CONTROL TECHNOLOGY

A range of control methods and technologies have been developed and are being widely used to control occupational exposures for spray painting in this industry. The most effective controls are engineering controls, particularly high volume low pressure spray guns and downdraft spray paint booths. New paint formulations have been developed to meet regulatory requirements in reducing solvent emissions in the industry. Other controls such as personal protective equipment including respiratory protection are also used to reduce employee exposures.

Paint Spray Equipment

Spray painting in auto body shops is a manual process where automotive painters use spray guns to apply successive coats of paint until the finish of the repaired sections of the vehicle matches that of the original undamaged portions. To speed drying between coats or for coatings which must be heated to cure, the painted vehicle surface is heated with heat lamps, in special infrared ovens, or in heated spray paint booths. After each coat of primer dries, the surface is sanded to remove any irregularities and to improve the adhesion of the next coat. Final sanding of primers may be done with a fine grade of sandpaper. A sealer is then applied and allowed to dry, followed by the final topcoat. When lacquer is used, the finished surface is usually polished after the final coat has dried, whereas enamel dries to a high gloss and is usually not polished.

Spray guns used in refinishing automobiles atomize paint with compressed air and project a paint mist onto the vehicle surface. The mechanism used in atomization and delivery of the paint directly affects the efficiency of the painting process. 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 spray gun nozzle. The waste paint directed outside the main spray pattern and not deposited onto the vehicle surface is referred to as overspray. In addition, atomized paint can be pulled away from the car surface by compressed air currents deflected by the car surface and the painting technician, and appears to "bounce back". The bounce back can account for 20% of the 60% of the paint which does not reach the car surface when conventional spray guns are used (Fettis, 1995).

<u>Conventional Air Spray Guns</u>

Conventional air spray guns have been the standard spray equipment used to apply coatings in the automotive refinishing industry. With this type of spray gun, a low volume (2 to 10 cubic feet per meter (cfm)) of air is pressurized and forced through a nozzle; the paint or coating is atomized in the air at the nozzle throat. Conventional spray guns are usually operated with air pressures of 30 to 90 pounds per square inch (psi) at a fluid pressure of 10 to 20 psi. Air is supplied by an air compressor during spraying operations. There are 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.

Three syphon-feed guns are used when large areas need to be painted. In contrast, gravity-feed guns have the paint cup above the gun and require less air pressure to move the coating through the gun (USEPA, 1994; Schrantz, 1992). Gravity-feed guns are used primarily for tough-up when small amounts of paint are required. Their use results in less waste and clear-up residue. The advantage of conventional spray guns is their capability to achieve very fine atomization. The disadvantages of this equipment is the development of excessive spray mist and over spray fog. Conventional spray guns equipment has a transfer efficiency in the range of 20% to 40%, and therefore most of the paint becomes an over spray that may contaminate the air in the worker's breathing zone (Heitbrink, 1996).

High Volume Low Pressure Spray Guns

High Volume Low Pressure (HVLP) spray guns are systems which use a high volume (30 cfm to 200 cfm) of low pressure (pressure at the gun of between 0.1 and 10.0 psi) and at a fluid pressure of 50.0 psi. The lower velocity of the atomizing air stream results in a more controlled spray pattern, less bounce back, and enhanced transfer efficiency. HVLP guns are estimated to have a transfer efficiency of at least 65% (Heitbrink, 1996). Some disadvantages to this equipment include: higher initial cost; inability to atomize coatings as finely as can be achieved with conventional spray guns; slower application speed; and the need for operator training. HVLP technology has become commonplace in auto body shops because of reduced paint usage and the acceptable finish quality provided by the guns on the market (BAAQMD, 1995). In 1995, approximately 64% of U.S. auto body shops reported owning HVLP equipment. Approximately 49% of small auto body shops (<$124,999 annual sales) and approximately 68% of very large (>$1 million annual sales) owned HVLP spray painting equipment. Also in 1995, approximately 12% of auto body shops surveyed planned to purchase HVLP spray equipment (BSB, 1995).

Testing conducted by the National Institute for Occupational Safety and Health (NIOSH) in an equipment manufacturer's test facility, demonstrated that particulate over spray concentration was reduced by a factor of 2, and that there was a 30% increase in the ratio of paint film thickness to mass of paint applied when a HVLP spray gun was used. These results indicate that using an HVLP spray-painting gun can reduce paint usage and over spray production, resulting in noticeably lower worker exposures (Heitbrink, 1996).

Discussions with a refinisher indicated that the establishment had 6 different models of HVLP spray guns. The manager confirmed that paint spray efficiency had increased to almost a 70% transfer rate, although some of the new low VOC paint formulations would not spray as well as some of the older lacquer paints. The high solid, low VOC paints often required more than 10 PSI nozzle pressure to atomize. A paint manufacture's vendor indicated that HVLP technology has come a long way in the last three years. He said that he could line up 6 HVLP guns, all with similar ratings and supply 40 PSI into each gun, but the nozzle spray would not be uniform. Often the output would range from 6 - 10 PSI. The representative indicated that true atomization of low VOC paint formulations often occurs at nozzle pressures higher than 10 PSI (CCC, 1996).

A closed container HVLP gun cleaner was seen on site. Both the shop manager and the paint vendor indicated that this equipment was purchased in response to a new regulation in Maryland.

Low Volume Low Pressure Spray Guns

Other guns used in the industry include low volume, low pressure (LVLP) guns. LVLP spray guns, like HVLP guns atomize coatings at lower pressure (9.5 to 10 psi) and at a lower velocity than conventional spray guns but use approximately 45 to 60 percent smaller volume of air than HVLP guns. Energy costs for air compression are reported to be less than with HVLP guns (USEPA, 1994).

Electrostatic Spray Guns and Powder Coating Systems

Electrostatic spraying systems, which have deposition efficiencies of between 60 and 90 percent, are widely used in U.S. automotive assembly plants. Air-powered, electrostatic spray guns function in essentially the same way as electrostatic spray guns. Although transfer efficiencies for powder spray guns are similar to wet spray guns, the powder can be reused and these systems can operate with powder utilization rates of up to 98 percent. Neither of these systems are practical for refinishing systems, however, for the following reasons: (1) prohibitively high cost of electrostatic spray guns, (2) large amount of coating contained in the hose connecting electrostatic spray gun to pot, which must be removed when changing colors, (3) high curing temperatures required for powder systems (i.e., resulting in damage to other vehicle components), and (4) grounding methods required for electrostatic systems in an OEM environment cannot be duplicated for automobile refinishing.

Appendix E is a comparison of the characteristics of paint spray equipment for automotive refinishers.

Spray Booths

Automobile spray painting operations produce aerosols containing droplets and solvent vapors where workers may be exposed. Spray booths, which are power-ventilated structures enclosing a spraying operation, can confine and limit the escape of spray, vapor, and residue, and safely conduct or direct over spray and vapors to an exhaust system. Automobile painting activities are usually performed inside a spray booth to ensure a good finish, to reduce employee exposures to inhalation of solvent vapors and paint solids, and to reduce the hazards of fire and explosion arising from components used in paints and varnishes (Goyer, 1995). After painting, spray booths are used for ambient air drying or for drying at elevated temperatures. Evaluations of controls in the auto body refinishing industry, conducted by NIOSH, indicate that currently available spray-painting booths do not completely control worker exposure to paint over spray (Heitbrink, 1995).

Dry-type booths use filters to intercept and trap particles of over spray while water-wash booths use a flow of water over a solid surface to accomplish the same thing. Dry filters are commonly used for low to intermediate volume spray operations (NFPA, 1981). Waterwash booths are spray booths equipped with a water-washing system designed to minimize concentrations of dusts or residues entering exhaust ducts and to permit the collection of dusts or residues. Where high volume spray coating operations are conducted for several hours a day, waterfall or cascade scrubbers are commonly used (NFPA, 1981). Either type can be used successfully in almost all applications, however; in general dry-type booths are most often used in automotive refinishing shops. Water-wash booths are rarely used in auto body refinishing shops (Garcia, 1996).

Typical automobile refinishing industry spray-painting booths have a painting cycle and a curing cycle. These booths are equipped with supply air fans and exhaust air fans. The supply air fan moves air from outside the shop through a heat exchanger or natural gas burners, through a bank of filters, and into the spray painting booth. The exhaust air moves out of the booth through filters and out of the building (Heitbrink, 1995). To cure paint and polyisocyanate hardeners, the booths are operated at temperatures as high as 79° C (175° F), although curing temperatures are typically 49°C to 60° C (120° to 140°F). Purchase costs of small basic spray paint booths range from $5,400 to $23,000 (Spray Systems,1996). A medium-size repair shop in Maryland installed two booths in 1992 at a cost of approximately $400,000. The purchase cost of each booth was approximately $60,000 but the installation required extensive foundation modifications to accommodate the ventilation system (CCC, 1996).

Three types of commercially available spray-painting booths found in auto body shops include downdraft, semi-downdraft, and crossdraft spray painting booths. The characteristics of these booths are summarized below and presented in Appendix F.

Crossdraft Spray Booths

In a crossdraft booth, the air enters through filters in the front of the booth and is exhausted through filters in the back of the booth (Heitbrink, 1995). Approximately 50% of U.S. auto body shops have crossdraft booths. An industry profile study, which provides data for 1995, indicates that approximately 42% of small (<$124,999 annual sales) auto body shops had downdraft spray booths and approximately 25% of very large firms (>$1 million annual sales) owned crossdraft spray booths (BSB, 1995). The cost for crossdraft spray booths are in the $5,500 to $23,000 range plus installation and modifications to the physical plant.

Downdraft Spray Booths

Downdraft spray-painting booths are designed to let air enter through filters in the ceiling of the booth and leave through a metal grate in the floor of the book. In most U.S. automotive assembly plants, painting is done in a downdraft paint spray booth. During the painting process, conditioned ambient air is introduced to the paint spray booth through the roof. The air and paint pass downward over the parts to be painted. The paint over spray and solvent fumes exit with the exhaust air from the painting area through grates on the floor (Eklund, 1995).

Approximately 30% of U.S. auto body shops in 1995 reported having downdraft spray-painting booths, including approximately 8% of very small firms and 83% of very large shops. Approximately 19% of auto body shops planned to purchase downdraft booths (BSB, 1995). The cost for downdraft spray booths are in the $12,000 to $60,000 range plus installation and modifications to the physical plant.

Semi-Downdraft Spray Booths

In a semi-downdraft booth, air enters through filters in the ceiling of the booth and is exhausted through filters in the back of the booth. During the painting process, conditioned ambient air is introduced to the paint spray booth through the roof. The air and paint pass down and across the parts to be painted. The paint over spray and solvent fumes exit with the exhaust air from the painting area through openings usually on one side of the booth (EPA, 1994).

Approximately 30% of U.S. auto body shops in 1995 reported having downdraft spray-painting booths, including approximately 8% of very small firms and 83% of very large shops. Approximately 19% of auto body shops planned to purchase downdraft booths (BSB, 1995). The BSB industry profile did not specify if the downdraft spray paint booth data represented semi-downdraft models. The cost for semi-downdraft spray booths are in the $10,000 to $23,000 range plus installation and modifications to the physical plant.

APPENDIX E

COMPARISON OF CHARACTERISTICS OF PAINT SPRAY EQUIPMENT FOR AUTOMOTIVE REFINISHERS

Type of Painting System	Performance Characteristics		System Transfer Efficiency (%)	Cost Range ($)	Population of Shops Using Equipment
	Advantages	Disadvantages			
Conventional	Low cost Low maintenance Excellent material atomization Excellent operator control Quick color change capabilities Coating can be applied by syphon or under pressure	Uses high volume of air Develops excessive spray dust and overspray fog Does not adapt to high volume material output (economies of scale) Low transfer efficiency Pressure fed systems require high volumes of coatings	20 to 40	up to 350	Specific population data is unknown. Some states have mandated the use of HVLP systems by automotive refinishers.
High Volume Low Pressure	Low blowback and spray fog Will apply high-viscosity high solid coatings (low VOC coatings) Relatively easy to clean Can be used for intricate parts Good operator controls	High initial cost Slower application speed with some coatings Does not fully atomize some coatings Higher maintenance costs Requires operator training Still relatively new to the market	at least 65	500-1000	64% of all shops
Low Volume Low Pressure	Low blowback and spray fog Will apply high-viscosity high solid coatings Easy to clean Can be used for intricate parts Good operator controls Needs less air compression then HVLP Lower energy requirements	High initial cost Slower application speed than HVLP Does not fully atomize some coatings Higher maintenance costs Requires operator training Still relatively new to the market	at least 65	500-1000	Population data is unknown
Powder Coating	Almost zero VOC emissions Excess or waste powder can often be melted Powder can be applied to hot or cold parts Ideal for robotic application Applied in single coat system Economical for long runs of a few colors	Generally, capital equipment outlay is greater than for conventional coatings High energy usage due to high temperature ovens Some powders require temperatures as high as 500°F for curing Not suited for every application (parts that can not tolerate high temperature plastics, rubber, upholstery	Up to 95	5000-100000	Population data is unknown Powder coating systems are used primarily in OEM operations.

Sources: EPA, 1994 and BSB, 1995

APPENDIX F

COMPARISON OF CHARACTERISTICS OF PAINT SPRAY BOOTHS

Paint Booth System	Performance Characteristics [1]		Cost Range[2]	Population of Shops Using Equipment [3]
	Functional Advantages	Disadvantages		
Downdraft	State of the Art worker protection Air movement - enters the booth through the ceiling and passes out the floor of the unit Lowest air turbulence of the three systems available Best system for preventing paint deformities	May cost more than other systems May require extensive renovation at existing facilities Operator training necessary Extra energy needed for heated systems	$12,000-$60,000	30% of all body shops use downdraft or semi-downdraft paint booth systems Most common paint booth system in shops with sales greater than $750,000 annually
Semi-Downdraft	Low air turbulence Air movement - enters the booth through the ceiling and passes out the back of the unit Installation may not require as much site renovation as downdraft	More air turbulence than downdraft May require extensive construction at existing facilities Operator training necessary Extra energy needed for heated systems	$10,000-$23,000	30% of all body shops use downdraft or semi-downdraft paint booth systems Most common paint booth system in shops with sales greater than $750,000 annually
Crossdraft	Most affordable system Air movement - enters the booth through one side and passes out the other Installation may not require as much site renovation as semi-downdraft or downdraft	Highest air turbulence of three available models Least effective model for preventing paint deformities Operator safety Extra energy needed for heated systems	$5,500-$23,000	50% of all body shops have a cross draft paint booth system Most common paint booth in body shops with sales less than $750,000 annually

Sources: 1 - EPA, 1994, 2 - Spray Systems and CCC, 1996, 3 - BSB, 1995)