United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA 453/R-94-031
April 1994

Air

EPA

Alternative Control Techniques Document: Automobile Refinishing

ACT

EPA-453/R-94-031

Alternative Control Techniques Document: Automobile Refinishing

Emissions Standards Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711
April 1994

This report has been reviewed by the Emission Standards Division of the Office of Air Quality Planning and Standards, EPA, and approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-35), U.S. Environmental Protection Agency, Research Triangle Park, N.C. 27711, Technology Transfer Network (TTN) under the Clean Air Act Amendments Main Menu, Title 1, Policy and Guidance, or from National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia 22161, (800) 553-NTIS.

NOTICE

There are no planned changes to this document. However, corrections or updates sometimes become necessary. Submission of a copy of the form below will ensure you receive any supplement or change to this report that is published in the next twelve months. Comments may be sent to the same address.

TO: Emission Standards Division
MD-13
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

ATTN: Mr. Mark Morris

Please forward any supplement or change to EPA Report Number EPA/450/R-94-031, "Alternative Control Techniques Document: Automobile Refinishing" to the address below.

____
____
____
____

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

This document provides information on alternative control techniques (ACT) for volatile organic compound (VOC) emissions from automobile refinishing.

This document contains information on emissions, controls, control options, and costs that States* can use in developing rules. The document presents options only, and makes no recommendations.

---

* As used in this document, the term "State" includes State and local air pollution authorities.

2.0 INDUSTRY DESCRIPTION

This chapter describes the automobile refinish industry. Section 2.1 provides an industry overview. Section 2.2 discusses the types of coatings used in refinishing. Section 2.3 describes the process steps and materials involved in refinishing. Preparation stations are discussed in Section 2.4, spray booths in Section 2.5, spray equipment in Section 2.6, and equipment cleaning in Section 2.7.

2.1 INDUSTRY OVERVIEW

As used in this document, "automobile" refers to passenger cars, vans, motorcycles, trucks, and all other mobile equipment that is capable of being driven or drawn upon a highway, such as farm machinery and construction equipment. "Refinishing" refers to any coating applications (to the interior or exterior bodies of automobiles) that occur subsequent to those at original equipment manufacturer (OEM) assembly plants, and includes dock repair of imported automobiles and dealer repair of transit damage before the sale of an automobile.

The automobile refinish industry consists of manufacturers that produce refinish coatings, distributors or "jobbers" that distribute coatings and other equipment, and body shops that repair and refinish automobiles.

2.1.1 COATING MANUFACTURERS

In 1989, sales of automobile refinish coatings in the United States totalled slightly over $1 billion.[1] Five companies accounted for 95 percent of these sales: E.I. du Pont de Nemours & Company, Inc. (including Nason™ Automotive Finishes), PPG Industries, The Sherwin-Williams

Company, BASF Chemicals, and Akzo Coatings.[2] Approximately one dozen smaller manufacturers supply the remaining 5 percent.[3] In the last few years, however, several other large foreign manufacturers have begun to enter the U.S. market, namely, ICI Autocolor, Spies Hecker, and Herberts Standox.

The five major manufacturers also produce components such as catalysts, solvents ("thinners" or "reducers"), and additives for use with their coatings. Approximately two dozen other U.S. manufacturers produce lower-cost coating components that are marketed for use with the coatings produced by the major manufacturers.[4] However, the major manufacturers report that these lower-cost components may reduce the overall quality of their coatings and, consequently, will not honor their warranties if such components are added to their products.[5]

2.1.2 COATING DISTRIBUTORS

Distributors of refinish coatings also sell mixing components and other products used for refinishing, such as mixing stations, infrared heating lamps, sandpaper, and masking tape. Some distributors also sell equipment and products necessary to perform body repairs. Distributors provide body shops with valuable product support services such as training in new products and equipment, mixing of topcoat colors, troubleshooting advice, and general product information.

Although at least one coating manufacturer, The Sherwin-Williams Company, operates retail stores that distribute only Sherwin-Williams products,[6] the large majority of the approximately 5,000 distributorships in the United States are not owned or operated by coating manufacturers. Another 10,000 body part distributors also sell refinish products.[7] Both types of distributorships are known as paint, body supply, and equipment (PBE) specialists, and are commonly referred to as "jobbers" or "refinish jobbers."

2.1.3 BODY SHOPS

There are approximately 50,000 body shops of various sizes and technology levels in the U.S.,[8,9,10] including small-size shops, medium-size shops, shops at new car dealerships, and large "production" shops. The work performed by most small- and medium-size body shops, which comprise most of the industry, is somewhat confined to repairing and refinishing small portions of an automobile (e.g., a panel, or a "spot" on a panel). About 90 percent of refinish work performed is spot repair.[11,12] Sixty percent of new-car dealerships (approximately 13,500 facilities nationwide) reportedly operate body shops.[13] New-car dealers refinish not only new cars damaged in shipment, but also cars that are brought in by customers for repair. Other types of shops specialize in repainting entire automobiles and are often referred to as "production" shops.

Although body shops in some areas of the United States must obtain permits or licenses to operate, painters are rarely required to be licensed.[14,15] Painter training is often provided by coating manufacturers and distributors and by trade organizations, but no formal apprenticeship programs have been instituted by the industry.

In contrast, the refinish industry in several European countries is reportedly structured differently. For instance, in Germany, the refinish industry comprises large, sophisticated shops.[16] In Holland, painters are required to be trained, pass a test, and obtain a license.[17] In several European countries, painters usually participate in apprenticeship programs. These apprenticeships are not usually mandatory, but are part of the European culture.[18]

The refinish industry in the United States is a dynamic industry that has changed dramatically in the past decade.[19] The industry is shifting away from a large number of small facilities toward fewer, larger shops, primarily because of worker health and safety issues and hazardous waste management concerns.[20] It is estimated that there were approximately

125,000 shops in operation in 1976, but by 1993 the number decreased to approximately 50,000.[21]

2.2 COATING TYPES AND PREPARATION

The main categories of coatings are primers and topcoats. The primer category consists of pretreatment wash primers, primers, primer surfacers, and primer sealers. Topcoats are applied over the primer coats and provide the final color to the refinished area.

Primers and topcoats can be classified as lacquer, enamel, or urethane coatings. These coatings differ in their chemistry, durability, and VOC content. Lacquer coatings cure by solvent evaporation only. Enamel and urethane coatings cure by solvent evaporation and chemical cross-linking reactions.[22]

Lacquers and some types of enamel coatings consist mainly of pigment, resin, and solvent (thinner or reducer). The resin and pigment are collectively referred to as coating "solids" or "nonvolatiles" because they remain on the substrate to form the dry film. Solvents suspend the solids in solution and reduce the viscosity so that the coating flows into a uniform film on the substrate. The solvents evaporate, and only trace quantities remain in the film on the substrate. In addition to the coating components discussed above, urethanes and some enamel coatings use catalysts (or hardeners) to initiate the chemical cross-linking.

Urethane coatings typically have a much higher volume percent solids than lacquers and a slightly higher percentage than enamels. This is an important feature because, as mentioned above, the coating solids are the permanent part of the paint that remain on the surface as a film. The greater the solids content of a coating, the less coating required to obtain the desired film thickness.

The coatings applied by body shops differ from those applied by OEM's. OEM facilities use coatings that require temperatures up to 400 °F (204 °C) to cure the paint. This is possible because no temperature-sensitive materials have yet been installed in the automobile. Body shops, on the other hand, must use coatings that cure at low temperatures (less than 150 °F [66 °C]) to avoid damaging the automobile's upholstery, glass, wiring, or plastic components.

2.2.1 Lacquer Coatings

Lacquers were one of the first types of coatings used on automobiles. Lacquers dry faster than most enamels or urethanes and, when dry, can be buffed to remove surface imperfections. These characteristics are attractive to body shops that do not have spray booths because the rapid drying helps minimize the opportunity for dirt to be trapped in the wet coating. One disadvantage of lacquers is that time and labor must be expended in buffing (compounding) lacquer finishes to achieve full luster.[23] Another disadvantage is that lacquer finishes are not as durable as enamel and urethane finishes.

2.2.2 Enamel Coatings

Enamel coatings, either alkyd or acrylic, have long been used in the automobile refinish industry. Alkyd enamel is a chemical combination of an alcohol, an acid, and an oil. Developed in 1929, alkyd enamels are less expensive than acrylic enamels but not as durable. Some acrylic enamels require hardeners to promote curing. Both types of enamels have a natural high gloss and do not require compounding to remove surface imperfections. Some enamel coatings can be polished, if necessary, to remove trapped dirt or dust.

2.2.3 Urethane Coatings

Urethane coatings are typically formed by a reaction between a hydroxyl-containing material and a polyisocyanate hardener. Their use is growing because of their superior gloss retention and durability. They are frequently used by the more technically sophisticated body shops for complete refinish jobs, such as refinishing of fleet vehicles.[24]

Urethane coatings dry more slowly than lacquers and enamels, and spray booths may be necessary to reduce drying time and provide a clean, dust-free curing environment. The possible presence of trace amounts of residual isocyanates requires painters to use an air-supplied respirator to reduce worker exposure. Isocyanate-free hardeners are available for use in some coating systems.[25]

2.2.4 Waterborne Coatings

A waterborne coating contains more than 5 weight-percent water in its volatile fraction.[26,27] Like enamel and urethane coatings, waterborne coatings dry relatively slowly. The use of a spray booth may be necessary to prevent contamination, and infrared heating equipment may be necessary to facilitate drying.

2.2.5 Additives and Specialty Coatings

Some additives and specialty coatings are necessary for unusual performance requirements, and are used in relatively small amounts to impart or improve desirable properties. Problems such as "fish eye" defects (a surface imperfection that can occur when the old finish contains silicone) can be prevented by the use of additives. Additives and specialty coatings include adhesion promoters, uniform finish blenders, elastomeric materials for flexible plastic parts, gloss flatteners, and anti-glare/safety coatings.

2.2.6 Coating Preparation

Most coatings are mixed with additional solvents (and sometimes catalysts) prior to application to ensure proper drying time, adhesion, appearance, and color-match. Topcoats in particular must be mixed exactly according to the manufacturer's instructions because even a slight deviation may result in unacceptable finish quality.

Many shops order topcoats to match the automobile being refinished from local automotive paint distributors. Others mix their own colors using mixing stations. A mixing station typically consists of a microfiche viewer or a computer that contains the coating manufacturer's mixing instructions, a digital scale, and a mixing machine. Shops that use mixing stations typically stock only a few primary colors, from which almost any OEM color can be produced.[28] According to an industry survey, about one-half of all shops own mixing machines.[29] Almost all large volume or sophisticated shops own mixing stations, but few small shops (those employing only one or two painters) own them.[30]

Shops that mix their own coatings strive to mix as little as possible to complete a job, but always with a slight excess to ensure that enough is available to complete the job. By minimizing the excess, the shop minimizes the cost of materials and the amount and cost of hazardous coating waste disposal.

2.2.7 Coating Systems

All of the major coating manufacturers market specific brands of primer and topcoat products as "systems." All of the coatings within a particular manufacturer's coating system are compatible and, according to the manufacturers, should be used exactly according to instructions and never interchanged with coatings from other systems.[31] Problems with adhesion, durability, and recoatability are reportedly common if coating systems are not maintained.[32]

2.3 PROCESS STEPS AND MATERIALS

The procedures for refinishing automobiles vary from shop to shop; however, some basic steps are followed, whether the job is to repair a spot, panel, or entire automobile. Generally, the surface is thoroughly cleaned to ensure proper adhesion of the coating, the metal surface is primed, a topcoat is applied, and the spray equipment is cleaned.

The following subsections describe the surface preparation and coating application processes. The spray equipment cleaning process is discussed in Section 2.6.

2.3.1 Surface Preparation

The first step in the refinish process is preparing the surface. The surface is normally washed with detergent and water and allowed to dry. It is then cleaned with either solvent or a solvent-based surface preparation product (solvent wipe) to ensure removal of all remaining wax, grease, and other contaminants.

Surface preparation products generally contain solvents (toluene, xylene, and petroleum distillates) and surfactants.[33] These products are wiped off after they have effectively dissolved the wax and grease from the surface. This step is important to avoid contamination and ensure proper adhesion of the coatings, and is necessary even if the existing paint does not have to be removed or if the parts to be coated are new. Some shops use waterborne, low-VOC surface preparation products instead of solventborne products. These products are discussed in more detail in Chapter 3.0.

If an existing primer/topcoat is in good condition (no chips or cracks), the new paint can be applied directly on top of it by merely "scuff-sanding" (or roughening) the surface to promote adhesion. If the existing finish has imperfections or the part has been damaged in an accident, the old finish should be completely removed down to bare metal.

Removal of old paint is by one of three methods: (1) by sanding (best for small areas), (2) with paint removers (which typically contain solvents such as methylene chloride, methanol, and ammonia, and are most efficient for large areas and complete panels), or (3) by sand blasting (best for complete automobiles or extremely large areas).[34,35] The paint removal step is followed by a final solvent wipe.

2.3.2 Primer Application

Before any coatings are applied to bare metal, the surface should be treated with a metal conditioner to etch the surface and prevent flash rusting, which can occur from bare metal exposure to the atmosphere. Metal conditioning can be achieved using a hand-applied acidic conditioner, or by the application of a pretreatment wash ("self-etching") primer, that both etches and primes the surface. Pretreatment wash primers contain at least 0.5 percent acid by weight, and can be applied prior to the application of solventborne or waterborne coatings. If a pretreatment wash primer is not used, the conditioned surface should be primed to provide corrosion resistance and promote adhesion.[36]

The term "precoat" has been used in several State automobile refinish rules to describe a bare metal coating category. A precoat is described as a coating that is applied to bare metal prior to the application of waterborne coatings. When pretreatment wash primers cannot be used (i.e., when they are incompatible with the substrate or other coatings), primers or primer sealers can be used to prepare the surface for subsequent waterborne coatings; therefore, a separate "precoat" category is not necessary.

2.3.3 Primer Surfacer Application

If imperfections remain in the surface after primer application, a primer surfacer is applied. Primer surfacers build film thickness in order to create a smooth surface after sanding, and provide adhesion and corrosion resistance.

2.3.4 Primer Sealer Application

If there are no surface imperfections, some shops apply only a primer sealer to provide more corrosion resistance, promote adhesion of subsequent coatings, and enhance the uniform appearance of the topcoat. Primer sealers prevent dulling of the topcoat caused by the penetration of topcoat solvents into the primer and primer surfacer coats.

2.3.5 Topcoat Application

The topcoat system, applied after the surface is prepared and free of defects, provides the final color and appearance. Topcoats may be single-stage, two-stage, or three-stage coating systems. Each stage of a two- or three-stage system directly impacts the durability of the topcoat system, and the ability to successfully match the old paint color.

Two-stage basecoat/clearcoat systems may have either a solid color or a metallic basecoat, covered by a transparent clearcoat for protection and gloss. The basecoat is approximately one-third and the clearcoat two-thirds of the total coating used.[37,38,39] Two-stage systems are popular because of their deep, rich finish, which reportedly cannot be duplicated by a single-stage coating.

Metallic finishes contain small metal flakes, typically aluminum, which are suspended in a mixture of binders, solvent, and pigment. Light reflects off these metal flakes to produce the metallic effect. Color-matching these coatings is difficult and depends on the alignment of the metallic particles, which is influenced by the evaporation rate of the solvent. OEM's use metallic coatings on at least 50 percent of all new automobiles.[40]

Three-stage systems consist of a basecoat, midcoat, and clearcoat. The basecoat and midcoat account for about one-half of the coating volume and the clearcoat for one-half.[41,42] Three-stage refinish systems are often used to match three-stage OEM finishes.[43]

Three-stage iridescent finishes are similar to metallic finishes; they contain flakes of mica in the midcoat that reflect light to produce an iridescent, or "pearl", effect.

As OEM topcoats have become more complex, the precise matching of original colors by painters has become more difficult. Annual changes in OEM color selections add a dimension of difficulty to achieving color-match. An automobile manufacturer typically will introduce over 10 new colors in a single year.[44] New car colors are developed by coating manufacturers, who preview them with automobile manufacturing stylists. The automobile manufacturer then determines from market research which colors to use.

Once a new color has been selected, the coating manufacturers develop coatings that achieve the desired appearance and performance specifications. Trial application by the automobile manufacturer may then take a number of months before the coating is approved for line application.

The typical automobile painter, however, lacks this period of "trial application" and is expected to meet color specifications and customer satisfaction for every job, regardless of previous experience with a particular color. Although refinish coating formulations are developed for each OEM color, there is often variability in the shade color, which requires the painter to make adjustments to the formula. Because of the difficulty of matching certain colors, the painter must sometimes refinish more of the automobile rather than just the damaged portion. This, of course, increases coating usage.

2.4 PREPARATION STATIONS

Preparation of the surface for repainting and application of the primer usually are done in open areas of body shops; however, in some shops these steps are performed in preparation, or "prep", stations. Prep stations typically are ventilated and equipped with plastic curtains to control dust and coating overspray. Many shops are equipped with portable infrared heating units to facilitate drying of primers during cool and/or humid shop conditions. Figure 2-1 presents a diagram of a typical heating unit.

2.5 SPRAY BOOTHS

Spray booths are clean, well-lit, and well-ventilated enclosures for coating operations. Because of their longer drying times, enamel, water-based, and urethane coatings are best applied in a spray booth to minimize the possibility of dirt adhering to the wet coating. Air is drawn into a spray booth through filters to assure a flow of clean air past the automobile being painted. This air hastens drying and provides a safer work environment for the painter by removing solvent vapors from the booth. Filters in the discharge from the booth remove coating overspray (the portion of the coating solids that does not adhere to the surface being sprayed) from the exhaust air.

There are three types of spray booths used in the refinish industry: crossdraft, downdraft, and semi-downdraft (Figure 2-2). Traditionally, the air flow in refinish spray booths has been from one side of the booth to the other, or "crossdraft." In the crossdraft design, incoming air is pulled into the booth through filters located in the entrance door. The air travels along the length of the car and then passes through coating arrestor filters at the opposite end,

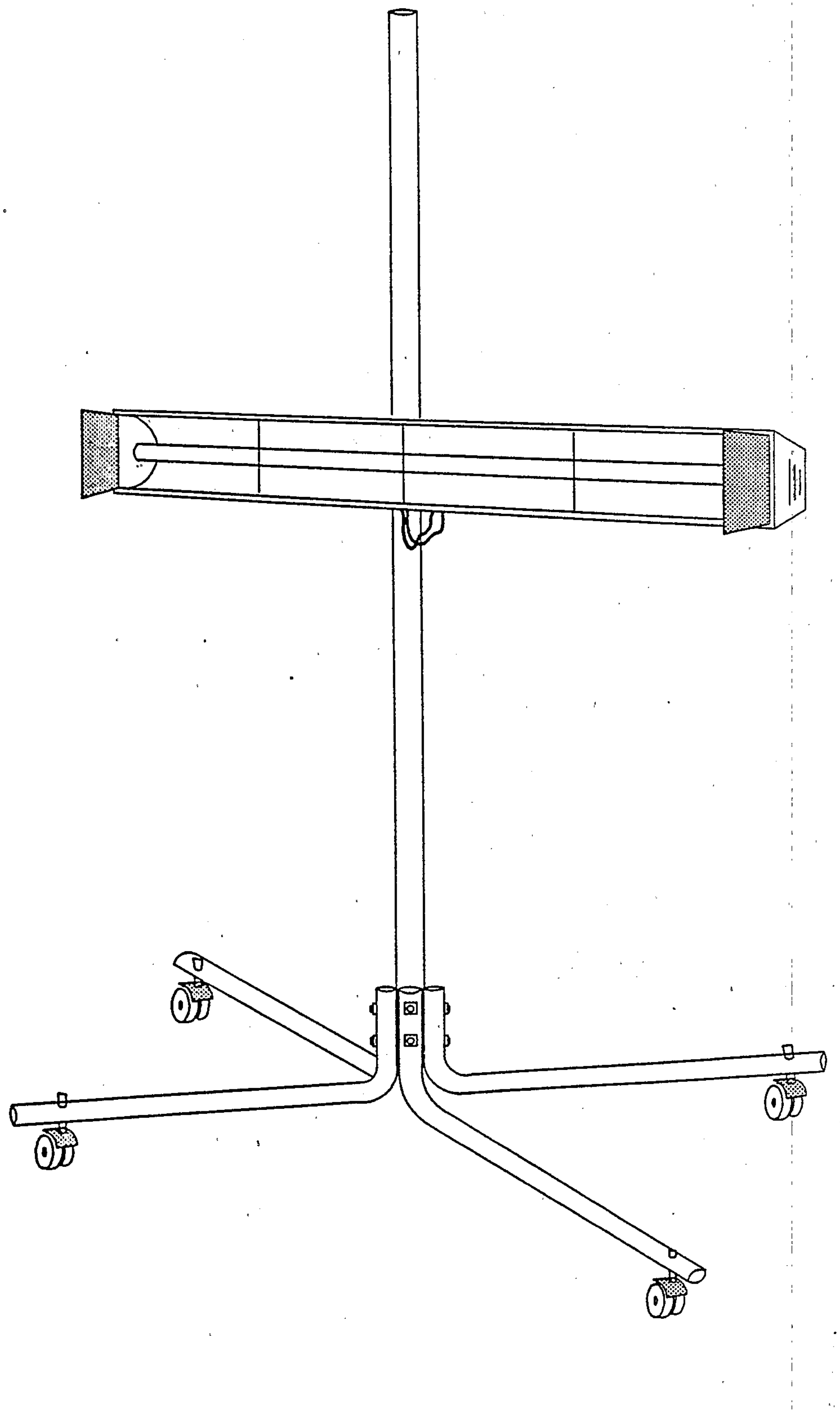
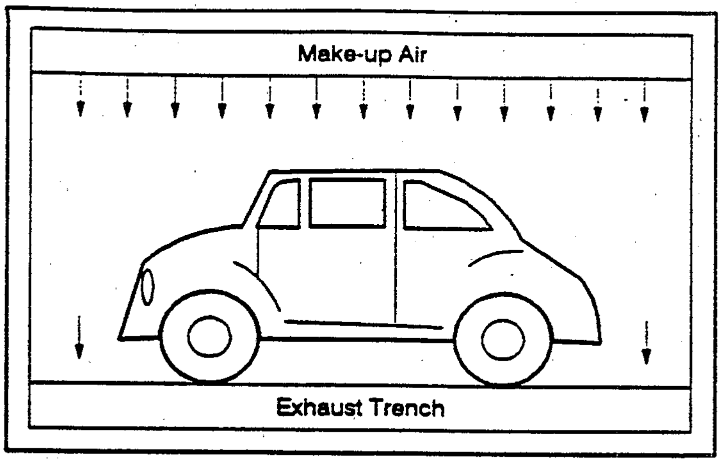
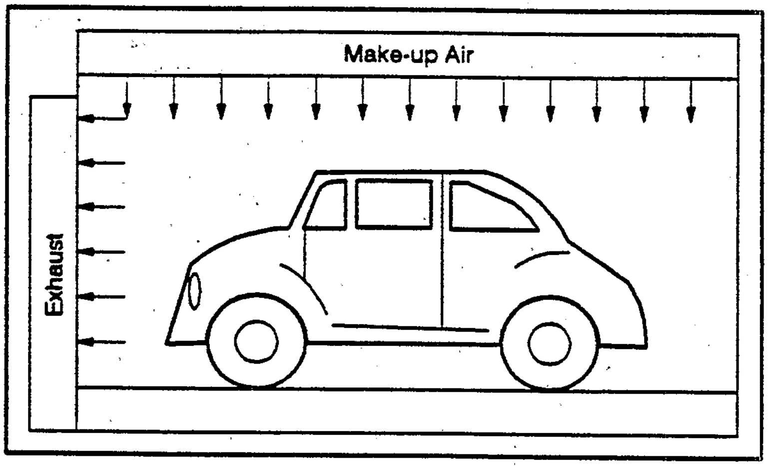


Figure 2-1. Typical Infrared Heating Unit

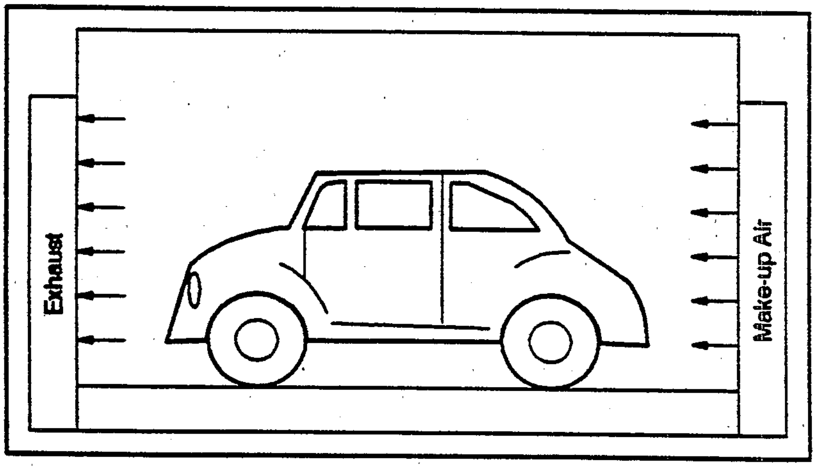
7128084RTP



Downdraft



Semi-downdraft



Crossdraft

5316238R

Figure 2-2. Spray booth make-up and exhaust air orientation where coating overspray is removed. The air then exits through an exhaust stack, carrying with it any solvent vapors or other VOC's.

Downdraft booths have a vertical air flow (top to bottom) and are considered state-of-the-art because they provide the cleanest drying/curing environment. In a downdraft booth, the air is pulled in through filters in the roof, travels down over the top of the automobile, picks up coating solvent and overspray, and passes into a grate-covered pit in the floor of the booth.

The downdraft booth is a better design than the crossdraft booth because the air is less turbulent, which helps minimize the mixing of overspray with air in the rest of the booth. In addition, air circulation is more uniformly concentrated around the automobile and solvent vapor is drawn down and away from the painter's breathing zone.

Downdraft booths can utilize dry-filtration or wet-filtration (waterwash) systems to capture coating overspray. In wet-filtration booths, water is used to capture overspray. Both types of filters only remove coating solids; they do not reduce VOC emissions to the atmosphere.

The semi-downdraft spray booth is a combination of crossdraft and downdraft booth designs. Air enters the booth through the ceiling and is discharged at the back of the booth. Air in a semi-downdraft spray booth is more turbulent than in a downdraft booth but less turbulent than in a crossdraft booth.

In order to decrease the drying time after coating application, most shops with spray booths use heated air drying systems. Smaller shops may use traveling ovens that can be rolled out for use inside the booth after the automobile has been sprayed. Small, portable, infrared heating units are also available either to warm metal surfaces prior to coating application or to speed the drying time of the repair.

Approximately 40 percent of all body shops own crossdraft booths and 30 percent own downdraft or semi-downdraft booths.[45] The portion that can heat the booth air is not known. As the refinish industry continues to move away from lacquer coatings and toward slower drying higher-solids and waterborne coatings, shops that do not already have spray booths are expected to purchase them.

2.6 SPRAY EQUIPMENT

Current practice in the refinish industry is to apply coatings with hand-held spray guns that use air pressure to atomize the coating. There are two basic types of spray gun systems: pressure-feed and suction-feed. In a pressure-feed system, the coating is contained in a "pot" that is connected by hose lines to the spray gun. Compressed air introduced to the pot pushes the liquid through the hose and out of the spray gun nozzle. Pressure-feed systems generally require significantly more coating than suction-feed because of the amount of residual coating in the pressure pot and hose lines.

In a suction-feed system, coating is contained in a "cup" mounted on the spray gun. The rapid flow of air through the air line and spray gun creates a vacuum which draws the coating from the cup and forces it through the gun nozzle.

Based on available data, it is clear that some spray equipment is likely to give better transfer efficiency than others. Simply defined, transfer efficiency is the ratio of the amount of coating solids deposited onto the surface of the coated part to the total amount of coating solids that exit the gun nozzle. Paint that is sprayed but not deposited onto the surface is referred to as "overspray." Increased transfer efficiency, or reduction of coating overspray, has a number of benefits. Because coating overspray releases the same amount of solvent as the coating that adheres to the substrate, reducing overspray reduces VOC emissions.

Less overspray also benefits the refinisher. Solvent concentration in the booth is reduced, less time is spent applying coatings (because more reaches the substrate), and solvent use for cleanup of overspray is reduced. Additionally, a shop that uses high-transfer efficiency spray equipment uses less coating, and therefore may also realize a savings in coating costs. The transfer efficiency of spray guns vary dramatically depending on a number of factors, such as the shape of the surface being coated, type of gun, velocity of the aerosol, skill and diligence of the operator, and extraneous air movement within the spray booth.

2.6.1 Conventional Air Spray Guns

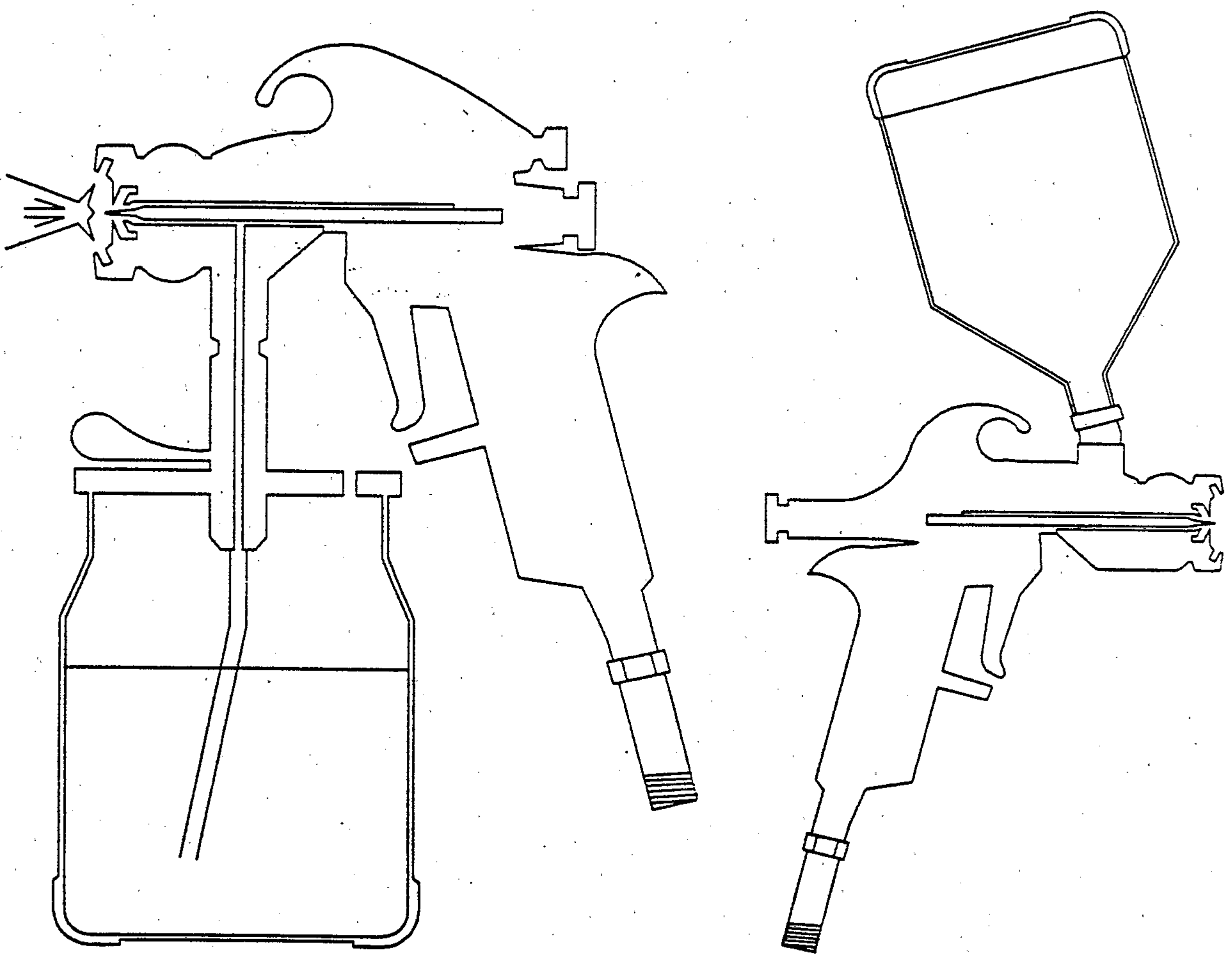
Conventional air spray guns are suction-feed and are the standard method of applying coatings. Figure 2-3 shows the two basic types of conventional spray guns: syphon-feed and gravity-feed. In syphon-feed guns the paint cup is attached below the spray gun, and the rapid flow of air through the gun creates a vacuum that siphons the coating out of the cup. Gravity-feed guns, which have the paint cup attached above the gun, require less air pressure to move the coating through the gun and provide substantially better transfer efficiency than syphon-feed guns.[46]

The air pressure at which conventional spray guns operate is usually 30 to 90 pounds per square inch (psi). One of the major problems with these guns is that the high velocity of the aerosol causes the coating particles to "bounce", which increases overspray. The transfer efficiency of conventional spray guns is substantially lower than that of "high-volume, low pressure" (HVLP) spray guns.

2.6.2 High-Volume, Low-Pressure Spray Guns

High-volume, low-pressure spray guns use large volumes of air at low pressure (10 psi or less) to atomize coatings. Because the atomized spray leaves the gun at a lower velocity than in conventional air spraying, there is less particle "bounce." As a result, higher transfer efficiency can be achieved, with overspray reportedly being reduced by 25 to 50 percent.[47]

The air source in an HVLP spray system can be a turbine or conventional compressed air. Both systems can be purchased to



Syphon-Feed

Gravity-Feed

5316239R

Figure 2-3. Conventional spray equipment handle multiple spray guns. The materials of construction of most HVLP systems are designed to be compatible with a full range of coatings. Many HVLP spray systems are designed to atomize high-, medium-, and low-solids coatings.

When first using HVLP spray equipment, the painter must adjust to the different characteristics of the spray pattern. Initially, HVLP spray guns are more difficult to use, especially for color-matching, because the greater transfer efficiency requires that the painter move the gun more quickly in order to avoid applying an excessively thick coat. Thick films can cause splotching, which occurs when solvent initially trapped in the thicker coating escapes to the surface and causes a blemish. Also, thicker films retard the evaporation rate of the solvent, which can influence the positioning of metallic flakes. In addition, the HVLP spray requires more skill to blend.[48] Once a painter becomes experienced with HVLP guns, however, these problems are overcome, with a significant cost savings because the amount of waste coatings can be reduced with no sacrifice in the quality of the refinished surface.

2.6.3 Low-Volume, Low-Pressure Spray Guns

Low-volume, low-pressure (LVLP) spray guns are quite similar to HVLP spray guns in that atomized coatings are released at lower pressure (9.5 to 10 psi) and lower velocity than conventional air spray guns. The transfer efficiency of LVLP spray guns is reportedly about the same as for HVLP spray guns. The primary difference is that LVLP guns use a substantially smaller volume of air for paint atomization (45 to 60 percent less). Consequently, energy costs for air compression are less than with HVLP guns.[49]

2.6.4 Electrostatic Spray Guns

Electrostatic spray systems create an electrical potential between the coating particles and the substrate. The charged coating particles are attracted to the substrate, thus reducing overspray and increasing transfer efficiency.

Typical electrostatic spray systems are pressure-feed. A large amount of coating is contained in the hose that connects the spray gun to the paint pot. It must be removed before the next coating can be applied with the gun. These designs appear impractical for the refinish industry, primarily because refinish facilities change coatings so often.[50] In addition, the cost of electrostatic spray systems may be prohibitive for most body shops.[51]

It has been reported that there are explosion and electrocution risks associated with use of electrostatic spray guns unless very strict operating procedures are observed.[52] Foremost, it is necessary to establish and maintain proper electrical grounding of all metallic objects in electrostatic spray areas, especially solvent and paint containers. If improperly grounded, these objects can develop high-voltage charges as they come in contact with the electrified air molecules and paint molecules. A spark near these objects may easily ignite any surrounding solvent vapors.[53] Users of electrostatic spray equipment should carefully observe all manufacturers' operating procedures.

2.7 EQUIPMENT CLEANING

Spray equipment can be cleaned manually or with any of several types of gun cleaning systems specifically designed for this purpose. About 60 percent of all body shops reportedly use some type of gun cleaning system.[54,55] Shops that do not have spray gun cleaning systems usually rinse the outside of the gun and cup, add solvent to the cup, and then spray the solvent into the air or into a drum set aside for spent solvent.[56]

An enclosed gun cleaner or washer (Figure 2-4) consists of a closed container (much like an automatic dishwasher with a door or top that can be opened and closed) fitted with cleaning connections. The spray gun is attached to a connection, and solvent is pumped through the gun and onto the exterior of the gun. The paint cup is also placed in the cleaner, where the interior and exterior are sprayed with

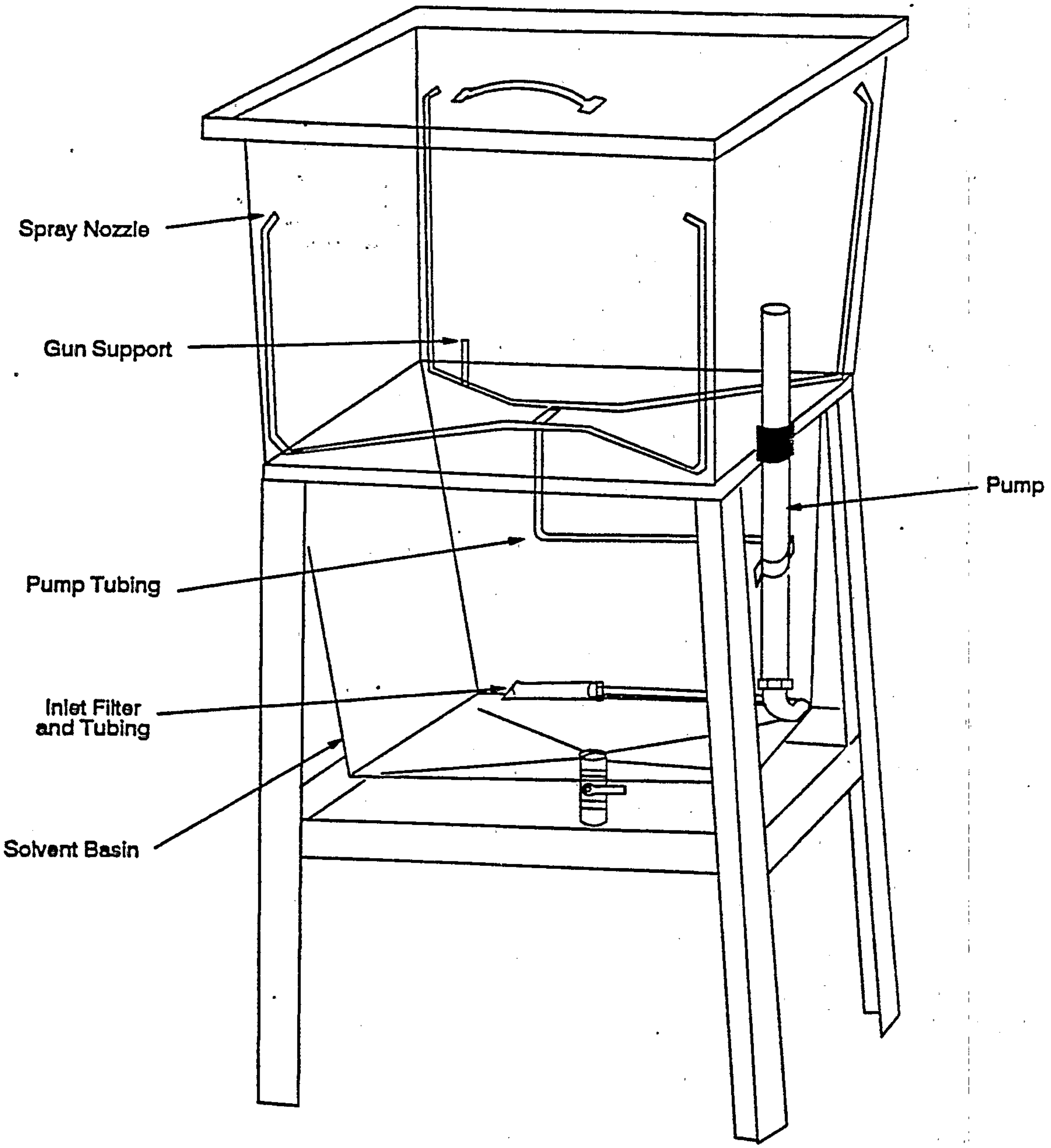


Figure 2-4. Typical enclosed gun cleaner

solvent. Many gun cleaners are capable of cleaning two guns and cups per cleaning and are typically designed to clean other equipment such as paint stirrers and strainers. Cleaning solvent falls back into the cleaner's solvent reservoir for recirculation. Solvent is recirculated until it is too contaminated for further use. Some enclosed gun cleaners are equipped with a second solvent reservoir that contains virgin solvent that is used as a final rinse.

A typical open gun cleaner, shown in Figure 2-5, consists of a basin similar to a sink in which the operator washes the outside of the gun under a solvent stream. The gun cup is filled with recirculated solvent, the gun tip is placed into a canister attached to the basin, and suction draws the solvent from the cup through the gun. The operator then removes the cup, places the gun's suction stem under the clean solvent spigot, pulls the trigger, and pumps solvent through the gun. The solvent gravitates to the bottom of the basin and drains through a small hole to a reservoir that supplies solvent to the recirculation pump. The recirculating solvent is changed when it no longer cleans satisfactorily.

Waste solvents generated by spray equipment cleaning are often disposed of by evaporation (via spraying into the air, or by placing in open drums) or incineration, or are reclaimed via distillation. Solvent can be reclaimed either at the shop or off-site. Off-site solvent reclaimers collect spent solvent from body shops, distill it, and return clean solvent to the shops. Some companies provide this service only for those shops that rent their gun cleaning systems.

In-house recycling can be as simple as letting spent solvents settle and decanting the "clean" layer for reuse. This method, gravity separation, is used where the purity of the solvent is not critical. Some on-site distillation units produce a more refined solvent, which reduces the amount of new solvent that must be purchased and eliminates disposal fees for the reclaimed solvent.

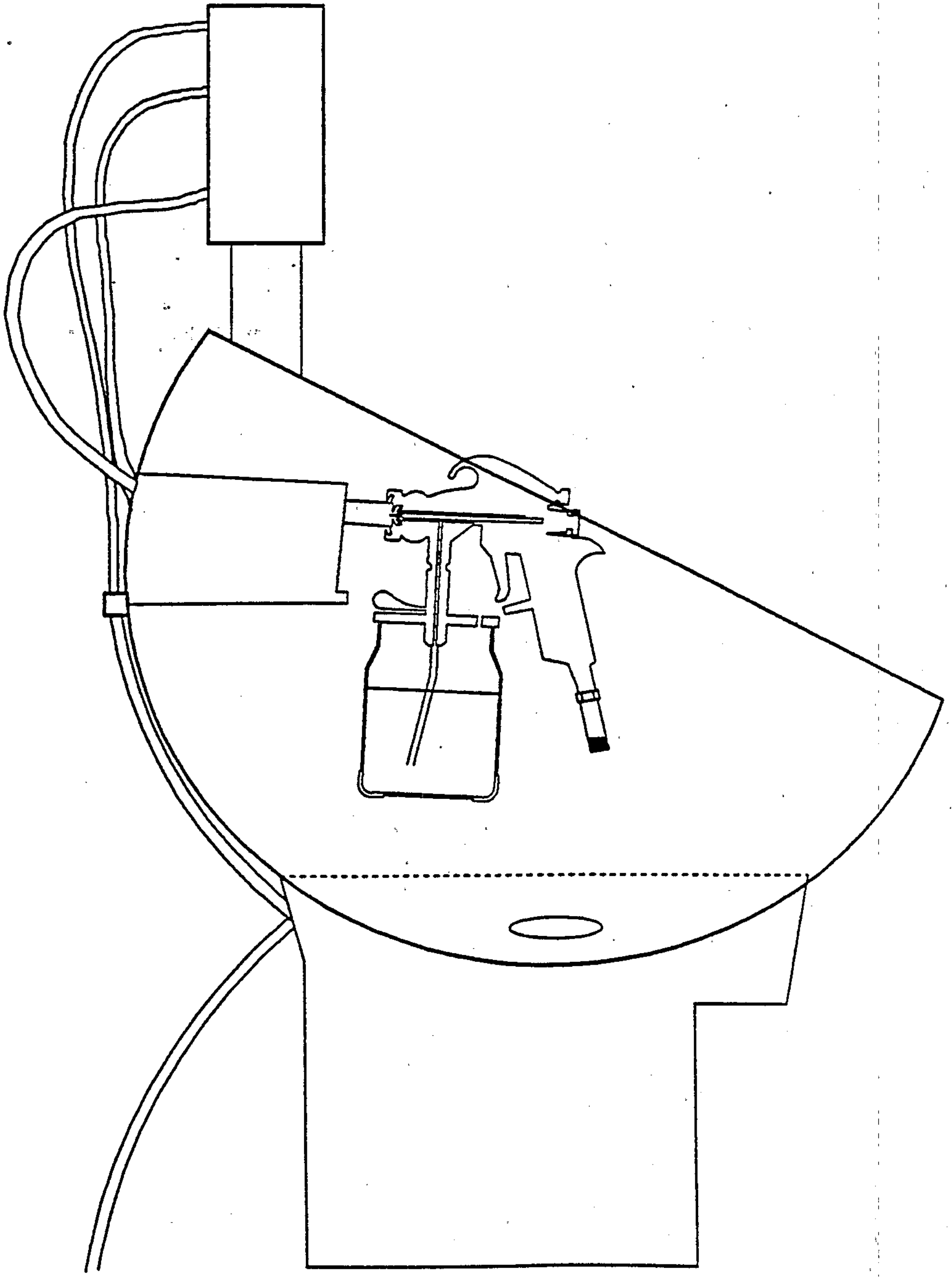


Figure 2-5. Typical open gun cleaner

5316241R

Care must be taken when a solvent reclaim unit is to be placed in use. Solvents are combustible and can also be an explosion hazard.[57] Explosion hazards are possible from the distillation residues that contain nitrocellulose. Nitrocellulose is found in lacquer paint but would not be expected in enamels and urethanes.[58] In addition, some on-site reclaimers are not explosion-proof and may pose a hazard when operated near other non-explosion-proof electrical equipment. It is recommended that reclaim equipment be operated outdoors and away from spark-producing equipment, and that the power is turned off when the machine is being emptied.[59]

The use of solvent for gun cleaning can reportedly be reduced by using teflon-lined paint cups, which makes paint removal easier. Some facilities use a small plastic liner inside the paint cup to make cleanup easier and reduce solvent use. The paint-covered plastic liner is discarded after each use and the paint cup remains essentially free of paint.

2.8 REFERENCES

1. Rauch Associates, Inc. The Rauch Guide to the U. S. Paint Industry. ISBN 0-932157-00-09. 1990. p. 85.

2. National Paint and Coatings Association, NPCA Automotive Refinish Coalition's Estimates of 1990 National Baseline VOC Emissions from the Automotive Refinish Industry. Washington, DC. March 1992.

3. Telecon. Sullivan, J., Radian Corporation, with Schultz, K. R., E. I. du Pont de Nemours & Company, Inc. April 9, 1993. Estimate of the number of refinishing coating manufacturers in the United States.

4. Ref. 3

5. Letter from Sell, J., Automotive Refinish Coalition to Jordan, B., EPA/CPB. December 2, 1991. Automotive Refinish Coalition's additional comments concerning technical and factual issues raised by the study. p. 2.

6. Ref. 1

7. Letter from Roland, D., Automotive Service Industry Association, to Ducey, E., EPA/CPB. January 22, 1993. Distributors of automotive refinishing coatings.

8. Collision Repair Industry. Repair in the 90's. Insight 1:5. February, 1991.

9. Letter from Graves, T. J., Esq., National Paints and Coatings Association, to South Coast Air Quality Management District. July 8, 1988. Automobile refinishing industry characterization and regulation.

10. Meeting Summary from Sullivan, J. W., Radian Corporation, to Schultz, K. R., E. I. Du Pont de Nemours & Company, Inc., July 29, 1992. Baseline emission estimates for the automobile refinishing industry.

11. Sell, J. Position Paper of the NPCA Automotive Refinish Coalition Concerning Draft Automobile Refinishing Control Techniques Guidelines. In: National Air Pollution Control Techniques Advisory Committee. Research Triangle Park, N.C. Office of Air Quality Planning and Standards. November 21, 1991. p. 1081.

12. Schultz, K. R., E. I. Du Pont de Nemours & Company, Inc. Comments on the Automobile Control Techniques Guideline Draft for NAPCTAC Review on 11/21/91. In: National Air Pollution Control Techniques Advisory Committee. Research

Triangle Park, NC. Office of Air Quality Planning and Standards. November 21, 1991. p.1070.

13. Letter from Randall, D. A., Automotive Service Association, to Ducey, E., EPA/CPB. June 27, 1991. Summary of Automotive Refinishing Model Shop Emission Reduction Costs.

14. Ref 13.

15. Letter from French, R., Collision Industry Conference, to Ellen, D., EPA/CPB. October 11, 1992. Body shop licensing.

16. Telecon. Shaw, I., Radian Corporation, with Sieradski, R., Akzo Coatings, Inc. October 12, 1992. European automobile refinishing industry.

17. Ref. 16.

18. Ref. 16.

19. Ref. 9.

20. Ref. 11.

21. Memorandum from Campbell, D. L., Radian Corporation, to Ducey, E., EPA/CPB. June 19, 1990. Trip report of site visits with Sherwin-Williams Sales Manager, Doug Smith.

22. PPG Refinish Manual. PPG Industries. 1989.

23. Ref. 22.

24. Memorandum from Ross A., EPA/ORD, to Ducey, E., EPA/CPB. September 17, 1991. Urethane Dispersions in Automotive Refinishing.

25. Letter from Sell, J., Automotive Refinish Coalition to Jordan, B., EPA/CPB. December 2, 1991. Automotive Refinish Coalition's Additional Comments Concerning Technical and Factual Issues Raised by the Study. p. 2.

26. Athanson, W. J. World Automotive Chemical Coatings--Solvents Glossary. D. Van Nostrand Co., New York, NY. 1989. p. 89.

27. U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Glossary for Air Pollution Control of Industrial Coating Operations. Second Edition. EPA-450/3-83-013R. Research Triangle Park, NC. December 1983. p. 23.

28. Telecon. Sullivan, J., Radian Corporation, with Smith, D., Sherwin-Williams Company. January 10, 1992. Paint mixing and recordkeeping.

29. Babcox Publications. 1993 Annual Industry Profile. June 1993. p. 51.

30. Ref. 28.

31. Ref. 11. pp. 1076, 1081, and 1082.

32. Clark, M. Common Complaints, Specific Solutions. Body Shop Business. June 1990. pp. 80-81.

33. Athey, C., C. Hester, M. McLaughlin, R.M. Neulicht, and M.B. Turner. Reduction of Volatile Organic Compound Emissions from Automobile Refinishing. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. EPA-450/3-88-009. 1988.

34. Ref. 22.

35. Telecon. Sullivan, J., Radian Corporation, with Smith, D., Sherwin-Williams Company. April 23, 1992. Coating preparation.

36. Bay Area Air Quality Management District. Staff Report on Proposed Regulation 8, Rule 45 - Motor Vehicle and Mobile Equipment Coating Operations. May 1, 1989.

37. Letter from Schultz, K., E.I. Du Pont de Nemours & Company, Inc., to Brower, G., New Jersey Department of Environmental Protection. January 24, 1989. pp. 3,4. New Jersey Refinish Rule Development Procedures.

38. Inglis, R. J. BASF Comments on Draft Automobile Control Techniques Guideline. In: National Air Pollution Control Techniques Advisory Committee. Research Triangle Park, N.C. Office of Air Quality Planning and Standards. November 21, 1991. Pp. 1012-1019.

39. Ocampo, G., Sherwin-Williams. Comments on Draft Automobile Control Techniques Guideline. In: National Air Pollution Control Techniques Advisory Committee. Research Triangle Park, NC. Office of Air Quality Planning and Standards. November 21, 1991. pp. 1045-1048.

40. Ref. 32.

41. Ref. 38.

42. Ref. 39.

43. Ref. 22.

44. Ref. 38.

45. Norton, J. 1992 Annual Industry Profile. Body Shop Business. 11:56. June 1992.

46. Memorandum from Campbell, D. L., Radian Corporation, to Ducey, E., EPA/CPB. June 20, 1990. Revised trip report--CBWD's, Inc.

47. Graco, Incorporated. Product Information. High Output HVLP Sprayers. 1990.

48. Ref. 33.

49. Telecon, Sullivan J., Radian Corporation, with Thomas, M., IWATA Paint Spray Equipment Manufacturing Company. November 26, 1992. Low-volume low-pressure spray guns.

50. Ref. 13

51. Ref. 33

52. Adams, J. New Application Methods and Techniques. Binks Manufacturing Company. Franklin Park, IL. In: SPCC '91 National Conference and Exhibition. Long Beach, CA. November 13, 1991. p. 37-56.

53. Ref. 52.

54. Telecon. Soderberg, E., Radian Corporation with Kusz, J., Safety Kleen Corporation. January 8, 1991. Gun cleaners.

55. Telecon. Campbell, D.L., Radian Corporation, with Schultz, K., E.I. Du Pont de Nemours & Company, Inc. December 12, 1990. Coating cost and industry characterization.

56. Ref. 54.

57. Gwynn, Sandra. Are Recylers Safe? Hammer and Dolly. June 1992. pp. 37 and 38.

58. Ref. 57.

59. Ref. 57.

3.0 EMISSION CONTROL TECHNIQUES

3.1 INTRODUCTION

The steps involved in automobile refinishing include surface preparation, coating application, and spray equipment cleaning. Each of these steps can be a source of VOC emissions. (Techniques for estimating these emissions are presented in Chapter 4.) This chapter discusses techniques for reducing VOC emissions from refinishing, which include:

- using low-VOC surface preparation products;
- using low-VOC ("high-solids" or waterborne) coatings;
- improving the transfer efficiency of spray equipment;
- using gun cleaning equipment that recirculates gun cleaning solvent;
- using add-on control devices;
- improving housekeeping practices and training programs; and
- reducing the number and severity of automobile collisions.

VOC emissions can be reduced by using waterborne surface preparation products, and by using coatings that are inherently low in VOC, such as urethanes. Emissions could also be reduced by reformulating conventional coatings to lower their VOC content. Improved transfer efficiency reduces VOC emissions by decreasing the amount of coating overspray. Gun cleaning equipment that controls evaporative losses also recirculates solvent for several cleanings to reduce solvent use. Add-on control devices examined for this industry are carbon adsorbers, incinerators, and biofilters.

Improved housekeeping practices include using closed containers for storing fresh and spent solvents. Training programs could focus on educating shop workers on ways to reduce solvent and coating use. Reducing the number and severity of collisions involves equipping automobiles with safety features such as anti-lock brakes and "5-mile-per-hour" bumpers.

Although beyond the scope of this study, increasing the minimum allowable structural strength of new automobile bumpers could be a pollution prevention step for this industry. The damage to sheet metal, lamps, etc., must, to some degree, reflect the effectiveness of the bumper in protecting the automobile from such damage. Less damage should translate to less coating use and reduced emissions.

Low-VOC surface preparation products are discussed in Section 3.2 and low-VOC primers and topcoats are discussed in Section 3.3. Gun cleaners are discussed in Section 3.4. Existing State regulations for automobile refinishing are presented in Section 3.5. Add-on control devices are discussed in Section 3.6. The use of improved housekeeping practices and training programs to reduce VOC emissions are discussed in Section 3.7.

3.1.2 Coating VOC Content

Before discussing techniques to reduce the VOC emissions from coating applications, it is necessary to discuss the methodology used to determine the VOC content of coatings. As explained in Chapter 2, the solids portion of a coating remains on the substrate to form the film; therefore, the VOC content of a coating ideally would be related to its volume solids. There is as yet, however, no generally accepted method for the determination of the solids content of coatings. This document continues the EPA's approach of relating the mass of VOC in a coating to the combined volumes of VOC and solids, expressed as: mass of VOC per unit volume of coating, minus volume of water and any negligibly photochemically reactive ("exempt") compounds. Unless otherwise stated, the VOC contents discussed in this document represent the amount of VOC in the coating as it is applied, that is, after the coating has been reduced or diluted by the painter prior to application.

3.2 EMISSION REDUCTIONS FROM SURFACE PREPARATION PRODUCTS

VOC emissions can be reduced during surface preparation by using products that contain less VOC than conventional products. Conventional surface preparation products average 6.4 pounds of VOC per gallon (lb VOC/gal), or 765 grams of VOC per liter (g VOC/ℓ).[1] These products consist mainly of solvent, the active ingredient for removing residual grease and wax from the surface to be painted.

The active ingredient in low-VOC surface preparation products is detergent rather than solvent. A gallon of these products contains less than 1.7 lb VOC/gal (200 g VOC/ℓ); more than a 70 percent reduction over conventional products.[2,3] The VOC contents of these products are not expressible in the same terms as coatings because they contain no solids. Low-VOC surface preparation products reportedly work as well as conventional products, but they must be allowed to remain on the surface longer before being wiped off and they require additional rubbing for thorough removal.[4,5] Conventional surface preparation products are wiped off almost immediately after being applied. Low-VOC surface preparation products are already required in several ozone nonattainment areas of the United States.

3.3 EMISSION REDUCTIONS FROM COATING APPLICATIONS

Emissions from coating applications can be reduced by: (1) applying coatings with lower VOC content, (2) using spray equipment that has a higher transfer efficiency so that less coating is wasted, and (3) abatement.

3.3.1 Low-VOC Coatings

Information on low-VOC coatings was gathered through a survey of the major manufacturers of automobile refinish coatings conducted by the EPA in March of 1990.[6] The survey revealed that all of the major manufacturers have developed coatings that contain substantially less VOC than conventional coatings. These coatings have been developed to comply with several State regulations that mandate their use.

Table 3-1 lists the various coatings used in automobile refinishing and the VOC contents of conventional coatings. This table also presents VOC limits for the various coatings, which are organized into three options.

The limits of Option 1 were derived by evaluating the availability and reported limitations of the coatings included in the survey. Coatings at these limits are currently available, and their use would not require the purchase of any additional equipment. Therefore, shops at all levels of technical sophistication should be able to use these coatings with no loss of productivity or quality.

The Option 2 limits were suggested by coating manufacturers several years ago when they anticipated that such coatings could be developed before they were required by a rule. The Option 2 primer/primer surfacer limit of 3.8 lb VOC/gal (455 g VOC/ℓ) and the 5.0 lb VOC/gal (600 g VOC/ℓ) limit for 3-stage topcoats are claimed by manufacturers to be "technology-forcing" because there are no coatings currently available at these limits. There are, however, 4.05 lb VOC/gal primer surfacers currently available. Whether coatings could be developed to meet the 3.8 and 5.0 lb VOC/gal limits before they are required by a rule is not known.

The VOC limits of Option 3 are identical to the limits determined to be Best Available Retrofit Control Technology (BARCT) by the California Air Resources Board (CARB) (effective January 1, 1992 through December 31, 1994), except for the precoat.[7] These coatings are currently available; however, their longer drying times would likely require the purchase of additional equipment (such as heating lamps) by shops in geographical areas with weather conditions less favorable than California's.

The VOC limits presented in this document are lower than the VOC contents of most refinish coatings currently used. Newer

TABLE 3-1. COATING CONTROL OPTIONS

Coating Category	VOC content (lb VOC/gal)			
	Conventional (average)	Option 1	Option 2	Option 3
Primers				
Pretreatment	5.8 - 6.5 (6.3)	6.5	6.5	6.5
Precoat	4.6 - 7.1 (5.8)	-	-	-
Primer/primer surfacer	4.6 - 7.1 (5.7)	4.6	3.8	2.8
Primer sealer	5.0 - 6.7 (6.3)	4.6	4.6	3.5
Topcoats		5.0	5.0	5.0
Single stage				
Lacquer	5.8 - 6.7 (6.3)			
Enamel	4.8 - 6.0 (5.6)			
Basecoat	5.8 - 6.7 (6.2)			
Clearcoat	4.6 - 6.7 (5.2)			
3-Stage topcoats		5.2	5.0	5.0
Specialty	7.0	7.0	7.0	7.0

technologies near commercialization hold promise of much greater reductions.

At least one manufacturer markets a solventborne 2.8 lb VOC/gal (335 g VOC/ℓ) coating which serves as both a primer surfacer and primer sealer. This coating does not take significantly longer to dry than conventional primers, and is compatible with most of the manufacturer's topcoat systems; however, it is incompatible with plastic substrates.[8]

The VOC contents of conventional pretreatment wash primers range from 5.8 to 6.5 lb VOC/gal (695 and 780 g VOC/ℓ); the average is approximately 6.3 lb VOC/gal (755 g VOC/ℓ).[9] A limit of 6.5 lb VOC/gal (780 g VOC/ℓ) is included in all options to ensure that this bare metal coating can be applied in a thin film and that it will be compatible with subsequent coatings. No emission reductions are anticipated from pretreatment wash primers, but significant reductions could not be expected since only about two percent of total automobile refinish emissions result from their application.

Precoats contain between 4.6 and 7.1 lb VOC/gal (550 and 850 g VOC/ℓ); the average is approximately 5.8 lb VOC/gal (695 g VOC/ℓ).[10] As discussed in Chapter 2, a separate category for precoats is not necessary; therefore, none of the options contain precoat categories.

Since primer sealers are sometimes used as bare metal coatings, the primer sealer limits of the options (discussed below) were used to estimate the emissions reductions from precoats. The Option 1 and 2 limit of 4.6 lb VOC/gal (550 g VOC/ℓ) would result in about a 60 percent reduction in VOC emissions from the average precoat; the Option 3 limit of 3.5 lb VOC/gal (420 g VOC/ℓ) would result in about an 80 percent reduction.

Conventional primer/primer surfacers contain between 4.6 and 7.1 lb VOC/gal (550 and 850 g VOC/ℓ); the average is approximately 5.7 lb VOC/gal (685 g VOC/ℓ).[11] The Option 1 limit of 4.6 lb VOC/gal (550 g VOC/ℓ) would result in about a 55 percent reduction in VOC emissions from conventional primer/primer surfacers; the Option 2 limit of 3.8 lb VOC/gal (455 g VOC/ℓ) would result in about a 70 percent reduction; the Option 3 limit of 2.8 lb VOC/gal (335 g VOC/ℓ) would result in about an 85 percent reduction.

Conventional primer sealers typically contain between 5.0 and 6.7 lb VOC/gal (600 and 805 g VOC/ℓ); the average is approximately 6.3 lb VOC/gal (755 g VOC/ℓ).[12] The Option 1 and 2 limit of 4.6 lb VOC/gal (550 g VOC/ℓ) would result in about a 75 percent reduction in VOC emissions from conventional primer sealers; the Option 3 limit of 3.5 lb VOC/gal (420 g VOC/ℓ) would result in about a 90 percent reduction.

As discussed in Chapter 2, topcoats are applied as a single coating, or a two-stage (basecoat/clearcoat) or three-stage (basecoat/midcoat/clearcoat) system. The following equation may be used to estimate the average VOC content of a two-stage topcoat:

$$VOC_a = \frac{VOC_{bc} + 2\ VOC_{cc}}{3}$$

where:

VOC_a = Average VOC content (lb VOC/gal)
VOC_{bc} = VOC content of basecoat (lb VOC/gal)
VOC_{cc} = VOC content of clearcoat (lb VOC/gal)

This equation is used because the basecoat is approximately one-third, and the clearcoat two-thirds, of the total film thickness of a two-stage topcoat system.

The following equation may be used to estimate the average VOC content of a three-stage system:

$$VOC_a = \frac{VOC_{bc} + VOC_{mc} + 2\ VOC_{cc}}{4}$$

where:

VOC_a = Average VOC content (lb VOC/gal)

VOC_{bc} = VOC content of basecoat (lb VOC/gal)

VOC_{mc} = VOC content of midcoat (lb VOC/gal)

VOC_{cc} = VOC content of clearcoat (lb VOC/gal)

This equation is used because the basecoat and midcoat each are approximately one-quarter, and the clearcoat one-half, of the total film thickness of a three-stage topcoat system.

The VOC contents of conventional refinish topcoats range from 4.6 to 6.7 lb VOC/gal (550 to 805 g VOC/ℓ).[13] The average VOC contents of the different topcoat types are presented in Table 3-1. The emission reductions from conventional topcoats that would result from a 5.0 lb VOC/gal (600 g VOC/ℓ) limit range from about 70 percent for lacquers to about 40 percent for all other topcoats. The 5.2 lb VOC/gal (625 g VOC/ℓ) limit for 3-stage topcoats included in Option 1 would result in about a 30 percent reduction from conventional coatings.

The use of topcoats with VOC contents below the Option 3 limits reportedly can result in inferior color-match. Coating manufacturers contend that the use of such coatings could actually increase VOC emissions because painters could be forced to refinish substantially larger portions of an automobile in order to blend the refinished area into the existing finish.

States may wish to consider different VOC limits for mobile equipment (e.g, farm machinery and construction equipment). Several States have made such a distinction in their rules. Lower VOC limits for topcoats are reportedly feasible for mobile equipment because high gloss and color-match are not as important as they are in passenger cars.

A rule containing VOC limits for coatings could be implemented and enforced at one or more points in the coating distribution chain. In California, most rules require body shops to keep records of the amount and VOC content of the coatings they use. If accurate records are kept, this is undoubtedly the most accurate. Shops maintain that such recordkeeping is burdensome and decreases their productivity. Such recordkeeping can also be burdensome to the State who would have to review records for a large number of shops.

A rule could be written such that only compliant coatings could be sold by distributors in the area affected by the rule. Recordkeeping at the shop level would be unnecessary if only compliant coatings could be purchased by shops. However, the purchase of compliant coatings by shops does not guarantee that coatings will not be diluted or reduced such that they are no longer compliant. Also, shops could purchase their coatings from distributors outside of the regulated area. Such purchases may be reduced by a statewide rule.

A rule enforced at the distributor level may decrease the burden on the State, since no shop records would be reviewed; however, the State may still need to visit shops if their rule contained shop requirements such as gun cleaners and high-transfer-efficiency spray equipment.

3.3.2 High-Transfer-Efficiency Spray Equipment

Although transfer efficiency is a simple concept, it is difficult to use for regulatory purposes because of the many factors that can affect it. As a consequence, transfer efficiency is not a quantifiable VOC control method, even though it can have a significant effect on coating usage and resulting emissions. States may choose to publicize the benefits of certain types of spray equipment (such as HVLP), or institute equipment standards that require their use.

3.3.3 New Developments in Spray Equipment

In addition to HVLP and LVLP spray equipment designed to increase transfer efficiency, several manufacturers are currently developing new types of spray equipment that may be feasible for use in automobile refinishing in the future. One manufacturer has developed a spray system that uses supercritical carbon dioxide to replace a large portion of the solvent normally required for the spray application of coatings. This system is currently infeasible for body shops because existing automobile refinish coatings have yet to be reformulated to allow application using this technology. Aside from its current technical infeasibility, its high capital cost ($50,000 to $70,000) makes it economically infeasible for most body shops. It is estimated that within 3 years such a system could be feasible for use in shops.[14]

3.4 EMISSIONS REDUCTIONS FROM EQUIPMENT CLEANING

Gun cleaning is a source of solvent emissions. As discussed in Chapter 2, spray equipment can be cleaned manually with little to no control of evaporative emissions or with gun cleaning equipment designed to reduce solvent consumption, evaporation, and worker exposure. Solvent may be emitted from gun cleaning equipment both during the actual cleaning operation (active losses) and during standby (passive losses).

As discussed in Chapter 2, most body shops already operate gun cleaners. State rules in several ozone nonattainment areas already require their use (Section 3.5). An estimated 60 percent reduction in VOC emissions is achieved by shops that switch from cleaning guns manually to a gun cleaner.

Gun cleaners are of two types, enclosed or open. According to a March, 1990, study comparing open and enclosed gun cleaners, VOC emissions from open and enclosed cleaners are about the same.[15] This report is based on comparisons of passive and active VOC losses from four models of open gun cleaners manufactured by the same company with five enclosed units manufactured by other companies. The study concluded that the bowl-shape of open cleaners causes the cleaning solvent to readily drain to the solvent reservoir, and the small diameter of the solvent drain hole and hose mitigates evaporative losses as well as the lid on enclosed systems.

In general, neither open nor enclosed gun cleaners are completely vapor-tight. For enclosed cleaners, a small amount of solvent evaporates from the cleaning basin because of an imperfect seal along the edge of the cleaner lid. One of the enclosed gun cleaner manufacturers in the above-mentioned study has since redesigned its seal to reduce VOC leakage.

Solvent emissions also occur from enclosed gun cleaners while the lid is open for insertion and removal of the spray guns. Rapid opening and closing of the lid causes significant turbulence of the air within the cleaner, which causes some displacement of the solvent-laden air from the cleaner. One manufacturer above offers an optional speed-controlled lid opener and closer designed to minimize turbulence and reduce displacement of solvent-laden air. The redesigned lid seal and speed-controlled lid have not been tested to quantify impacts on emissions.

3.5 EXISTING STATE REGULATIONS

A number of States containing ozone nonattainment areas have already adopted rules for automobile refinishing. A summary of these regulations is presented in Table 3-2. The following subsections briefly describe the regulations in these States.

3.5.1 New Jersey

The New Jersey regulation applies to the entire State, and specifies the maximum allowable VOC emissions per volume of coating. No requirements are specified regarding surface preparation or equipment cleaning operations.[16]

3.5.2 New York City

The New York City Metropolitan Area regulation applies to the five boroughs of New York City and four surrounding counties. The regulation limits the VOC content of automobile refinish coatings applied.[17]

3.5.3 Texas

In Texas, automobile refinishing is regulated under a rule covering several types of surface coating processes. The Texas regulation limits the VOC content of coatings and surface preparation products in all nonattainment areas. Body

TABLE 3-2. EXISTING REGULATIONS

Area	Surface preparation VOC limit (lb VOC/gal)	1995 coating VOC limits (lb VOC/gal)	Gun cleaner requirement
New Jersey[a]	None	Basecoat: 6.0 Clearcoat: 4.4 Others: 5.0	No
Texas[b]	1.4	Pretreatment: 6.5 Precoat: 5.5 Primers: 5.0 Primer sealer: 6.0 Topcoat: 5.0 3-stage topcoat: 5.2 Specialty coating: 7.0	Yes
New York City	None	Repair/touchup: 6.2 Overall (full job): 5.0	No
California Air Resources Board (CARB)[c,d]	1.67	Pretreatment: 3.5 Precoat: 3.5 Primer/primer surfacer: 2.1 Primer sealer: 2.8 Topcoat: 3.8 Metallic/Iridescent topcoat: 4.5 Specialty coating: 7.0	Yes

[a] Regulation applies to entire state.

[b] Regulation applies in nonattainment areas only.

[c] Most air quality management districts in California are expected to adopt rules with these requirements by January 1995.

[d] CARB recommends lower limits for mobile equipment.

shops in these areas are also required to use enclosed gun cleaners.[18]

3.5.4 California

Several California air quality districts have adopted rules for automobile refinishing, including the Bay Area, South Coast, Ventura, San Joaquin, Santa Barbara, and Mojave. Others, such as San Diego and Sacramento, have rules in development. With minor differences, these rules contain the same requirements determined to be the "best available" control technology by CARB,[19] including VOC content limits for coatings and surface preparation products, and spray gun efficiency and cleaning requirements.

3.6 ADD-ON CONTROLS

Add-on controls are used to remove VOC's from spray booth exhausts in a variety of industries. They can be grouped into two broad categories: destructive and recovery devices. The most common destructive technique is incineration. Recovery techniques adsorb, scrub, or condense solvent and other VOC's from the air.

These devices are currently economically infeasible for body shops. The annual operating cost of an incinerator is estimated to be $120,000.[20] The annual operating cost of a carbon adsorber is estimated to be $40,000.[21] These costs are prohibitive to body shops, one-quarter of which have annual sales less than $100,000.[22]

The intermittent spray booth activity in many shops also makes add-on devices very expensive on a cost per emission reduction basis. At least one manufacturer, however, is designing a lower cost incineration system specifically for the process conditions of refinish spray booths. Because of the high costs of currently available add-on control devices, they are not further discussed.

3.7 EMISSION REDUCTIONS FROM IMPROVED HOUSEKEEPING PRACTICES AND TRAINING PROGRAMS

In addition to the emission reduction techniques already described, solvent evaporation can be minimized through diligent housekeeping practices. Shops can reduce VOC emissions by storing fresh and spent solvent in closed containers that decrease vapor loss by minimizing the amount of time that solvent is exposed to the atmosphere. Coating waste can be minimized by mixing only as much coating as is needed to complete a job. Waste paint, spent solvent, and sludge from gun cleaners and in-house distillation units should also be stored in closed containers and disposed of properly by transfer to designated hazardous waste management facilities. To assist local enforcement agencies in tracking disposal and ensuring proper disposal, a manifest system should be used.

"Miscellaneous" solvent use should also be minimized. For example, some shop employees use solvent to remove coating overspray from spray booth walls. Spray booth walls can be cleaned with non-VOC products made specifically for this purpose rather than solvent. Several companies market waterborne strippable coatings designed for spray booth walls. When this coating becomes covered with overspray, it is pulled off the booth walls, and another coat is applied. This process change can almost eliminate the need to use solvent to clean booths.

Coating use (and costs) and VOC emissions can also be reduced through training programs that explain why and how solvent emissions contribute to unhealthful air, and teach good work practices. These programs could recommend the use of higher-transfer-efficiency spray equipment, inform painters of the importance of minimizing overspray, and teach methods by which color-match can be achieved without extensively diluting the coating with additional solvent. Training programs can also help painters select the correct types of coatings to use on certain substrates and in certain conditions (i.e., varying temperature or humidity) so that jobs do not have to be redone.

3.8 REFERENCES

1. Letter from Ocampo, G.P., The Sherwin-Williams Company, to Ducey, E., U.S. Environmental Protection Agency. October 30, 1990.

2. South Coast Air Quality Management District. Staff Report on Proposed Rule 1151--Motor Vehicle and Mobile Equipment Non-Assembly Line Coating Operations. June 16, 1988.

3. State of California Air Resources Board. Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Automobile Refinishing Operations. January 8, 1991.

4. Telecon. Soderberg, E., Radian Corporation, with Schultz, K., E.I. Du Pont de Nemours & Company, Inc. February 4, 1991. Low-VOC surface preparation products.

5. Telecon. Gilbert, J., Radian Corporation, with Torres, T., H Street Auto Body. August 10, 1992. Low-VOC refinishing products.

6. Memorandum from Campbell, D.L., Radian Corporation, to Ducey, E. EPA/CPB. February 28, 1991. Summary of Coating Manufacturer's Survey Responses -- Automobile Refinishing CTG.

7. Ref. 3.

8. PPG Industries. Product Bulletin No. 184. December, 1993.

9. National Paint and Coatings Association. NPCA Automotive Refinish Coalition's Estimates of 1990 National Baseline VOC Emissions from the Automotive Refinish Industry. Washington, DC. March 1992. 6 pp.

10. Ref. 9.

11. Ref. 9.

12. Ref. 9.

13. Ref. 9.

14. Telecon. Morris, M., U.S. Environmental Protection Agency, with West, T., Union Carbide. April 11, 1994. Carbon Dioxide Spray Systems.

15. ENSR Consulting and Engineering. Comparison of Solvent Emissions from Two Types of Spray Gun Cleaning Systems. Prepared for Safety-Kleen Corporation. ENSR Document No. 5831-005800. March 1990.

16. New Jersey State Department of Environmental Protection and Energy. Control and Prohibition of Air Pollution by Volatile Organic Compounds. Title 7, Chapter 27. New Jersey. State Department of Environmental Protection and Energy. January 28, 1992.

17. New York State Department of Environmental Conservation. An Evaluation of Alternatives to Reduce Emissions from Automobile Refinishing in New York, New York. New York State Department of Environmental Conservation. August 1987.

18. Texas Natural Resources Conservation Commission. Control of Air Pollution from Volatile Organic Compounds. Regulation 5, Chapter 115, Subchapter E. Austin, Texas. November 10, 1993.

19. Ref. 7.

20. U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards. OAQPS Control Cost Manual. Fourth Edition. EPA 450/3-90-006. Research Triangle Park, NC. January 1990. pp. 4-1 to 4-44.

21. Ref. 20.

22. Babcox Publications. 1993 Annual Industry Profile. p. 29. June 1993.

4.0 BASELINE EMISSIONS AND EMISSION REDUCTIONS

Volatile organic compound emissions from automobile refinishing occur during surface preparation, coating application, and spray equipment cleaning. This chapter presents estimates of the VOC emissions from each of these processes and emission reductions that can be achieved using the control techniques described in Chapter 3.

Since most of the automobile refinish rules developed by States will be in effect by early 1995, projections of 1995 emissions were used as the "baseline" from which emission reductions were measured. Considering the reductions already achieved by State rules, baseline VOC emissions were estimated for each refinish process, and are presented in Table 4-1. Table 4-2 presents estimates of the reductions achievable using the control techniques described in Chapter 3.

4.1 SURFACE PREPARATION

4.1.1 Baseline Volatile Organic Compound Emissions from Surface Preparation

Emissions from surface preparation are a function of the VOC content of the surface preparation product, the amount of product used per refinish job, and the number of refinish jobs performed. As discussed in Chapter 3, several State regulations require the use of low-VOC surface preparation products. For purposes of estimating baseline emissions it was assumed that conventional surface preparation products will continue to be used in unregulated areas; in States that have rules, it was assumed that products have the maximum VOC content permitted by the limits of the respective rules.

For each refinish job, it was assumed that approximately

TABLE 4-1. 1995 BASELINE VOLATILE ORGANIC COMPOUND EMISSIONS IN NONATTAINMENT AREAS (tons/yr)

Area	Surface preparation	Coating application	Gun cleaning	Total emissions
New Jersey	23	1,300	107	1,430
New York City	53	2,000	243	2,300
Texas	12	2,100	96	2,210
California	39	2,750	280	3,070
Remaining U. S. nonattainment areas	426	23,900	1,946	26,270
Total U. S. nonattainment areas	553	32,050	2,672	35,280

TABLE 4-2. ANNUAL EMISSION REDUCTIONS IN NONATTAINMENT AREAS (tons/yr)[a]

Area	Low-VOC surface preparation products	Option 1 coatings	Option 2 coatings	Option 3 coatings	Gun cleaners
New Jersey	17	350	390	440	67
New York City	39	320	390	460	152
Texas	0	180	250	330	0
California	0	0	0	0	0
Remaining U. S. nonattainment areas	313	9,600	10,170	10,790	1,221
Total U. S. nonattainment areas	369	10,450	11,200	12,020	1,440

[a] Baseline year = 1995.

4 oz, or 0.25 pints (0.12 ℓ), of surface preparation product are used.[1-5] Approximately 19 million refinish jobs are performed in the United States each year,[6-8] and the number of jobs performed in a particular geographical area of the United States is assumed to be a function the area's population. The number of refinish jobs performed in an area is estimated by the following equation:

$$J_a = J_{US} * (P_a / P_{US}) \qquad (4.1)$$

where:

J_a = Number of refinish jobs performed in area;

J_{US} = Number of refinish jobs performed in the United States;

P_a = Population of area; and

P_{US} = U.S. population.

Census data for 1990 were used in this document to estimate 1995 populations. The U.S. population in 1990 was approximately 248,710,000.[9] Population data for each nonattainment area were compiled from available 1990 metropolitan area statistics.

Annual surface preparation product use in an area is estimated by the following equation:

$$SP_a = J_a * (0.25/8) \qquad (4.2)$$

where:

SP_a = Area surface preparation product use (gal/yr);

J_a = Number of refinish jobs performed in area;

0.25 = Pints of surface preparation product used per job; and

8 = Pints per gallon.

As shown in Table 4-3, it is estimated that 226,000 gal/yr

TABLE 4-3. 1995 SURFACE PREPARATION PRODUCT USE, EMISSIONS, AND EMISSION REDUCTIONS IN NONATTAINMENT AREAS

Area	Baseline product use (gal/yr)	Baseline emissions (tons/yr)	Emission reductions (tons/yr)
New Jersey	7,280	23	17
New York City	16,590	53	39
Texas	17,730	12	0
California	51,320	39	0
Remaining U.S. nonattainment areas	133,030	426	313
Total U.S. nonattainment areas	225,950	553	369

of surface preparation products are used in nonattainment areas.

Baseline emissions from surface preparation were estimated by the following equation:

$$E_{sp} = SP_a * VOC_{sp} / 2,000 \qquad (4.3)$$

where:

E_{sp} = Area VOC emissions from surface preparation (lb/yr);

SP_a = Area surface preparation product use (gal/yr);

VOC_{sp} = VOC content of surface preparation product (lb VOC/gal); and

2,000 = Pounds per ton.

The above equations were used to estimate 1995 baseline VOC emissions from surface preparation in nonattainment areas of the United States. As shown in Table 4-3, emissions were estimated separately for each nonattainment area with an existing regulation, and for all unregulated nonattainment areas combined.

4.1.2 Reduction of Volatile Organic Compound from Surface Preparation Operations

The use of surface preparation products with lower VOC contents will reduce VOC emissions. Waterborne surface preparation products with VOC contents below 1.7 lb VOC/gal (204 g VOC/ℓ) are currently available. The emission reductions achieved in nonattainment areas by using these low-VOC products are presented in Table 4-3. VOC emissions are reduced by about 70 percent.

4.2 COATING APPLICATION

4.2.1 Baseline Volatile Organic Compound Emissions from Coating Applications

Estimates of 1995 VOC emissions from coating applications were based on 1988 coating usage and emission estimates provided by coating manufacturers[10,11]. The amount of coatings projected for application in nonattainment areas in 1995, and the resulting VOC emissions, are presented in Table 4-4. Application of about 12 million gallons of coatings is estimated to result in about 32,000 tons of VOC emissions. Primer coatings account for approximately 23 percent of the emissions, topcoats for approximately 74 percent, and specialty coatings for the remaining 3 percent.

Emissions from coating applications are dependent on coating usage and VOC content. The amount of coating required for a refinish job ultimately depends on the solids content of the coating. The relationship between the VOC (predominantly solvent) and solids in a solventborne coating was approximated using the following equation:

$$V_s = 1 - (VOC_c / d) \qquad (4.4)$$

where:

V_s = Volume solids content of coating (fraction);

VOC_c = Solvent (VOC) content of coating (lb solvent/gal coating); and

d = Density of solvent (lb solvent/gal solvent).

The amount of coating solids applied in the United States was estimated by the following equation:

$$C_s = C_c * V_s \qquad (4.5)$$

where:

C_s = Gallons of coating solids applied in the United States;

TABLE 4-4. 1995 VOLATILE ORGANIC COMPOUND EMISSIONS IN NONATTAINMENT AREAS FROM REFINISH COATINGS

Coating category	Coatings applied (10^3 gallons)	Emissions (tons/yr)
Primers		
Pretreatment wash primer	210	650
Precoat	60	170
Primer/primer surfacer	1,600	4,260
Primer sealer	720	2,170
Topcoats		
Single stage		
Lacquer	600	1,800
Enamel	1,980	5,240
Basecoat	1,810	5,340
Clearcoat	4,640	11,520
Specialty	260	910
Total	11,880	32,050

C_c = Gallons of coatings applied in the United States; and
V_s = Volume solids content of coating (fraction).

The amount of coating solids applied in a particular area of the United States is assumed to be a function of the population of that area, and was estimated by the following equation :

$$C_{sa} = C_s * (P_a / P_{US}) \qquad (4.6)$$

where:

C_{sa} = Gallons of solids applied in area;
C_s = Gallons of solids applied in the United States;
P_a = Population of area; and
P_{US} = U.S. population.

By rearranging equation 4.5, the amount of coating used in a particular area ("area coating use") can be estimated by dividing the amount of coating solids applied in the area by the coating VOC content that is typical or, in the case of regulated areas, required in the area. Area coating use was estimated by the following equation:

$$C_{ca} = C_{sa} / V_{sa} \qquad (4.7)$$

where:

C_{ca} = Area coating use (gal/yr);
C_{sa} = Gallons of coating solids applied in area; and
V_{sa} = Volume solids content of coating (a function of the presence and stringency of the area's applicable rule) expressed as a fraction.

The VOC emissions in an area from coating applications were estimated using the following equation:

$$E_t = (C_{ca} * VOC_c) / 2,000 \quad (4.8)$$

where:

E_t = Area coating application emissions (tons/yr);

C_{ca} = Area coating use (gal/yr);

VOC_c = VOC content of coating (lb VOC/gal); and

2,000 = Pounds per ton.

Equations 4.4 through 4.8 were used for each coating category and nonattainment area of the United States to estimate baseline VOC emissions and emission reductions.

4.2.2 Reduction of Volatile Organic Compound Emissions from Coating Applications

The use of coatings with VOC contents lower than those of conventional coatings will reduce VOC emissions. Table 4-5 presents the projected reductions from the use of coatings that meet the limits of Options 1 through 3. Option 1 reduces baseline emissions by about 10,500 tons, or 33 percent; Option 2 reduces the baseline by about 11,200 tons, or 35 percent; and Option 3 reduces the baseline by about 12,000 tons, or 38 percent.

No emission reductions are anticipated in California because by 1995 all nonattainment areas are expected to be subject to rules at least as stringent as Option 3. Reductions of about 300 to 500 tons are expected in New Jersey nonattainment areas, where the VOC limits of their existing rule are higher than those of Option 1. Similar reductions are expected in New York City, which, like New Jersey, has higher VOC limits than those of Option 1. About 200 to 300 tons of reductions are expected in nonattainment areas in Texas.

TABLE 4-5. ANNUAL EMISSION REDUCTIONS IN NONATTAINMENT AREAS FROM COATING CONTROL OPTIONS[a] (tons/yr)

Area	Baseline emissions	Option 1 emission reductions	Option 2 emission reductions	Option 3 emission reductions
New Jersey	1,300	350	390	440
New York City	2,000	320	390	460
Texas	2,100	180	250	330
California	2,750	0	0	0
Remaining U.S. nonattainment areas	23,900	9,600	10,170	11,790
Totals	32,050	10,540	11,200	12,020

[a] Baseline year = 1995.

4.3 EQUIPMENT CLEANING

4.3.1 Baseline Volatile Organic Compound Emissions from Equipment Cleaning

Emissions from cleaning spray equipment are a function of the number of refinish jobs performed and the method of cleaning. A gun is required to be cleaned approximately four times with each refinish job. Multiplying the four cleanings by the 19 million refinish jobs performed in the United States annually, it was estimated that there are 76 million cleanings annually.

Like the amount of coating used, it was also assumed that the number of gun cleanings in any area of the United States is a function of its population, estimated by the following equation:

$$N_a = N_{US} * (P_a / P_{US}) \tag{4.9}$$

where:

N_a = Number of gun cleanings in area;
N_{US} = Number of gun cleanings in the United States;
P_a = Population of area; and
P_{US} = U.S. population.

Approximately 60 percent of body shops in unregulated nonattainment areas of the United States use gun cleaners.[12,13] For areas that require gun cleaners, it was assumed that all shops are in compliance with the requirements.

4.3.1.1 Emissions from Gun Cleaners

Although gun cleaners are designed to minimize VOC emissions, VOC evaporates during cleaning ("active losses"), and, to a lesser degree, when the cleaner is not in use ("passive losses") because of brief periods of solvent exposure to the atmosphere and imperfect lid seals. Active losses are approximately 0.06 pounds per cleaning.[14] The number of cleanings performed using gun cleaners is estimated by the following equation:

$$N_{gc} = N_a * F_a \qquad (4.10)$$

where:

N_{gc} = Number of gun cleanings performed in area using gun cleaners;

N_a = Number of gun cleanings in area; and

F_a = Fraction of shops in area that use gun cleaners.

Gun cleaners are assumed to be in use about five percent of the time; therefore, passive losses occur about 8320 hours per year. Passive losses are approximately 0.004 pounds per hour.[15] The number of shops and, thus, gun cleaners, in a particular area is assumed to be a function of its population. There are approximately 50,000 body shops in the United States.[16-18] The number of gun cleaners in an area is estimated by the following equation:

$$N_{gun} = 50{,}000 * (P_a / P_{US}) * F_a \qquad (4.11)$$

where:

N_{gun} = Number of gun cleaners in area;

F_a = Fraction of shops in area that use gun cleaners;

P_a = Population of area; and

P_{US} = U.S. population.

Total emissions from gun cleaners, consisting of active and passive losses, are estimated by the following equation:

$$E_{gc} = (N_{gc} * A / 2000) + (N_{gun} * P * H / 2{,}000) \qquad (4.12)$$

where:

E_{gc} = Area emissions from gun cleaners (tons/yr);

N_{gc} = Number of gun cleanings performed in area using gun cleaners;

A = Active VOC emissions (lb/cleaning);

2,000 = Pounds per ton;

N_{gun} = Number of gun cleaners in area;

P = Passive VOC emissions (lb/hr); and

H = Hours per year the gun cleaner is not in use.

4.3.1.2 Emissions from Manual Gun Cleaning

Shops not equipped with a gun cleaner usually rinse the outside of the spray gun with solvent, fill the gun cup with solvent, and then spray the solvent through the gun into a container of spent solvent.[19] The number of manual gun cleanings performed in an area is estimated by the following equation:

$$N_{mc} = N_a * (1 - F_a) \qquad (4.13)$$

where:

N_{mc} = Number of manual cleanings performed in area;

N_a = Total number of gun cleanings performed in area; and

F_a = Fraction of shops in area that use gun cleaners.

It was assumed that approximately 10 ounces of solvent are used per manual gun cleaning, and that 80 percent of the solvent evaporates to the atmosphere. Emissions from manual gun cleaning were estimated by the following equation:

$$E_{mc} = N_{mc} * (10 / 128 / 2{,}000) * d * 0.8 \qquad (4.14)$$

where:

E_{mc} = Area emissions due to manual gun cleaning (tons/yr);

N_{mc} = Number of manual gun cleanings performed in area;

10 = Ounces per cleaning;

128 = Ounces per gallons;

2,000 = Pounds per ton;

d = Density of solvent = 7.1 lb/gal (850 g/ℓ); and

0.8 = Fraction of solvent that evaporates.

4.3.1.3 Total Gun Cleaning Emissions

The baseline VOC emissions for any area are the sum of emissions from gun cleaners and manual cleaning. (In areas that require gun cleaners, there were assumed to be no emissions from manual cleaning.) Total gun cleaning emissions were estimated by the following equation:

$$E_g = E_{gc} + E_{mc} \tag{4.15}$$

where:

E_g = Total area emissions from gun cleaning (tons/yr);

E_{gc} = Area emissions from gun cleaners (tons/yr); and

E_{mc} = Area emissions due to manual gun cleaning (tons/yr).

The above equations were used to estimate 1995 baseline VOC emissions from gun cleaning in nonattainment areas of the United States. As shown in Table 4-6, emissions were estimated separately for each nonattainment area with an existing regulation, and for all unregulated nonattainment areas combined.

4.3.2 Emission Reductions from Gun Cleaning

As shown in Table 4-6, nonattainment area gun cleaning emissions would be reduced by about 55 percent by requiring gun cleaners. None of these reductions are achieved in regulated areas; emissions in unregulated areas are reduced about 65 percent.

TABLE 4-6. 1995 GUN CLEANING EMISSIONS AND EMISSION REDUCTIONS IN NONATTAINMENT AREAS (tons/yr)

Area	Baseline gun cleaning emissions	Annual emission reductions
New Jersey	107	67
New York City	243	152
Texas	96	0
California	280	0
Remaining U.S. nonattainment areas	1,946	1,221
Total	2,672	1,440

4.4 REDUCTION OF VOLATILE ORGANIC COMPOUND EMISSIONS USING IMPROVED HOUSEKEEPING PRACTICES

The emission reductions achievable through improved housekeeping practices would vary significantly from shop to shop because of the variability in current work practices. Nonetheless, there are common-sense measures that all shops can adopt to reduce emissions. Workers should take care to minimize coatings and solvents use. Recycling or incinerating waste coatings and solvents at licensed waste disposal/treatment facilities can reduce VOC emissions. The regulating agency can require that all shops maintain a manifest of these wastes to ensure that they are delivered to a licensed facility.

4.5 REFERENCES

1. Telecon. Forrester, J., Radian Corporation with Goulding, B., Maaco Auto Painting and Bodyworks. August 14, 1992. Surface preparation product usage.

2. Telecon. Forrester, J., Radian Corporation, with Dameron, C., CBWD's Collision Repair Center. August 10, 1992. Surface preparation product usage.

3. Telecon. Forrester, J., Radian Corporation, with Barefoot, A., Northside Body Shop. August 14, 1992. Surface preparation product usage.

4. Telecon. Sullivan, J., Radian Corporation, with O'Neal, J., Tyree's Cars, Inc. August 14, 1992. Surface preparation product usage.

5. Telecon. Sullivan, J., Radian Corporation, with Haslip, G., Auto Alignment. August 14, 1992. Surface preparation product usage.

6. Meeting Summary from Sullivan, J.W., Radian Corporation, to Schultz, K.R., E.I. Du Pont de Nemours & Company, Inc. July 29, 1992. Baseline emission estimates for the automobile refinishing industry.

7. Telecon. Sullivan, J., Radian Corporation, with Hunke, M., Dawn Enterprises. July 23, 1992. Annual automobile insurance statistics.

8. Collision Repair Industry. Repair in the 90's. Insight. 1:5. February, 1991.

9. U. S. Bureau of the Census. Statistical Abstract of the United States: 1991 (11th edition). Washington, DC. 1991. p. 7.

10. National Paint and Coatings Association. NPCA Automotive Refinish Coalition's Estimates of 1990 National Baseline VOC Emissions from the Automotive Refinish Industry. Washington, DC. March 1992.

11. Letter from Inglis, R., BASF Corporation, to Sullivan, J.W., Radian Corporation. March 8, 1993. Emission estimates for the automobile refinish industry.

12. Telecon. Soderberg. E., Radian Corporation with Kusz, J., Safety-Kleen Corporation. January 8, 1991. Percent of refinishing shops that use Safety-Kleen spray gun cleaners.

13. Telecon. Campbell, D., Radian Corporation with Schultz, K., E.I. DuPont de Nemours & Company, Inc. December 12, 1990. Automobile and truck refinishing industry characterization.

14. ENSR Consulting and Engineering. Comparison of Solvent Emissions from Two Types of Spray Gun Cleaning Systems. Prepared for Safety-Kleen Corporation. Camarillo, California. p. 3-2, 3-9, 3-10.

15. Ref. 14.

16. Ref. 6.

17. Ref. 8.

18. Letter from Graves, T.J., Esq., National Paints and Coatings Association, to South Coast Air Quality Management District. July 8, 1988. Automobile refinishing industry characterization and regulation.

19. Telecon. Soderberg, E., Radian Corporation with Kusz, J., Safety-Kleen Corporation. January 8, 1991.

5.0 COST IMPACTS

This chapter discusses the methods and assumptions used to estimate the cost impacts of implementing the control techniques described in Chapter 3. Sections 5.1 and 5.2 present estimates of the costs that coating manufacturers and distributors, respectively, would incur from the implementation of the coating options. Section 5.3 discusses the costs incurred by body shops from the implementation of the coating options, and from the use of low-VOC surface preparation products and gun cleaners. Cost effectiveness of the control techniques are discussed in Section 5.4.

5.1 COSTS TO COATING MANUFACTURERS

Coating manufacturers may incur costs from the implementation of the VOC limits of the coating options due to (1) process modifications, (2) disposal of obsolete products, and (3) training. Research and development (R&D) costs associated with formulating low-VOC coatings were not considered, since these costs have generally already been forced by State regulations.

5.1.1 Process Modifications

Implementation of the coating options will require manufacturers to modify production facilities. Transition to coatings compliant with Options 1 and 2 is estimated to cost about $3 million. Most of this cost would be to modify pumping and mixing equipment to process high-solids coatings.[1] Although solventborne coatings are available that meet the primer and primer sealer VOC limits of Option 3, these limits would likely be met using waterborne coatings because of difficulties in the application of high-solids coatings, such as the difficulty in applying a thin coat of primer sealer. Modifications required to produce waterborne coatings will cost about $32 million, primarily to upgrade process equipment from carbon steel to corrosion resistant materials.[2-5]

5.1.2 Disposal Costs

Another potential cost would be the disposal of any coatings in body shop inventories that are made obsolete by the control options. There are several ways to minimize this potential cost, including a "phase-in" period to allow for the depletion of inventories, and redistribution of noncompliant coatings to unregulated attainment areas. Manufacturers were unable to quantify the costs of redistributing noncompliant coatings, but they are anticipated to be small.[6,7] Noncompliant coatings remaining when the phase-in period ends may be returnable to manufacturers, who would dispose of the coatings if another market for them could not be found.[8] Due to the phase-in period and nominal redistribution costs, it was assumed that the costs of noncompliant coating disposal and redistribution are insignificant.

5.1.3 Training Costs

Implementation of the coating options would likely require that manufacturers teach their sales representatives, technicians/trainers, district/other managers, marketing personnel, and "product specialists" (personnel who provide the interface between R&D and marketing departments) to use the new coatings. It was estimated that approximately 1,000 employees would require one day of training.[9,10] The cost for each was estimated at $425, including travel, lodging, and wages.[11] Training costs for all options are assumed to be equal.

5.1.4 Annual Costs to Coating Manufacturers

Process modification and training costs were annualized over 10 years at an interest rate of 7 percent. These costs are presented in Table 5-1.

Table 5-1. ANNUAL COSTS OF CONTROL TECHNIQUES (10^3 $)

	Option 1	Option 2	Option 3
Manufacturer costs			
Process modifications	430	430	4,560
Training	60	60	60
Distributor training costs	80	80	80
Body shop costs			
Surface preparation	780	780	780
Training	240	240	240
Heating systems	0	6,080	6,080
Gun cleaners	(1,230)[a]	(1,230)	(1,230)
Total annual costs	360	6,440	10,570

[a] Values in parentheses represent costs savings or credits.

5.2 COSTS TO DISTRIBUTORS

Coating distributors must be trained in order to provide essential services (e.g., mixing of topcoat colors, troubleshooting advice, general product information) to their customers. An estimated 1,300 distributors would have a representative attend a 1-day training seminar.[12,13] The total cost for each distributor was estimated to be $425, including travel, lodging and wages.[14,15]

The training costs for distributors were also annualized over 10 years at an interest rate of 7 percent, and are presented in Table 5-1.

5.3 COSTS TO BODY SHOPS

Costs incurred by shops may include surface preparation product costs, painter retraining, infrared heating system purchase/operation, and productivity losses. Shops would likely incur only surface preparation product costs and training costs if the VOC limits of Option 1 were implemented, while Options 2 and 3 may trigger all of the costs mentioned above.

5.3.1 Surface preparation product costs. Low-VOC surface preparation products cost about $5 more per gallon than conventional products.[16] As previously discussed, the same amount of product is reportedly needed to prepare a surface for refinishing; therefore, the incremental cost to body shops for low-VOC surface preparation products is $5 per gallon. As shown in Table 4-3, approximately 160,000 gallons of product are applied in nonattainment areas without VOC limits for surface preparation products.

As discussed in Chapter 3, low-VOC surface preparation products may require more time for thorough cleaning and removal than conventional products. Although this additional time could decrease shop productivity, it is not expected to be significant.

5.3.2 Training costs. Because compliant coatings may mix, spray, and dry differently than noncompliant coatings, painters must be retrained in these areas. It was estimated that 15,150 painters will require training. Coating manufacturers, who will provide the training, estimate that the requisite 8 hours of instruction[17,18] can be scheduled (during weekends or evenings) with no loss of shop revenue.[19,20]

Because training may require overtime, it was assumed that shops will reimburse painters with overtime wages of $12 per hour (1.5 times the normal hourly wage) and the cost of two meals ($15).[21] It was also assumed that no travel costs will be incurred; training will be made available locally.[22-24] The 8-hour course will be offered at no charge by coating manufacturers.[25-28]

5.3.3 Infrared Heating System Costs. As discussed earlier, coatings compliant with Options 2 and 3 may require supplementary heat because their drying characteristics are affected by ambient conditions. Without supplementary heating they reportedly can require up to two days to dry.[29] To minimize productivity losses, shops may purchase heating systems to use during periods of adverse ambient conditions.

Two moderate-to-large heaters were assumed to be necessary at shops. Most shops already own one heating system, so the costs presented in this document are for the purchase and operation of an additional heating system at 15,150 shops. Heating systems are estimated to cost $2,120 each, and are used on approximately 25 percent of refinish jobs.[30,31]

5.3.4 Spray Gun Cleaning Costs. Costs associated with gun cleaners include capital and maintenance costs. Gun cleaners are estimated to cost $1,000 each.[32] Annual maintenance costs include replacement parts and operating labor, and were assumed to be 4 percent of the gun cleaner capital cost.

Gun cleaners are designed to reuse cleaning solvent. Gun cleaners use about 7 ounces less solvent per cleaning than manual cleaning, resulting in substantial cost savings.

5.3.5 Potential Productivity Losses

Coatings that meet the limits of Options 2 and 3 may affect shop productivity because of their longer drying times. The following is a discussion of the potential effects on productivity of the various coatings.

Primer surfacers. Although a 3.8 lb VOC/gal primer surfacer (Option 2) is not currently available, it is not likely that the use of such a coating would affect shop productivity. The availability of a 4.05 lb VOC/gal primer surfacer implies that surfacers at this VOC level do not affect shop productivity. Further, although it may not be perfectly suitable for passenger car refinishing, the currently available 2.8 lb VOC/gal primer surfacer/sealer does not adversely affect productivity and, in fact, may increase productivity according to product literature.[33] Since a primer surfacer at the Option 2 limit is not currently available, conservative estimates of annual costs for Option 2 include the purchase of infrared heating systems.

As previously discussed, Option 3 primer surfacers are typically based on waterborne technology. Productivity losses may occur in some geographical areas if these surfacers are used. In humid, cool conditions, waterborne surfacers are reported to dry slowly, and drying times of up to two days under such conditions are reportedly common in the absence of supplementary heating.[34]

The impacts on productivity that would be caused by use of Option 3 surfacers are highly variable and impossible to quantify on a nationwide basis. For instance, a substantial number of shops would not lose any productivity because they would compensate for increased drying time by performing other work while the surfacers are drying, and by scheduling work flow through the shop differently. However, many shops cannot merely work on other refinish jobs while jobs with primer surfacer coats are drying because these shops do not have adequate floor space. Shops may need to use drying equipment, such as infrared heating systems, to reduce drying time.

Shops that use infrared heating systems to accelerate drying may still lose up to 15 minutes per job positioning the heating systems.[35] It should be noted that the use of heating systems may not totally eliminate productivity losses.

Primer sealers. No productivity losses are anticipated from the primer sealers of any option. Shop employees in the SCAQMD reported that primer sealers equivalent to Option 3 dry as quickly as conventional primer sealers.[36-42]

Topcoats. Coating manufacturers report that low-VOC topcoats do not dry significantly slower than conventional topcoats and, consequently, no productivity losses are expected from the use of low-VOC topcoats.[43] Manufacturers claim, however, that shops without spray booths that use lacquer topcoats will lose productivity when switching to compliant topcoats. The longer drying times of compliant topcoats leave the wet surface exposed to airborne contaminants. Manufacturers maintain that shops must expend more labor during polishing to remove the additional contamination.[44]

Costs for shops without spray booths that use lacquers have not been included in this document, primarily because lacquer use for automobile refinishing has steadily dropped over the last few years, a trend which would likely continue even in the absence regulatory action. In 1988 and 1993, lacquers were used on 25 percent and 14 percent of refinish jobs, respectively.[45,46] Furthermore, there is evidence that most shops without spray booths are already using conventional enamels or urethanes, which, as mentioned previously, do not dry significantly faster than low-VOC topcoats.

5.3.6 Annual Costs to Shops

The capital costs of heating systems and gun cleaners, and the costs of training were annualized over 10 years at an interest rate of 7 percent. These annualized costs, annual costs of electricity and maintenance of heating systems, annual gun cleaner maintenance costs, and annual costs of low-VOC surface preparation products are presented in Table 5-1.

5.4 COST EFFECTIVENESS

Average cost effectiveness is the cost to reduce VOC emissions by 1 ton. Average cost effectiveness values were calculated by dividing annual costs by annual emission reductions. Although surface preparation and gun cleaner costs are presented with the coating options in Table 5-1, these control techniques could be implemented separately; therefore, the cost effectiveness of these techniques are described individually.

VOC reductions from the use of low-VOC surface preparation products cost about $2100 per ton. Although there are annual capital recovery and maintenance costs associated with using gun cleaners, the savings achieved from the use of less solvent results in a credit of about $900 per ton of VOC emission reductions.

The annual costs of the coating options include costs for process modifications, manufacturer, distributor, and body shop training, and infrared heating systems (Options 2 and 3). The average cost effectiveness of Options 1 through 3 are $80, $600, and $900 per ton, respectively.

Incremental cost effectiveness is the cost to achieve the incremental emission reductions from implementing one option instead of another. The cost for the additional emission reductions achieved by Option 2 over Option 1 is about $8,000 per ton. The incremental cost effectiveness of implementing Option 3 (instead of Option 2) is about $5,000 per ton.

5.5 REFERENCES

1. Telecon. Sullivan, J. W., Radian Corporation, with Schultz, K. R., E.I. du Pont de Nemours & Company, Inc. March 16, 1993. Costs of regulation.

2. Ref. 1.

3. Meeting Summary from Sullivan, J. W., Radian Corporation, to Sell, J., National Paint and Coatings Association, et. al. January 8, 1993. National Paint and Coatings Association Automotive Refinish Coalition views on future Federal regulation.

4. Letter from Schultz, K. R., E.I. du Pont de Nemours & Company, Inc., to Sullivan, J. W., Radian Corporation. June 18, 1993. Cost estimates of plant modifications necessary to produce waterborne coatings.

5. Sullivan, J. W., Radian Corporation. September 13, 1993. Calculation of costs to manufacture waterborne primers.

6. Telecon. Burk, D. G., Radian Corporation, with Inglis, R., BASF, Inc. June 2, 1993. Effects of regulation on inventory distribution and coating waste handling and disposal cost.

7. Telecon. Burk, D. G., Radian Corporation, with Sieradzki, R., AKZO, Inc. June 3, 1993. Effects of regulation on inventory distribution and coating waste handling and disposal cost.

8. Telecon. Sullivan, J. W., Radian Corporation, with Schultz, K. R., E.I. du Pont de Nemours & Company, Inc. April 9, 1993. Impacts of regulation.

9. Meeting Summary from Sullivan, J. W., Radian Corporation, to Sell, J., National Paint and Coatings Association, et. al. Model shops and costs of Federal regulation. July 9, 1993.

10. Memorandum and attachments from Sullivan, J. W., Radian Corporation, to Radian Project File. August 31, 1993. Training and low-VOC coatings.

11. Letter from Sell, J., National Paint and Coatings Association, to Ducey, E., EPA/CPB. June 3, 1993. Costs of Federal regulation.

12. Letter from Roland, D. R., Automotive Service Industry Association, to Ducey, E., EPA/CPB. January 22, 1993. Comments on chapters 4 and 5 of draft Automobile Refinishing CTG.

13. Sullivan, J. W., Radian Corporation, September 13, 1993. Calculation of manufacturer and distributor training costs.

14. Ref. 10.

15. Ref. 11.

16. Ref. 1.

17. Ref. 10.

18. Ref. 11.

19. Ref. 10.

20. Letter from Carragher, R. J., Automotive Service Industry Association, to Ducey E., EPA/CPB. May 10, 1993. Comments on training for the automotive refinishing industry rulemaking.

21. Ref. 20.

22. Ref. 10.

23. Ref. 11.

24. Ref. 20.

25. Ref. 9.

26. Ref. 10.

27. Ref. 20.

28. Telecon. Burk, D. G., Radian Corporation, with Sieradzki, R., AKZO Coatings, Inc. March 25, 1993. Painter retraining.

29. Memorandum from Sell, J., National Paint and Coatings Association, to Sullivan, J. W., Radian Corporation. August 23, 1993. Additional background information concerning the Automotive Refinish Background Information Document.

30. Telecon. Sullivan, J. W., Radian Corporation, with Gregory, D. April 1, 1993. Edwin Trisk heating lamps.

31. Telecon. Sullivan, J. W.,Radian Corporation, with Hutchins, J. March 22, 1993. Infratech curing systems.

32. Ref. 9.

33. PPG Industries. Product Bulletin No. 184. December, 1993.

34. Ref. 29.

35. Ref. 29.

36. Sullivan, J. W., Radian Corporation. Site visit at R. B. Paint and Body Center. Sante Fe Springs, CA. prepared for Morris, M., EPA/CPB. August 25, 1993.

37. Sullivan, J. W., Radian Corporation. Site visit at One Day Paint and Body, Anaheim, CA. Prepared for Morris, M., EPA/CPB. August 25, 1993.

38. Sullivan, J. W., Radian Corporation. Site visit at Lee's Body Works. Sante Fe Springs, CA. Prepared for Morris, M., EPA/CPB. August 25, 1993.

39. Sullivan, J. W., Radian Corporation. Site visit at Maaco Auto Painting. Sante Fe Springs, CA. Prepared for Morris, M., EPA/CPB. August 25, 1993.

40. Sullivan J. W., Radian Corporation. Site visit at House of Imports. Buena Park, CA. Prepared for Morris, M., EPA/CPB. August 25, 1993.

41. Sullivan, J. W., Radian Corporation. Site visit at Camenita Collision Center. Sante Fe Springs, CA. Prepared for Morris, M., EPA/CPB. August 25, 1993.

42. Sullivan, J. W., Radian Corporation. Site visit at Dave Salas Metric's Auto Body Shop. Sante Fe Springs, CA. August 25, 1993.

43. Ref. 9

44. Ref. 9

45. Body Shop Business. 1990 Annual Industry Profile. 9:49. June 1990.

46. Babcox Publications. 1993 Annual Industry Profile. p. 48. June 1993.

TECHNICAL REPORT DATA

(Please read Instructions on reverse before completing)

1. REPORT NO.
EPA-453/R-94-031

2.

3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE

Alternative Control Techniques Document:
Automobile Refinishing

5. REPORT DATE
April 1994

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Technical Support Division
Research Triangle Park, NC 27711

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Technical Support Division
Research Triangle Park, NC 27711

13. TYPE OF REPORT AND PERIOD COVERED

Final

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This document provides information on alternative control techniques (ACT) for volatile organic compound (VOC) emissions from automobile refinishing. This document contains information on emissions, controls, control options, and costs that States can use in developing rules. The document presents options only, and makes no recommendations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Volatile Organic Compounds Automobile Refinishing Alternative Control Techniques		

18. DISTRIBUTION STATEMENT Release Unlimited	**19. SECURITY CLASS** *(Report)* Unclassified	**21. NO. OF PAGES** 80
	20. SECURITY CLASS *(Page)* Unclassified	**22. PRICE**

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE