repaint entire automobiles; in fact, several nationwide chains specialize in this service.

Surface preparation and painting are both sources of VOC emissions. The former includes first washing and/or steam cleaning the car, followed by sanding, solvent cleaning, and applying a primer. Solvent cleaning entails hand-wiping the surface. The primer and paint are applied with hand-held, compressed-air, spray guns.

Total VOC emissions from painting an entire automobile average about 12.2 pounds. During the busiest season, a large custom shop will paint about 30 cars per week, and this type of shop emits an estimated 6.3 tons of VOC per year. The rate of VOC emissions from establishments that specialize in body repair work is much lower. A large shop that specializes in low-cost painting can paint up to 20 cars per day, and the estimated VOC emission rate for this type of shop is 14 tons per year.

The use of incineration, catalytic incineration, and carbon adsorption control systems is not practical for automobile refinishing shops. The paints, paint thinners, and primers used in these shops contain xylene, toluene, and petroleum distillate, and OSHA regulations limit the concentrations of these VOCs in ambient air to 100 ppm. The control device would require

large volumes of dilution air, and the cost of heating this large air volume rules out incineration on economic grounds. Inasmuch as paint solids render catalytic incineration ineffective, this control is automatically eliminated. Carbon adsorption is impractical because of the diversity of VOC species in the process exhaust. An additional problem is that most VOC emissions occur during or shortly after application of the finish, and any control device would have to be sized to handle this maximum emission rate. For this reason, the control device would be operating far below its rated capacity most of the time and thus be greatly underutilized.

The reduction of VOC emissions through the use of water-based coatings or coatings with a higher solids content and the possibility of more efficient application techniques were examined. Water-based coatings and those with higher solids content apparently do not produce a finish equivalent to that of a new car. One nationwide chain has evaluated and is continuing to evaluate these possibilities with an eye toward reducing material costs.

There is no proposed draft regulation at this time, but the Philadelphia Air Quality Control Region should continue to monitor progress in the areas of improved transfer efficiency and new product development to determine if and when new regulations might become feasible.

1. INTRODUCTION

Over the past several years EPA's Office of Air Quality Planning and Standards (OAQPS) has developed a series of Control Techniques Guidelines (CTGs) for volatile organic compounds (VOC) to assist state and local agencies in the development of regulations for VOC control. Although these CTGs cover major VOC source categories from an overall nationwide perspective, several VOC source categories that are not covered by CTG documents are major contributors to the ozone problem within given areas.

Air pollution control agencies in the Philadelphia Air Quality Control Region (AQCR) have requested guidance in determining whether VOC controls are available for non-CTG sources. These agencies desire information that may assist them in developing appropriate regulations. One such VOC source category to be investigated is automobile refinishing. An industry estimate indicates that there are 2000 automobile refinishers in the Philadelphia area (M. Martino, Maaco Enterprises, Inc., personal communication, February 8, 1983); however, a survey of the Philadelphia, Camden, New Jersey, and Wilmington, Delaware, yellow pages indicated 451, 193, and 99 automobile refinishers, respectively, for a total of 744 automobile refinishers in the Philadelphia area.

1.1 SOURCE DESCRIPTION AND TYPES OF VOC EMISSIONS

Most automobile refinishing is done in conjunction with body repair work, which usually involves refinishing only part of the car and carefully matching the color of the new paint with that of the existing paint. Several nationwide chains, however, specialize in repainting entire automobiles.

Surface preparation prior to painting begins with washing or steam-cleaning the automobile. Except for the lowest-priced automobile painting jobs, additional surface preparation may include light sanding and hand-wiping with solvent to remove oil, wax, and grease. About one quart of solvent is used to clean a typical car. The next step in the process is to mask off the parts of the car that are not to be painted. Primer is then applied to the areas to be refinished with a hand-held, compressed-air, spray gun. One to two quarts of primer will cover an entire automobile.

Painting the car requires about one gallon of paint, which may be acrylic lacquer, acrylic enamel, alkyd enamel, or polyurethane enamel. Each gallon of acrylic lacquer requires 5 to 7 quarts of thinner; acrylic enamel, 2 quarts; alkyd enamel, 1 to 2 quarts; and polyurethane enamel, up to 1 quart (J. Hill, Hill's Paint and Body Shop, personal communication, April 15, 1983). A gloss hardener is sometimes used on enamel to speed up drying, about one pint per gallon of paint. Because hardener is expensive, however, shops try to avoid its use. For example, hardener normally will not be used if overnight drying is convenient. Some larger shops use bake ovens to speed up drying.

Three to six coats of paint are applied with a hand-held, compressed air, spray gun. If lacquer is used, light sanding is required after each coat; consequently, lacquer finishes are very expensive. Lacquer coatings can be spot-repaired, however, which reduces the amount of repainting necessary. Laccuer also dries faster than enamel, which is advantageous when shop floor space is limited. The faster drying also makes lacquer coatings less likely to pick up dust and dirt from the shop environment during drying. For these reasons, custom shops and those that do a high-volume business often use lacquer despite its extra cost.

The VOC content of lacquers and enamels ranges between 4.5 and 5 pounds per gallon.[1] The solvents include toluene, xylene, petroleum distillate, and mixtures of aliphatic ketones, alcohols, and esters. The solvent used for cleaning is primarily a light petroleum distillate. Primer and paint thinner solvents are essentially the same as paint solvents.

The VOC emissions from painting a single automobile are estimated to be 12.2 pounds (5.55 kilograms). This estimate is based on the following usage:

1. One gallon of paint containing 4.8 pounds (2.2 kilograms) of VOC;

2. One quart of degreasing solvent containing 1.8 pounds (0.8 kilograms) of VOC (density equal to No. 1 fuel oil);

3. Two quarts of sealant containing 2.4 pounds (1.1 kilograms) of VOC (VOC content equivalent to the paint); and

4. Two quarts of thinner containing 3.3 pounds (1.5 kilograms) of VOC (density equivalent to acetone).

During the busiest season, a large custom painter will paint six cars per day or 30 cars per week. (Automobile refinishing shops typically operate just over 8 hours a day, Monday through Friday.) This corresponds to an hourly emission rate of 9 pounds (4 kilograms) or a daily emission rate of 73 pounds (33 kilograms). The estimated average annual emission rate is 6.3 tons (5.7 megagrams).

A large painting specialty shop paints a maximum of 20 cars per day. If the shop uses only paint and thinner, it will emit 8.7 pounds of VOC per car. This corresponds to a VOC emission rate of 20 pounds (9.2 kilograms) per hour or 160 pounds (73 kilograms) per day. The estimated annual VOC emission rate from these shops is 14 tons (13 megagrams).

A typical body repair shop has a much lower emission rate. The estimated emission rate for such a shop is 1 ton (0.9 megagram) per year.

2. EMISSION CONTROL TECHNIQUES

The control of VOC emissions from automotive surface coating operations is complicated by two factors: (1) most of the emissions occur during and shortly after application of the coating; and (2) the coatings contain VOCs such as toluene, xylene, and petroleum distillate and OSHA regulations limit concentrations of these compounds in ambient air to 100 ppm. Meeting the OSHA standard requires the dilution of the VOC-containing streams with large volumes of air.

2.1 ADD-ON CONTROLS

Incineration is technically feasible, but it is impractical because of the large quantity of dilution air that must be heated to around 816°C (1500°F). Catalytic incineration is impractical because solid particles from the paint accumulate on the catalyst surface and render it inactive. Carbon adsorption is not a feasible control because a huge unit would be required to control the large volumes of VOCs that are emitted at very low concentrations from the process. Also, it would be difficult (if not impossible) to strip high-boiling-solvent components from the carbon bed. Water-soluble VOC species such as acetone and isopropanol cannot be easily separated from condensate if steam is used to regenerate the carbon. Thus, extensive paint reformulation would be necessary, even if a system that is not prohibitively large could be designed. The control efficiency of a carbon adsorber would be severely limited because the exhaust stream would have a VOC content of 10 to 25 ppm compared with a 50 to 100 ppm VOC concentration in the inlet stream.

2.2 LOWER VOC CONTENT COATINGS

General Motors uses water-based coatings in its assembly lines, but a 1977 report indicates that no satisfactory water-based coatings have been developed for the automotive refinishing market.[2] Apparently, this is still the case.

Since almost all existing coatings are thinned with solvents prior to their application, the use of these coatings or modifications of these coatings with higher solids content does not appear to be promising. The goal of the automotive refinishing industry is to produce a finish with an appearance equivalent to that of a new car; anything less is unmarketable.

2.3 OTHER CONTROLS

The use of enclosed booths for automobile painting could reduce the capital costs of VOC control. Because less dilution of air would be needed, a smaller-capacity control device, such as a carbon adsorber or incinerator, could be used. Operating costs also would be lowered, but some of this savings would be offset by the capital and operating costs of the booth. Costs analyses show that add-on controls are not cost-effective, even if a favorable exact VOC dilution is assumed. The OSHA upper limit of 100 ppm would be attainable with enclosed booths, but most automobile refinishing shops emphasize body repair work and painting is only a necessary secondary activity. Enclosed booths dedicated to painting would tie up much needed floor space in body shops when space is often limited. Increasing the amount of space in such shops would mean additional operating costs as well as the costs of VOC control devices.

The automobile refinishing industry has experimented with electrostatic spray guns, but none of them have worked as well as the conventional hand-held, compressed-air spray gun (M. Martino, Maaco Enterprise, Inc., personal communication, April 20, 1983). Also, it takes 2.5 to 3 times longer to paint the car with an electrostatic spray gun.

2.4 IMPROVED TRANSFER EFFICIENCY

Transfer efficiency is defined as the percent of the coating emitted from an applicator that actually coats the surface. In the wood furniture coating industry, a typical transfer efficiency is 40 percent.[3] For the application of paints on the assembly line: electrostatic spraying had transfer efficiencies as high as 93 percent; airless non-electrostatic spraying had transfer efficiencies of 44 percent; air non-electrostatic spraying had transfer efficiencies of 37 percent, and water-borne coating application had transfer efficiencies of 30 percent (A. Rawaka, South Coast Air Quality Managment District, personal communication, October 24, 1983). No transfer efficiency estimates for automobile refinishing were available.

Paint spray guns have been developed that promise to improve transfer efficiency[4] and better transfer efficiency would reduce VOC emissions by reducing paint consumption. Maaco Enterprises, Inc., a nationwide chain of automobile painting and body repair shops, has evaluated and worked with different types of spray guns and spraying techniques with an eye toward improving transfer efficiency as a means of reducing material costs (M. Martino, Maaco Enterprises, Inc., personal communication, April 20, 1983). In their opinion, however, these new paint spray guns do not produce a finish of acceptable quality.

3. COST ANALYSIS

The cost of the material for a $500 to $750 automobile paint job is about $200 (J. Hill, Hill's Paint and Body Shop, personal communication, April 15, 1983). The remainder covers labor, overhead, and profit. About $125 of the $200 is for coating materials; the rest is for tape, sandpaper, and cleanup supplies. The material cost associated with a $79.95 budget repaint job is about $20.00 (B. Bennett, Earl Scheib, Inc., personal communication, March 23, 1983). Obviously there is considerable incentive to reduce material costs through improved transfer efficiency.

3.1 PARAMETERS FOR ADD-ON CONTROLS

Estimates for control costs represent a large custom shop capable of painting 6 cars a day or 30 cars a week. Estimated VOC emissions amount to 12.2 pounds per car, or 6.3 tons per year. Assuming that the control device would need to process 3000 scfm of VOC-laden air and the average molecular weight of the VOC equals that of toluene, this would correspond to the evaporation of 4.46 pounds per hour of VOC diluted to 100 ppm. This is equal to the evaporation of 2 quarts of solvent over a 32-minute period. To accomplish this, the shop would have to schedule operations so that only one paint, degreasing solvent, or sealant spraying operation took place at any one time.

3.2 INCINERATION

Two cases are considered. In the first case, the VOC is diluted with air to 100 ppm, incinerated at 816°C (1500°F), and the exhaust gases are vented. In the second case, the exhaust gases are used to preheat the incoming air-VOC stream. The latter would reduce fuel requirements by 54 percent, but capital costs would double.

Estimated capital costs are $45,000 for the incinerator and $90,000 for the incinerator-preheater combination. Installation costs are equal to capital costs. Capital-related annual costs are as follows: (1) a capital recovery factor of 14.67 percent of the total capital investment, based on a 12-year equipment life and a 10 percent interest rate[5]; (2) property taxes and insurance at 4 percent of total cpaital costs; and (3) operating and maintenance costs at 4.75 percent of total capital costs. Assuming that OSHA standards could be met by diluting the 12.2 pounds of VOC emitted while painting an automobile and that the average molecular weight of the VOC species is equal to that of toluene, 491,000 scf of air would be required. Heating this air to 816° (1500°F) would require 13.87 million Btu. If a credit of 25,000 Btu per pound is allowed for the 12.2 pounds of VOC, heat requirements would be 13.56 million Btu. If this heat were supplied by natural gas at a cost of $4 per million Btu (N. Houey, Department of Energy, personal communication, February 23, 1983) and the incinerator were 100 percent efficient, the fuel cost would be $55.35 per car (or $25.46 per car with the heat exchange option). It should be noted that according to AP-42,[6] the combustion of the natural gas required to control 12.2 pounds of VOC emissions would produce 2.37 pounds of nitrogen oxide emissions.[6] This would offset to some degree the reduction of VOC emissions. Incineration is estimated to have an overall efficiency (capture efficiency multiplied by the efficiency of the control device) of about 67.5 percent.

3.3 CARBON ADSORPTION

The estimated cost of a carbon adsorber is about $36,000, and installation costs would run about 50 percent of the unit cost. This makes the installed cost about $54,000. Capital-related annual costs are as follows: (1) capital recovery factor of 11.75 percent of the total capital investment, based upon a 20-year equipment life and a 10 percent interest rate; (2) property taxes and insurance at 4 percent of total capital costs; and (3) operating and maintenance costs at 4.75 percent of total capital costs. Steam requirements would be 5 pounds per pound of VOC, and the cost would be $3.50 per thousand pounds. Recovered VOC credits are estimated to be 10 cents per pound. The recovered VOC would be a hydrocarbon mixture, and some VOC would have to be recovered from a water solution; these considerations reduce VOC recovery credits.

The overall efficiency (capture efficiency multiplied by the efficiency of the control device) probably would not exceed 67 percent. The VOC-air mixture entering the adsorber would have a maximum VOC content of 100 ppm. The exit gas from a carbon adsorber in good working condition would typically contain 10 to 25 ppm VOC. If the air stream entering the adsorber were less than 100 ppm VOC, the recovery efficiency could be much less than 67 percent. This treatment assumes that carbon adsorption is technically feasible, which may not be the case.

3.4 COST-EFFECTIVENESS

Table 1 shows capital and annual costs for incineration, incineration with heat recovery, and carbon adsorption. Costs range from $2,500 per ton of VOC controlled with the carbon adsorption option to $18,600 per ton of VOC controlled with incineration. The basis for these estimates may be overly optimistic. None of these control methods is considered cost-effective.

TABLE 1. CAPITAL COSTS, ANNUAL COSTS, AND COST-EFFECTIVENESS FOR VOC CONTROL SYSTEMS (SEPTEMBER 1982 DOLLARS).

	Incineration	Incineration with heat recovery	Carbon adsorption
Capital Cost			
Installed equipment	90,000	180,000	54,000
Annual Cost			
Capital recovery factor	13,200	26,400	6,300
Operating and maintenance	4,300	8,600	2,600
Property taxes and insurance	3,600	7,200	2,200
Steam and fuel	57,200	26,300	200
Total annual cost	78,300	68,500	11,300
VOC recovery credit	0	0	800
Net Annual Cost	78,300	68,500	10,500
Tons of VOC Controlled	4.2	4.2	4.2
Cost per Ton of VOC Controlled	18,600	16,300	2,500

4. REGULATORY ANALYSIS

No draft regulation for the automobile refinishing industry is presented herein.

The California Air Resources Board has classified regulating the automobile refinishing industry as a low-priority item. That agency maintains that although statewide estimated emissions amount to 25,000 tons per year, enforcement would be nearly impossible because of the large number of small sources that would have to be policed (T. Preston, California Air Resources Board, personal communication, February 2, 1983). This same situation exists in the Philadelphia AQCR. Extensive development work is being done in the areas of improved transfer efficiency and new product development. It is recommended that the Philadelphia AQCR continue to monitor progress in these areas.

REFERENCES

1. Material Safety Data Sheets, E. I. duPont de Nemours and Company, Inc., F and F Department, Wilmington, Delaware:

    a. White Lucite Acrylic Lacquer, 5338-L, November 23, 1981.
    b. Blue Lucite M. M. Lacquer, 5366-L, June 15, 1976.
    c. White Centari Acrylic Enamel, 508-A, November 2, 1981.
    d. Blue Centari Acrylic Enamel, 45370-A, May 6, 1982.

    Properties of duPont automobile paints.

2. Booz, Allen, and Hamilton, Inc. Surface Coating in the Automotive Refinishing Industry. (Draft final report.) Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. December 30, 1977.

3. PEDCo Environmental, Inc. Volatile Organic Compound Emission Controls for the Wood Furniture Industry. Arlington, Texas. January 1983.

4. Fitz and Fitz, Inc. Sales brochure. Auburn, Washington.

5. U.S. Environmental Protection Agency. Draft Document, Control Technique Guidelines for the Control of Volatile Organic Emissions from Wood Furniture Coating. Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. April 1979.

6. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors. Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. Third Edition. AP-42, including Supplement 12 of April 1, 1981.