A small-business guide

Auto Body Shops

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ABOUT THIS GUIDE

Members of the small-business community historically have had little contact with their electric utility providers. This guidebook was developed to facilitate communication between utilities and the auto body shops in their communities.

The *Auto Body Shops* guidebook is intended to familiarize readers with the business of auto body refinishing by providing descriptions of the basic processes and practices, and summaries of the issues and challenges faced by auto body shops, especially smaller, independently owned shops. It focuses on delineating how electric equipment can address the needs and interests of auto body shop owners and operators.

This guidebook is one of a series of publications about small businesses produced by the Electric Power Research Institute (EPRI). The *Auto Body Shops* guidebook is based on extensive and ongoing research and contains the latest information available at the time of publication. Nevertheless, it is a work in progress rather than a definitive and final document. The information and resources presented offer the reader a solid base from which to develop electric-based solutions to energy and business needs.

This guidebook is organized as a reference guide for use on an as-needed basis. Section tabs are included to facilitate quick access to topics of interest; icons representing energy end uses are also provided to help with locating further information on electrotechnology solutions.

The job of an auto body shop is to return a damaged car, motorcycle, van, or truck to its original condition, or to otherwise make an automobile "look like new." In 1992, there were more than 35,000 auto body shops in the United States, employing a total of nearly 166,000 people and generating revenues of about $12.3 billion. More than 75% of these establishments are small, owner-operated businesses with fewer than seven employees. The good news for these businesses is the prediction of a continuing and growing demand for auto body shop services as Americans strive to economize by extending the life of existing automobiles. The caveat: for an auto body shop to thrive and prosper from this demand, it must be geared to provide new services and new environmental accountability.

Specifically, rapid innovations in automobile manufacturing in the last two decades have pushed shops in the refinishing business to purchase special equipment that allows them to match the new finishes. More recently, new environmental regulations seeking to control ozone, a by-product of the use of solvents and solvent-based paints and a component of smog, have forced shops in smog-prone areas to adopt alternative paints and/or employ emissions-control equipment. In both cases, business owners and operators are under pressure to invest in new technologies, retrain employees, and keep additional records. That means money and time out-of-pocket for no additional revenue.

Faced with the challenges of changing consumer needs and new environmental regulations, auto body shop owners and operators are seeking tools and methods to reduce operating costs, improve productivity and product quality, and control regulated emissions. The accompanying table identifies specific electrotechnologies that address these small-business concerns. These electrotechnologies and other high-efficiency electric technologies are described in detail in the *Auto Body Shops* guide (EPRI TR-106676-V2), which is available from the EPRI Distribution Center. *Short-wave cure: Painting autos in electric speed* (SU.106504.P1) is a case study example of the short-wave drying and curing technology. To order the guide, the case study, or other guides in the series, call the Center at (510) 934-4212.

Electrotechnologies for Auto Body Shops

	Short-Wave IR Drying and Curing	Outdoor Lighting	Electric Infrared Space Heating
Description	Uses portable or statonary systems of quartz lamps and reflectors to direct short-wave radiation at a coating, generating heat within the coating so that it dries from inside out, providing extremely quick, no-blister curing.	Six types of lighting technologies are available; each offers different characteristics in wattage, brightness, light tone, efficiency, and lifespan; they can be combined to meet site-specific needs.	Uses ceiling-mounted infrared (electromagnetic radiation) fixtures to heat people and objects in a space, rather than the air around them.
Auto Body Shop Need	Affordable, easy-to-operate, quicker drying/curing technology for use with all paints and coatings, including newer high-solids, waterborne, and powder coatings.	Lighting improves the visibility and attractiveness of a facility (providing a form of advertising), reduces the potential for crime, and increases employee safety.	To provide warmth and comfort for workers cost-effectively, while also allowing for high ventilation rates.
Application	Used in drying or curing paints and coatings; lamps are modular—spot heaters or panels can be arm-mounted for portability, or lamps can be configured as a stationary oven.	Signage on or near the facility; general lighting in parking lots, walkways, delivery areas.	Can be used to heat repair bays, paint booths, and storage areas—shop areas that require high ventilation rates and that may be exposed to the outdoors.
Benefits	Provides consistently high-quality results in 50–80% less time than conductive ovens; no preheating required; reduced requirements for ventilation and floor space.	Increased public perception of goodwill, success, quality from signage; reduced accidents, injuries, and crime from area lighting.	Relatively inexpensive and easy to install; ensures worker comfort while allowing a background temperature of 50–60°F, thereby reducing energy use.
Cost	A small spot or panel heater costs $1000–$2500; a custom-designed oven, $10,000–$250,000.	Systems are custom-designed to meet a facility's needs and budget.	A small, four-fixture unit costs under $2000; a large, industrial-size system with specialized controls costs over $100,000.

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INTRODUCTION TO AUTO BODY SHOPS

When the automobile became affordable for the general public in the late 1930s, auto body shops were a natural adjunct and began to crop up across the country. Today there are more than 35,000 auto body shops in the United States. Most are small, owner-operated, family-operated shops with fewer than seven employees. In recent years, these smaller shops have been under pressure to keep up with the brisk pace of technological advancements in the automobile industry and to comply with new environmental regulations. Both factors are rapidly increasing the cost of doing business because they require shops to invest in new products and equipment, retrain employees, and keep additional records. Many of the smaller shop owners are finding these expenses beyond their capacity to purchase or finance.

Business Statistics

The auto body refinishing industry (SIC 7532) is composed of shops that repair and refinish the interior and exterior structures of autos, vans, motorcycles, and light- and medium-duty truck cabs. These shops can be divided into two distinct subsets: those that repair and refinish ("body repair shops") and those that only refinish ("paint shops"). As illustrated in Table 1, most shops engage in both repair and refinishing. Although this guide focuses on auto body shops, many of the processes, business needs, and technology solutions discussed are also applicable to automobile dealerships (SIC 5511) that have their own refinishing operations.

According to the U.S. Department of Commerce, there were more than 35,000 auto body establishments in the United States in 1992 (see Table 1). These establishments are almost entirely independent small businesses and small businesses that are part of regional or national chains, such as Earl Scheib and Maaco Enterprises. More than 75% of auto body shops operate independent, family-owned body repair shops with three to six employees. As illustrated in Table 2, more than 99% had fewer than 50 employees and only 15 shops nationwide had more than 100 employees.

Table 1
Overview of the Auto Body Industry

Subset	No.of Establishments	No. of Employees	Receipts ($ million)
Body Repair	32,280	153,890	11,490
Paint Shops	2,760	12,010	770
TOTAL (SIC 7532)	**35,040**	**165,900**	**12,260**

Source: U.S. Department of Commerce, Bureau of the Census, *1992 Economic Census CD-Rom: Report Series*, 1995.

Consolidation is a long-standing trend in this business. Over the past 15–20 years, the number of auto body shops has shrunk from nearly 39,000 in 1977 to 32,610 in 1992. The increasingly technical nature of the work is reflected in this trend. Until recently, auto body shops had managed to keep up with the pace of technological change within the industry. In the 1980s, however, the major automakers switched to unibody construction and metallic paint finishes. Consequently, frame straightening and quality paint application began to require specialized equipment costing thousands of dollars. Many smaller shops could not afford the massive capital investments required to remain competitive and eventually went out of business or merged with larger companies. National chains, with better access to capital, technology, and training, faired better. Despite these changes favoring consolidation, chains still represent only an estimated 3% of all auto body shops.

New environmental regulations are also increasing the industry’s cost of doing business. The primary environmental concern in the auto body industry is solvents. The solvents found in auto body paint evaporate into volatile organic compounds (VOCs) at room temperature and become a gas when exposed to the air. In the presence of sunlight, these VOCs react with other gases and form ozone, a component of smog. As smog, ozone is a health hazard and, according to the federal Clean Air Act Amendments of 1990, each state must control ozone emissions to achieve a federally mandated level.

Larger auto body shops operating in ozone nonattainment areas may be affected by these regulations. For example, a large auto body shop emitting more than 100 tons of VOCs per year in a nonattainment area such as Sacramento, California, could be required by local air quality management district regulations to reduce the concentration of solvents in its coatings and to use what are known as “high transfer efficiency methods” of applying coatings.

Table 2
Breakdown of Auto Body Shops by Size Category

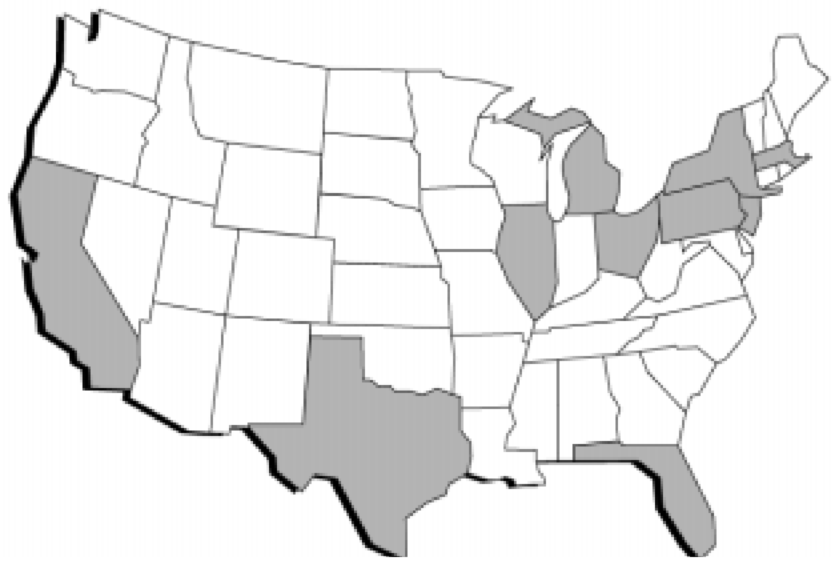
Size	No. of Establishments	Percent of Total
Small (0–50 employees)	32,543	99.80
Medium (51–100 employees)	52	0.15
Large (100+ employees)	15	0.05
TOTAL (SIC 7532)	**32,610**	**100.00**

Source: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns, 1992 - United States*, CBP-92-1, 1995.

These technical and environmental challenges are clearly the downside for auto body shop operators now and in the foreseeable future. The upside is an increasing demand for services. As new-car costs escalate, an increasing number of Americans are extending the life of their current vehicles by repairing and refinishing them. According to the U.S. Department of Commerce, paint and body shops handled receipts of $12.3 billion in 1992, about one-third of the total receipts in the automotive repair industry, and a significant increase from receipts of $3.2 billion in 1977. Although a 1995 industry survey revealed that more than 65% of all shop owners think their business will become more successful over the next five years, experts predict an annual decline of a few thousand establishments per year over the next few years ("1995 Industry Profile: Body Shop Business," by MarketScope, a division of Babcox Publishing).

Auto body shops are found throughout the United States, but they tend to be concentrated near urban centers and industrial areas. As a result, the Pacific Coast and the eastern Midwest regions have the largest percentage of shops. Likewise, California and New York have the largest number of auto body shops, with 12% and 7% of the industry, respectively (see Figure 1). Other top states include Illinois, Texas, Florida, and Pennsylvania, each representing approximately 5% of the industry. Ohio, Michigan, New Jersey, and Massachusetts round out the top 10 states.

State	Auto Body Shops
CA	3736
NY	2099
TX	1721
PA	1663
IL	1600
FL	1489
OH	1291
MI	1229
NJ	1162
MA	993



Source: U.S. Department of Commerce, Bureau of Census, *County Business Patterns, 1991*.

Figure 1
Top 10 States for Auto Body Shops (1991)

Auto Body Shop Operations

The refinishing process involves three basic steps: surface preparation, coating application, and drying/curing (see Figure 2), although specific procedures vary from shop to shop. Electricity is generally used throughout the process. Emissions of VOCs also occur throughout the process, primarily during surface preparation, application of primers and topcoats, and spray gun cleaning. VOC emissions are also generated when paint/solvent is mixed and when curing takes place.

Surface Preparation

The surface of the auto body is prepared for refinishing by cleaning it with solvents—to remove wax, grease, and other contaminants. These solvents are a contributor to the shop's VOC emissions. This step is often conducted in a spray booth.

Coating Application

In the coating step, liquid paints or coatings are sprayed onto the auto body with conventional or high-efficiency spray guns, typically in a spray booth. The application of coatings is often a three-part process:

- The auto body is first treated with a pretreatment wash. Primer and precoat are then applied to etch the surface, deactivate the metal, provide corrosion resistance, and promote adhesion.
- Primer surfacer and sealer are then applied to fill in surface imperfections and enhance the uniformity of topcoats.
- Topcoatings are applied, generally a series of coatings; the last is the "clearcoat." These coatings determine the final color of the refinished area.

All conventional primers and topcoats contain solvents. The increasing use of complex topcoats by car manufacturers, such as metal and pearl coatings, is forcing refinishers to increase their use of solvents in order to achieve a proper match or blend with other body parts. Color matching often depends on the alignment of metallic particles in the paint, a characteristic that is influenced by the evaporation of the solvent carriers.

Lacquer, enamel, and urethane coatings are commonly used at the auto body refinishing level. Small shops without spray booths and drying ovens are the most likely users of lacquer coatings because these coatings dry more quickly than enamels or urethanes. Urethane coatings are extremely durable and have a high gloss finish, but take longer to cure. As a result, they are typically used by more sophisticated shops with spray booths.

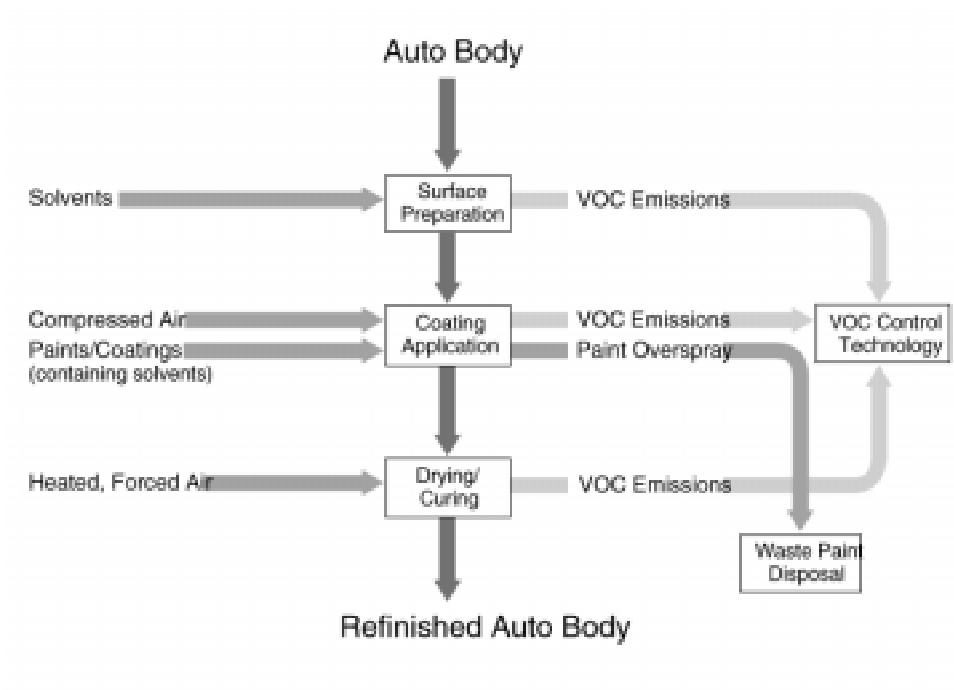


Figure 2
The Auto Body Refinishing Process

A spray booth provides a clean, well-lit, and well-ventilated area in which to work, thereby minimizing the potential for dirt and dust to adhere to the coatings before they are dried or cured. In addition, a booth hastens drying and provides a safe working environment for employees because it removes solvent vapors and coating overspray (the portion of the coating solids that does not adhere to the surface being finished) from the air. Ovens and spray booths typically have induced-draft fans that collect the VOC-laden air and pipe it away to an incinerator or other VOC control device.

Coatings are most often applied with hand-held spray guns that atomize a coating into small droplets. Compressed air is supplied to the spray gun and the paint container. The pressurized air mixes with the liquid paint, atomizing it, and propels it from the gun nozzle to the object to be coated. Both the atomization of solvent-based paint by the spray gun and subsequent gun cleaning are significant contributors to a shop's VOC emissions.

Coating application typically takes place in a spray booth. Three types of booths are used, named for the direction of the airflow: downdraft, crossdraft, and semi-downdraft. Downdraft booths provide the cleanest drying/curing environment due to minimized air turbulence and effective floor venting. Spray booth exhaust systems have dry or wet filters that capture particulates and paint, although neither are effective at controlling VOCs.

As the auto manufacturing industry moves away from solvent-based coatings and toward solvent-reduced or solvent-free coatings, refinishing shops that do not currently have spray booths (e.g., those now using lacquer coatings) will need to install them in order to accommodate the more critical drying and curing needs associated with high-solids and waterborne coatings. Spray booths may also help shops comply with current and/or future regulation of VOCs.

Drying and Curing

The last step in the refinishing process is drying or curing the paint to form a solid film of paint. Coatings can be dried with ambient air, but in order to decrease drying time after each application, many shops use forced-air drying systems. Drying can also be accomplished in ovens that use gas, fuel oil, electricity, steam, or infrared (IR) radiation as their source of energy. The ovens, usually heated by gas or oil, reach a temperature of 120–140°F. Smaller shops often use traveling ovens or portable IR lamps that can be rolled into the spray booth.

During the drying/curing step, VOC emissions "flash-off," or evaporate, from the solvent-based paints. Depending on the area of the country in which a shop is located, these VOCs may need to be reduced or captured. At the original equipment manufacturer (OEM) level, new short-wave IR drying tunnels are becoming more common. Short-wave IR drying speeds up drying times and does not require a large volume of airflow, thereby helping to localize the origin of the VOC emissions.

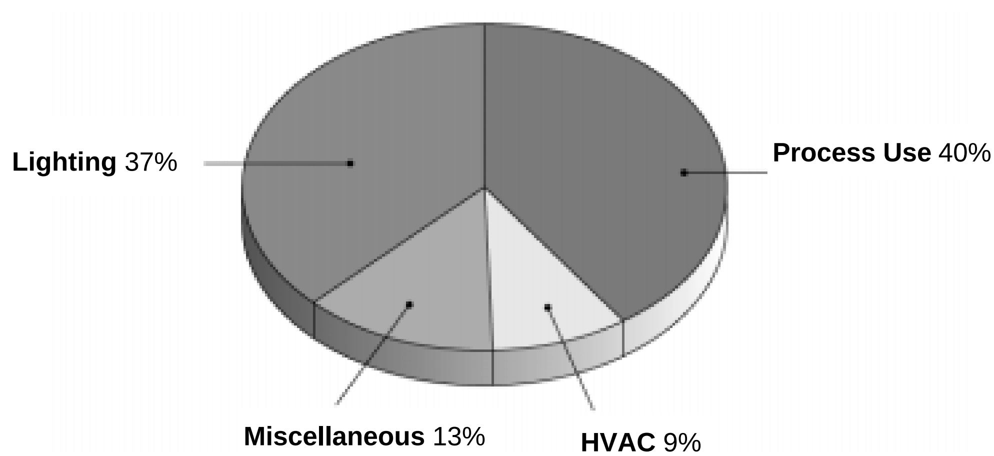
Energy Use

Auto body shops typically operate six days per week; one to one-and-a-half shifts per day. Although exact figures are not available, estimates based on Department of Energy energy consumption data suggest that auto body shops consumed approximately 4.8 trillion Btu of energy in 1992. This figure is significant, representing 5–10% of total operating expenses. Although auto body shops may be interested in energy issues, they are typically more concerned about productivity and product quality issues, and compliance with environmental regulations.

The two primary sources of energy for auto body shops are electricity (49%) and natural gas (48%). Fuel oil makes up the remaining 3%. Although auto body shops use basically equal amounts of electricity and natural gas, electricity accounts for over 82% of energy costs, while natural gas accounts for only 16%.

As illustrated in Figure 3, 40% of the electricity used by auto body shops is consumed in process uses, primarily for motors that drive compressors and fans. Lighting (37%) accounts for the second largest portion of electricity use. The remainder is consumed in miscellaneous uses, such as VOC control (13%) and heating, ventilating, and air conditioning (9%).

The average electricity intensity for all auto body shops is approximately 11 kWh per square foot (see Table 3). This is less than the electric intensity for some other commercial establishments, such as grocery stores, restaurants, medical clinics, and hotels and motels. Regionally, electric intensity is higher in the northeast, primarily due to the greater use of space heating.



Source: U.S. Department of Energy, Energy Information Administration, *Commercial Building Energy Consumption and Expenditures* and *Commercial Building Characteristics*, 1992.

Figure 3
Typical Electricity Use in Auto Body Shops

Table 3
Electricity Consumption in Auto Body Shops (1992)

Census Region and Division[1]	Total Electricity Consumption (thousand kWh)	Total Floor Space (thousand sq. ft)	Total Electric Intensity (kWh/sq.ft.)
Northeast	**88,178**	**5,197**	**17.0**
New Zealand[2]	952	863	1.1
Middle Atlantic	87,226	4,334	20.1
Midwest	**141,134**	**12,819**	**11.0**
East North Central	120,725	9,261	13.0
West North Central	20,409	3,558	5.7
South	**268,705**	**23,348**	**11.5**
South Atlantic	86,693	6,768	12.8
East South Central	74,214	7,294	10.2
West South Central	107,798	9,286	11.6
West	**190,201**	**20,397**	**9.3**
Mountain	118,000	14,929	7.9
Pacific	72,201	5,468	13.2
TOTAL	**688,218**	**61,762**	Average **11.1**

[1] **New England:** CT, MA, ME, NH, RI, VT. **Middle Atlantic:** NJ, NY, PA. **East North Central:** IL, IN, MI, OH, WI. **West North Central:** IA, KS, MN, MO, ND, NE, SD. **South Atlantic:** DC, DE, FL, GA, MD, NC, SC, VA, WV. **East South Central:** AL, KY, MS, TN. **West South Central:** AR, LA, OK, TX. **Mountain:** AZ, CO, ID, MT, NM, NV, UT, WY. **Pacific:** AK, CA, HI, OR, WA.

[2] Based on a sample size of one.

Source: U.S. Department of Energy, Energy Information Administration, *Commercial Building Energy Consumption and Expenditures* and *Commercial Building Characteristics*, 1992.

2

BUSINESS CHALLENGES AND NEEDS

An auto body shop owner's primary goal is to complete high-quality automobile refinishing jobs as quickly as possible at the lowest possible cost. Shop owners are likely to be interested in "energy improvements" only if the improvements also enhance the shop's productivity or product quality, reduce the shop's operating costs, or help the shop comply with an environmental regulation. This guidebook links business challenges and electric-based technologies.

Competition

With more than 35,000 establishments nation-wide vying for jobs, the auto body industry is a competitive one. Each shop gets the vast majority of its business through word-of-mouth and/or insurance referrals. A reputation of providing low price, quick turnaround, and a high-quality product is essential to success. Shop owners are therefore always on the lookout for ways to reduce operating costs and improve productivity and product quality.

Need

Reduce Operating Costs

Auto body shops "win" business by being low cost. Jobs come in through a low-bid process or through an outside insurance adjuster at a price set by the adjuster's company; costs are intensely scrutinized. Generally, there is very little to differentiate one shop from another; price is tangible but quality is subjective, and the average consumer is guided by price. Reducing operating costs is therefore the predominant concern for the shop owner.

Technology Solutions

High-volume, low-pressure spray guns, short-wave electric IR drying, energy-efficient indoor and outdoor lighting, adjustable speed drives on spray booth fans, and electric IR space heating all offer auto body shops the opportunity to reduce operating costs by reducing energy consumption. Technologies that have the potential to reduce auto body shop operating costs in the future include electrostatic spray guns and ultraviolet curing.

See pages 3-3, 3-6, 3-10, 3-11, 3-12

Need

Improve Productivity and Product Quality

Customers expect quick turnaround. Many Americans consider being without an automobile for more than a day or two an extreme inconvenience. To carry a good reputation, a shop must be able to move jobs along at a brisk pace. A typical shop has four bays or work areas devoted to body work and two bays devoted to painting. Shops that allow paint jobs to air dry—which sometimes takes an entire day—are highly limited in the number of refinishing jobs they can process each week.

Customers also expect a high level of quality in the final product; specifically, they expect the repaired finish to match the original finish. As finishes and painting technologies have become more complex at the auto manufacturing level, auto body shops are being forced to adopt more and more complex refinishing technologies to achieve a comparable finish. Smaller shops in particular are finding it difficult to generate the capital necessary to invest in new materials, new equipment, and additional worker training.

In addition, paint jobs are subject to contamination from dirt, dust, and other particles in the air during the drying period. Any technology that speeds up the painting or drying process can help improve both productivity and product quality.

Technology Solutions

Both short-wave electric IR drying and adjustable speed drives on spray booth fans have the potential to directly improve productivity and/or product quality. Energy-efficient lighting and electric IR space heating may also indirectly influence productivity and product quality by enhancing employee vision and comfort. In addition, ultraviolet curing may be available to auto body shops in the future to increase drying/curing productivity.

See pages 3-6, 3-10, 3-12

Environmental Issues

Auto body shops are among the types of small businesses most affected by environmental and health and safety regulations and issues. Two of the most important national regulations have an impact on this industry because they call for the control of VOCs. The Clean Air Act Amendments (CAAA) of 1990 regulate the emission of VOCs as contributors to tropospheric ozone; the Occupational Safety and Health Act (OSHA) regulates worker exposure to VOCs and other hazardous air pollutants (HAPs).

Need

Control VOC Emissions

Increased environmental protection legislation, in the form of the CAAA, brought new challenges to paint shops in the 1990s. The auto body industry uses significant quantities of solvents and solvent-based paints that evaporate as VOCs at room temperature and hence are the subject of growing concern and regulatory controls. These VOCs combine with NO_X in the presence of sunlight to form ozone, a major component of smog. Until the CAAA, VOC emissions were left largely uncontrolled.

Ozone levels in many areas of the country currently exceed the standards set by the U.S. Environmental Protection Agency (EPA). Local districts are now required to develop plans to meet these standards. In some areas, these plans include regulations to reduce solvent emissions from industrial coating applications, such as in auto body shops. Special VOC regulations exist in many states, counties, and cities that require shops to reduce the amount of VOCs released into the atmosphere. States may either adopt the federal rule or promulgate their own, more stringent rule. California has already begun promulgating its own rules. For example, the South Coast Air Quality Management District—in the Los Angeles area—now restricts the level of solvents in paints, and the San Diego Air Quality Management District requires shops in the auto body industry to use emission control equipment or alternative coatings to reduce VOC emissions. Generally, shops in many areas of the country are facing the choice of adopting either alternative reduced-solvent or solvent-free coatings, special spray equipment to limit the amount of VOCs escaping into the atmosphere, or emission control equipment to capture and destroy or recycle VOCs. Shops in other areas, particularly areas currently meeting federal ozone standards, may not face such regulations.

At the federal level, in April 1996, the EPA proposed reducing VOCs from the auto refinishing process by regulating the coating manufacturing industry instead of the coating application industry. Auto body shops therefore would not be required to install expensive VOC control equipment. Rather, coating manufacturers would comply with the rule by reformulating the coatings sold to auto body shops so they have a lower VOC content. The EPA anticipates that the proposed new regulations will be finalized by March 1997. Auto body shops can stay informed on this issue by contacting the EPA's Small Business Ombudsman (800/368-5888) or their state Small Business Technical Assistance Program.

In addition to concern about VOC release to the atmosphere, VOCs must be controlled to prevent worker exposure. Many of the solvents found in automobile coatings are also HAPs, which can be toxic to humans. As a result, auto body shops are subject to OSHA regulations. The most common type of worker exposure is the inhalation of solvent vapors. OSHA sets permissible exposure levels (PELs) for a variety of solvents. A PEL is a time-weighted average that permits higher periods of exposure during an eight-hour day, providing there is a sufficient period of low exposure. For the auto body industry, this means that paint booths must have high ventilation rates, and workers must wear masks or respirators when painting to minimize their exposure.

Technology Solutions

High-volume, low-pressure spray guns can be used to reduce VOC emissions at the source. Used in combination with the new high-solids or waterborne coatings, electric short-wave IR drying can also help an auto body shop reduce VOC emissions. Emerging technologies that can reduce or eliminate VOC emissions include electrostatic spray guns (used with powder coatings) and ultraviolet curing (used with VOC-reduced or VOC-free coatings). Emerging technologies for VOC destruction include biofiltration, membrane separation, and ultraviolet oxidation.

See pages 3-3, 3-6

3

TECHNOLOGY SOLUTIONS

This section describes each of the technology solutions identified in the previous section. Each technology is summarized, linked by end-use application to a business need, and categorized as an “electrotechnology” or an “efficiency technology.” Electrotechnologies are selected new or alternative electric technologies. Efficiency technologies are electric technologies that offer opportunities to decrease energy use. In many auto body shop applications, the electrotechnologies can increase production, improve product quality, or control VOC emissions, and may couple increased energy costs with an overall decrease in operating costs.

Also discussed are “emerging electrotechnologies”; these are electrotechnologies that are not currently available to the industry but that hold good potential for addressing an industry need in the near future. Each electrotechnology is more completely described in Section 4. Vendors of these technologies, sources for information on efficiency technologies, and trade associations are listed in the Resources section of this guide.

The technology solutions are grouped and discussed by end-use category, beginning with “Process and Miscellaneous Uses.” Note that while “process” and “miscellaneous” end uses were discussed separately in Section 1, they are grouped here because VOC-control technologies, a “miscellaneous” end use, are needed specifically in relationship to the processes of coating, drying, and curing. Table 4 links the end uses, technology solutions, and business challenges.

Table 4
Technology Solutions to Auto Body Industry Needs

End Use	Solution Type	Technology Type	Business Needs: Reduce Operating Costs	Business Needs: Improve Productivity/ Product Quality	Business Needs: Control VOC Emissions
Process and Misc./ Coating	Efficiency Technology	High-Volume, Low-Pressure Spray Guns	■		■
Process and Misc./ Coating	Emerging Electrotechnology	Electrostatic Spray Guns	■		■
Process and Misc./ Drying and Curing	Electrotechnology	Short-Wave IR Drying and Curing	■	■	■
Process and Misc./ Drying and Curing	Emerging Electrotechnology	Ultraviolet Curing	■	■	■
Process and Misc./ VOC Control	Emerging Electrotechnology	Biofiltration			■
Process and Misc./ VOC Control	Emerging Electrotechnology	Membrane Separation			■
Process and Misc./ VOC Control	Emerging Electrotechnology	Ultraviolet Oxidation			■
Lighting	Efficiency Technology	Energy-Efficient Indoor Lighting	■	■	
Lighting	Electrotechnology	Energy-Efficient Outdoor Lighting	■	■	
HVAC	Efficiency Technology	Adjustable Speed Drives	■	■	
HVAC	Electrotechnology	Electric Infrated Space Heating	■	■	

Process and Miscellaneous Uses

Nearly 53% of total electricity consumption in an auto body shop supports process and miscellaneous technologies used in three auto body operations: surface coating; drying and curing; and, in some cases, VOC control.

Surface Coating

Coatings are typically applied with hand-held spray guns that atomize the coatings into small droplets. A compressor powered by a 10–15 horsepower motor supplies compressed air to the spray gun and the paint container. The pressurized air mixes with the liquid paint, causing it to atomize. The small droplets of atomized paint are then propelled from the gun nozzle to the auto body.

Conventional compressed-air atomization enjoys two key advantages. First, it is the oldest, most common, and most easily controlled finishing system available. The spray pattern can be adjusted from a small dot to a large elliptical pattern that measures several feet across, and the degree of atomization can be adjusted from a fine to a coarse finish. Secondly, the process can easily spray almost any coating at a reasonable speed.

The primary disadvantage of compressed-air atomization is its poor transfer efficiency. In most applications, more material is wasted than is actually deposited on the intended surface. The low transfer efficiency is the result of the turbulence created by the high air pressure. In addition to excessive waste of paint, this leads to frequent and costly spray booth filter replacement, associated waste disposal costs, and potential violation of environmental regulations. EPA regulations in some states require a minimum transfer efficiency of 65% for coating application methods. As a result, many auto body shops may have to switch to more efficient and less polluting methods of paint atomization for their coating operations. High-volume, low-pressure and electrostatic spray guns offer great potential.

Efficiency Technology Solution

High-Volume, Low-Pressure Spray Guns. A conventional spray gun, with paint atomization at a pressure of 40–60 pounds per square inch (psi), has a transfer efficiency of approximately 30%. A high-volume, low-pressure (HVLP) spray gun, on the other hand, has a transfer efficiency of 90%. The paint is atomized at a much lower pressure (a maximum of 10 psi), which results in a lower paint particle velocity. A slower-traveling paint particle results in much less paint “bounce-back,” therefore fewer VOCs are emitted and less paint is wasted.

Many state and local air pollution agencies consider HVLP spray guns a viable alternative for lowering VOC emissions. While the proportion of establishments using

HVLP technology varies depending on local VOC regulations, one vendor estimated that nearly 90% of auto refinishers in California are currently using some type of HVLP spray gun. According to the MarketScope 1995 industry survey, 64% of all body shops are using HVLP paint equipment and 12% plan to purchase it in the future.

Emerging Electrotechnology Solution

Electrostatic Spray Guns. Electrostatic spray guns are used to apply powder coatings. They charge a coating with a high-voltage, low-amperage direct current either before or immediately as it exits the spray gun. The electrostatically charged paint is then directed by air and attracted to the electrically grounded parts to be coated. The advantages of this method include minimization of overspray and enhancement of "wrap around" of the paint. Wrap around ensures that the edges or other sharp points are coated with paint.

Electrostatic coating has been used for some time in finishing metal and plastic products. The high transfer efficiency of electrostatic spray finishing—nearing 100%—not only saves material but helps to reduce VOC levels in the spray booth exhaust (due to the reduced amount of coating used). This equipment also makes it possible to effectively atomize the new high-solids (VOC-reduced) and waterborne (VOC-minimized) coatings that are becoming increasingly popular in the coating industries. Coaters in regions of the United States classified by the EPA as nonattainment areas for ozone may have to choose either HVLP or electrostatic finishing in order to comply with environmental regulations.

While this technology would dramatically reduce VOC emissions and paint waste in the auto body industry, refinishers are not yet using it. The dissuasive factors include increased electrical requirements, higher costs, and higher complexity—which requires additional operator training.

Alternatives to Conventional Solvent-Based Coatings

High-Solids Coatings

In principle, if less solvent is used to dilute a coating, less VOCs will be emitted. High-solids coatings contain 60% solids and 40% solvents, compared to the conventional ratio of 40% solids and 60% solvents. Technically, the ratio of solids to solvents can grow; it is now constrained by spray-delivery equipment. In practice, however, workers may ignore mixing guidelines and adopt whatever solvent ratios they feel are necessary for a good blend.

Waterborne Coatings

A coating is considered waterborne by the EPA if it contains more than 5% water. Waterborne coatings are currently available but take longer to dry than conventional solvent-based coatings. Increased use of waterborne coatings has stimulated interest in infrared (IR) curing systems. With short-wave IR drying systems, waterborne coatings dry as fast or faster than solvent-based coatings.

Powder Coatings

Powder coating is solvent-free, containing only resins and pigments. While it is not yet used in the auto body shop industry, it is one of the newest, most environmentally sound, and fastest growing methods of metal and plastic finishing today. Powder coating uses the principles of electrostatic attraction to direct powdered paint to a conductive part, where it is cured and fused to the part with heat or other energy. When used with a properly operating reclaim system, the coating system can be considered almost 100% transfer efficient. All oversprayed materials are recovered and reused, eliminating the overspray disposal problems inherent in wet paint applications. The application of powder as a primer surface and as a clearcoat also has potential.

Many industrial coating applications, such as the coating of metal parts, are switching to powder coatings because of state or local VOC emission reduction requirements and the durable, high-quality finish that it provides. However, for auto body shops, there are two important drawbacks to the use of powder coatings: (1) the high cost of system conversion, and (2) the technical difficulties associated with the use of electrostatic equipment (required to apply the powder to the surface) on fully assembled or used cars. Nonmetallic, nonconductive parts, such as urethane bumpers and body fillers, make it very difficult to coat such vehicles with electrostatic systems.

In most auto body shops, the typical method of applying a powder coating is by mixing it with a liquid clearcoat. The mixture—usually called “pearl” or “candy” coating—can then be sprayed without the need for specialized new equipment, and can be cured with a heat source. However, unlike the electrostatically applied powder coating, this modified spray-applied powder coating does not reduce VOC emissions, since the clearcoat is typically solvent-based.

Drying and Curing

Solvents are used in paints to carry the finish material, provide smooth coverage, and speed drying. They evaporate at room temperature and create VOC emissions. Coating manufacturers are investing millions of dollars in research to develop paints that deliver better quality finishes and that emit fewer VOCs. This has resulted in the introduction of high-solids paints, waterborne paints, and powder coatings (see sidebar, page 3-4). High-solids basecoat paints have somewhat reduced VOC emissions, waterborne paints have even lower VOCs, and powder coatings contain no solvents and create no VOCs.

Reformulated coatings are the compliance method of choice at the OEM level, due to their low cost and simplicity compared with other compliance options. However, these coatings have longer drying times and more complex finishes, which is driving the OEMs to use new drying and curing systems—such as IR drying of waterborne, high-solids, and powder coatings, and ultraviolet curing of novel finishes—to improve the productivity and product quality of their finishing operations. Because refinishers must attempt to match OEM finishes, auto body shops are forced to embrace the same types of paints and drying/curing processes used by the manufacturers.

How quickly these signs of change will give way to wholesale change throughout the industry is not yet clear, especially since the key driving force is legislation governing VOC emissions. Estimates obtained in 1987 indicated that at that time, 20% of the automotive industry was using high-solids coatings, 20% was using powder coatings, 10% was using radiation-curable coatings (i.e., curable with ultraviolet radiation), and 10% was using waterborne coatings. While these figures are more representative of the automobile manufacturing industry than of the auto body industry, waterborne primers and basecoats, along with high-solids coatings, are likely to become more common in the auto body industry over the next few years.

Electrotechnology Solution

Short-Wave Infrared Drying and Curing. Electric IR technology is well-suited to heating, drying, and curing surface coatings, and has been used to cure paint on auto bodies since the mid-1930s. It is well-known in the automobile coating industry at the OEM level, and increasingly at the body shop level. The IR process dries paint from the inside out, so high temperatures can be accommodated, thereby shortening the drying time without fear of blistering the paint, as can happen in a conventional oven. The metal of the auto body conducts heat well, and enough energy is absorbed by the metal substrate that areas not directly in the IR beam are heated by conduction.

Electric short-wave IR has numerous advantages over conventional medium- and long-wave IR, air drying, and conventional gas-fired ovens, including improved energy efficiency, shorter drying times, a smaller footprint, precise control, low maintenance, improved product quality, and reduced environmental impact. By allowing the use of reduced-solvent or solvent-free coatings, short-wave IR drying can reduce or eliminate the VOC emissions that “flash off” from solvent-based coatings as they are dried or cured.

The productivity of an auto repair shop depends on the rate at which successive coats of finish can be applied. Waterborne paints can take up to twice as long to air dry as conventional solvent-based coatings. This reduces productivity and increases the exposure of uncured finishes to degradation. The decreased drying time associated with short-wave IR can restore or improve the productivity of shops that use new coating formulations. In one EPRI case study, a portable short-wave IR lamp reduced auto drying times by more than 50%—from 25 minutes with a standard heat lamp (medium-wave IR) to 12 minutes.

Emerging Electrotechnology Solution

Ultraviolet Curing. Using ultraviolet (UV) radiation to cure coatings produces many of the same advantages as short-wave IR radiation: reduced requirements for labor, space, and energy, and extremely rapid curing and drying times. This technology, however, is being used in only a few automotive applications at the OEM level and has not been demonstrated at the body shop level. It is well-accepted in industrial applications, particularly where a clean or very thin coating is required, such as in decorating metal, hardening polymers on no-wax flooring materials, and putting protective insulating coatings on printed circuit boards. In addition, while UV equipment is available for a range of applications, it is not readily available to the auto body shop industry and would require a larger investment than short-wave IR drying equipment. As waterborne paints further penetrate the OEM market, UV curing equipment may become increasingly common in auto body shop applications.

VOC Control

Although less desirable than making process changes to reduce VOC emissions, body shops could potentially install add-on control technologies such as incineration or carbon adsorption to destroy or capture and recycle VOCs. Medium-sized and larger shops (i.e., shops with 50 or more employees) with paint mixing rooms and drying ovens usually have induced-draft fans that collect VOC-laden air and pipe it to the control technology. Using control technologies can be a problem, however, if different VOC-emitting processes are being employed. The various exhaust streams may be incompatible as a result of using different solvents and coatings and may have to be treated separately.

In general, two types of incineration are available for destroying solvent vapors in industrial applications: thermal incineration and catalytic or flameless incineration. Both can typically achieve greater than 95% destruction of VOCs. Incineration relies on the oxidation of the solvent to carbon dioxide and water, which can then be released safely to the atmosphere. Solvents that contain halides such as chlorine or bromine, sulfur compounds, silicon, or heavy metals, however, may require additional treatment.

While solvent incineration systems are in use at industrial painting and coating facilities, adoption of incineration units at refinishing shops is regarded as unlikely.

Solvent incineration systems for the largest auto refinishing shops would cost between \$400,000 and \$1,000,000. It would be difficult to justify such costs for all but the largest shops—those performing more than 1000–2000 major refinishing jobs annually. A catalytic incinerator for a large shop, for example, would draw about 25 kW and use about 50,000 kWh annually.

Carbon adsorption is a viable alternative if the exhaust air stream contains a low concentration of VOCs. This technology is readily adaptable to existing VOC-collection systems and is less expensive than incineration. In carbon adsorption, VOC molecules are trapped and held on carbon's vast internal surface area. (The grains in one pound of activated carbon have an internal surface area of about five million square feet; thus, one pound of activated carbon can hold 20–50% of its weight in VOCs.) Activated carbon can be used to collect or capture VOCs in exhaust streams from paint spray booths, paint and solvent mixing areas, and other contaminated areas. Adsorption can be used by itself or as a preconcentrator for an incinerator.

When the carbon reaches its adsorption limit, it must be regenerated or discarded. Regeneration involves passing low-pressure steam through the carbon bed, desorbing the solvent, and carrying it away as vapor. The vapor then passes through a condenser, and the liquid solvent and water are collected in a tank. Since the solvent has a lower specific gravity, it floats on the water and can be removed and reused or disposed of. As auto body shops are not likely to have the on-site steam required for carbon regeneration, a carbon adsorber may slightly increase electricity use.

At present there are no electric-based alternatives to incineration or carbon adsorption. Three emerging electrotechnologies may, however, play a role in VOC control in the future. These include biofiltration, membrane separation, and ultraviolet oxidation.

Emerging Electrotechnology Solution

Biofiltration. Biofiltration is being explored as a benign substitute for incineration and carbon adsorption. While the technology is technically feasible for the auto body industry, it is not currently economically feasible because shop-sized systems are not yet commercially available. In a biofiltration system, VOC-laden exhaust streams are humidified and passed through a biologically active bed. VOCs are diffused through the material and are destroyed by aerobic biodegradation. Bacteria convert 90% of the VOCs to carbon dioxide, water, and sometimes inorganic acids. Although the biological filter media needs periodic replacement, it is not considered a hazardous waste.

The low concentration of VOC emissions associated with auto body shops makes biofiltration a potential future control option. At lower concentrations, the costs of incineration can be significant, and biofiltration may be a competitive alternative. The main advantages of this technology are low capital and operating costs (due to room temperature operation) when compared to other VOC-control technologies such as incineration, and the absence of residues that require further treatment or disposal. In Europe, many chemical process industry plants are using biofilters to deodorize and remove VOCs from waste gases. In the United States, units have been limited to chemical industry applications, but the potential for the technology is believed to be enormous.

Emerging Electrotechnology Solution

Membrane Separation. Membrane separation technology uses a semipermeable composite membrane to separate as much as 99% of VOCs from a vapor stream. The membrane is permeable to VOCs but not to air. A vacuum pump or compressor is used to create a vapor pressure differential that pulls the organic vapors across the membrane. After VOCs are separated from the airstream they are sent to a condenser for recovery as solvent. The costs of operating the unit are proportional to the volume of air treated and are relatively independent of the concentration of solvent. (Carbon adsorption costs usually increase with solvent concentration, while incinerator operating costs decrease as solvent concentration increases.) Although the process is not limited to high concentrations of VOCs, it may not be as economical as carbon adsorption at very low concentrations.

There are currently a number of membrane separation installations in the United States, all in the chemical process industry. The developers, who are working under EPA funding, believe that the technology will become applicable for small VOC-laden vapor streams, such as those characterizing auto body shops, but pilot-tests have not yet been conducted.

Emerging Electrotechnology Solution

Ultraviolet Oxidation. Ozone has been used for years for purification, disinfection, detoxification, and deodorization. Its high oxidizing potential allows it to rapidly destroy a variety of wastes including VOCs. Currently, some non-automotive coatings operations are using ultraviolet light and activated ozone to destroy VOCs and thereby comply with emissions requirements. Installed to treat paint spray booth and oven emissions, a UV oxidation unit has the advantages of destroying VOCs in their original media, forming no by-products, and requiring no further treatment.

While UV oxidation is a proven technical success, its high capital and operating costs suggest that it will find only niche applications, particularly in processes with a limited ability to reformulate coatings. UV oxidation could, however, become a viable VOC control technology in the auto refinishing sector if more stringent emissions regulations are imposed (thereby warranting the expense) and/or technological advances reduce the system costs.

Lighting

As noted earlier, quality work and reasonable turnaround times are essential attributes for a successful, competitive auto body shop. Adequate lighting, to aid worker vision, is critical to ensuring that body parts are properly shaped, treated, and finished. Due to the nature of the work, both the repair areas and paint booths used for surface preparation and paint application require high levels of lighting with good color rendition.

Three types of lighting systems are used in auto body shops. The most common system is fluorescent tubes with magnetic ballasts. A typical shop lights the majority of the facility with this type of system. Fluorescent lamps are available in a variety of shapes and sizes. Some of the most commonly used are four-foot-long tubes used in two-tube, three-tube, and four-tube fixtures. Eight-foot-long tubes are also used, particularly in larger facilities. U-shaped tubes are also popular for use in square fixtures. Few auto body shops use compact fluorescent lamps.

The second most common lighting source is the incandescent lamp, used in 40% of auto body shops. These fixtures are relatively inexpensive and are easy to install but are the least efficient lighting source available. As a result, auto body shops use them to light only an average of 8% of shop floor space: to light offices, hallways, and common areas, but not the repair and finishing areas. They are also used for illuminating signs, displays, and exit signs.

High intensity discharge (HID) lamps are also used in auto body shops. Approximately 18% of auto body shops use HID lamps, particularly the larger shops. The HID family of lamps includes mercury vapor, metal halide, and high-pressure sodium lamps. All of these lamps are more energy efficient than fluorescent lamps and have significantly longer lives. Unfortunately, their color rendition is not as good as fluorescent lamps; hence, HID lamps are most commonly used in parking lots, driveways, and large warehouse-style facilities.

Efficiency Technology Solution

Energy-Efficient Indoor Lighting. The most efficient form of fluorescent lighting available today is the T-8 fluorescent lamp with an electronic ballast. Conversion from a magnetic (T-12, 40-watt) ballast to an electronic (T-8, 32-watt) ballast can be accomplished by either retrofitting the existing fixture or installing a new fixture designed for T-8 lamps, at a cost of roughly $40 and $100, respectively. Ceiling-mounted incandescent lamps can be successfully replaced with compact fluorescent lamps when the ceiling height is less than 12 feet, such as in hallways. Mercury vapor lamps can be replaced with either metal halide or high-pressure sodium lamps with relatively short payback. All of the HID lamps have significantly longer lives than incandescent lamps and many fluorescent lamps.

Electrotechnology Solution

Energy-Efficient Outdoor Lighting. Many auto body shops also have some form of outdoor lighting. Existing applications may range from incandescent lights highlighting a shop's sign to mercury vapor lights in the parking lot and driveway. These lighting systems normally represent only a small portion of the energy bill because they are on for limited periods of time and because they seldom contribute to the facility's peak electrical demand. This means that the cost for operation, in terms of cents per kilowatt-hour, is normally less than for other systems (e.g., cooling, heating, and indoor lighting). As a result, the potential savings from energy conservation projects is likely to be small. However, more significant benefits may accrue by increasing outdoor lighting levels to reduce the potential for crime, increase employee safety, and improve the visibility and attractiveness of the facility exterior and grounds (a form of advertising that lends an aura of success).

Heating, Ventilating, and Air Conditioning

Auto body shop heating, ventilating, and air conditioning (HVAC) systems are very basic. Shops typically leave overhead doors open in the summer for cooling, and use direct-fired or hot water unit heaters for heating in the winter. Few shops have air conditioning; some shops have gas radiant heaters.

Conversely, auto body shop ventilation systems can be complex. These systems, which serve the shop paint booth(s), are essential to product quality and environmental compliance. As a result, shop owners are likely to focus energy and process improvement projects on the paint booth area.

The purposes of a paint (spray) booth are to

- provide a dust-free environment for a quality finish;
- provide a method of handling overspray;
- provide a well-lit, ventilated area for employees;
- capture, contain, and remove solvent vapors (VOCs); and
- provide an enclosed area for curing and drying the finish at temperatures of 120–140°F.

Booths are designed for crossdraft or downdraft airflow and employ various filtering and air cleaning systems. According to a 1995 industry survey, 50% of all body shops own crossdraft booths, 30% own downdraft booths, and an additional 20% are planning to purchase a downdraft booth in the near future. Also, nearly 30% use air filtration systems, and more than 12% plan to purchase a filtration system in the near future.

Both downdraft and crossdraft booths are sold as complete packages. A downdraft booth package, for example, consists of a booth with a ceiling air distribution system and a floor exhaust grille. The makeup-air intake duct is mounted outside the building and is typically connected to an outdoor furnace. The furnace discharges into the booth ceiling plenum and the air is vented into the booth through a filter system that covers the entire ceiling. The floor exhaust grille is located under the vehicle and is connected, under the floor, to an outside filter system. These filters collect paint overspray and are disposed of by certified hazardous waste specialists. With the booth doors closed, this paint system prevents undesirable infiltration into the shop. Older booths, however, may have exhaust systems that lack a complimentary makeup-air system; this may cause unwanted infiltration into the shop. Control of such infiltration could help reduce heating costs.

Efficiency Technology Solution

Adjustable Speed Drives. Airflow in the paint booth is an important factor in the quality of a paint finish. Adjust-able speed drives (ASDs) can be installed on both supply and exhaust fans to improve productivity, product quality, and energy efficiency. The drives use solid-state electronics to vary the frequency of the electricity applied to the motor. By reducing the frequency below the nominal 60 Hz, ASDs can efficiently reduce the speed or output of a motor, thereby permitting the airflow in the booth to be varied. The ability to alter airflow in the booth can improve productivity by reducing the number of defects that would require redoing a job; it can increase energy efficiency by providing only the amount of air needed for each job.

Electrotechnology Solution

Electric Infrared Space Heating. Electric IR space heating is an innovative HVAC-related electrotechnology that can potentially help auto body shops reduce operating costs and increase comfort. IR space heaters can be used to heat repair bays, paint booths, and storage areas in an auto body shop—areas that require high ventilation rates and may be exposed to the outdoors.

IR space heating is accomplished through electromagnetic radiation. Although these systems are referred to as “space heaters,” they do not actually heat the space, but rather the objects (e.g., people) in the space. The heaters and their radiation are typically directed at the people in the space, but also heat other objects, such as floors, walls, and furnishings. These objects in turn retransmit the heat they receive.

IR space heaters are relatively inexpensive to purchase and easy to install and operate, when compared to conventional space heating systems such as the hot water unit heaters common in auto body shops. In addition to electricity, natural gas and propane can be used to fuel an IR heater. These heaters can reduce overall energy requirements by keeping people warm while allowing the background temperature to be maintained at 50–60°F. Their primary disadvantage is that if used to maintain background temperatures of 70°F, their overall efficiency is no greater than conventional resistance heating. In addition, for people to feel comfortable, they need to be radiated from both sides, requiring installation of heaters in a criss-cross pattern. The technology is widely used in warehouse-type settings, and units are available from several manufacturers.

4

ELECTROTECHNOLOGY PROFILES

This section provides profiles of the electrotechnologies identified in Sections 2 and 3. Each profile explains the technology, its advantages and disadvantages, commercial status, and costs. The profiles have been designed as stand-alone descriptions so they can be utilized separately from this guidebook. For further information, or to learn more specific technical details, turn to Section 5 for a list of equipment vendors.

Short-Wave IR Drying & Curing

Basic Principle

Infrared (IR) is part of the electromagnetic spectrum, occurring between visible light and radio waves (0.7 to 1000 microns). IR wave-lengths are separated into three ranges: long, medium, and short. Electric IR radiation is produced by heating an emitter of IR radiation. The radiation emitted is then absorbed by the substance at which it is directed, causing the molecules of the substance to vibrate and generate heat. In auto body refinishing, the heat thus generated dries or cures a coating from the inside out. IR systems require no special airflow for heat transfer because energy radiates directly to the coated surface without heating the air. By localizing the origin of the emissions, and allowing the use of reduced- or nonsolvent coatings, the technology enables auto body finishing facilities to significantly reduce or eliminate VOC emissions.

System Description

Although medium-wave IR (e.g., standard heat lamp) equipment has been used to cure paint for many years, equipment incorporating the newer, short-wave technology is far superior for curing paints and coatings.

A typical short-wave IR system includes quartz lamps and reflectors. Large systems are configured as a tunnel or bank of lamps on a process line; smaller applications use moveable arch or portable arm-mounted lamps (see figure). An IR system reaches full power in less than one second and can be accurately regulated with simple controls. Electric IR systems are also highly energy efficient, especially in comparison to gas IR systems. In an electric IR system, more than 85–90% of the energy used is converted to radiation, and 50–70% of the energy is absorbed by the substance that needs drying. A gas IR system transfers only 20–25% of the energy to the drying substance and produces emissions of its own.

Arm-Mounted IR Unit for Spot Curing

Advantages

- Dries or cures a coating in very little time. Process time can be reduced by as much as 50–80% in comparison to conductive ovens.
- Markedly increases production potential.
- Quick startup and shutdown eliminates costly preheating, thereby increasing the overall efficiency.
- Relatively insensitive to changing conditions (i.e., temperature, humidity), resulting in consistent, high-quality results.
- Modular design and small size of IR panels allows flexibility; they are easily incorporated into existing production lines and have minimal requirements for floor space.
- Reduced need for air circulation since IR heats the product directly.
- Long lifespan, little routine maintenance.
- Short payback period.

Disadvantage

- The initial capital cost can be high.

Short-Wave Infrared Curing System Characteristics

Heater Head Dimensions	Diameter 2″ Length: 47″ Width: 25″
Power Rating	8–15 kW per square foot
Energy Consumption	4160 kWh annually*
Key Inputs Power Other	 Electricity None
Key Outputs Solid Waste Air Emissions Water Effluent	 None None None
Cost Purchase Installation Other Supplies	 Panel: $1000–$2500 Custom oven: $10,000–$250,000 Minimal None

*Assuming an 8-kW unit used 2 h/d, 5 d/wk, 52 wk/yr.

Commercial Status

Long- and medium-wave IR are well-known and have been used to cure coatings since the 1930s. A variety of IR source systems are available through numerous vendors. Systems can be obtained with heating element temperatures ranging from 600–4000°F, thereby producing radiation in the 1.0–6.0- micron wavelength. However, as the auto manufacturing industry makes increased use of high-solids, waterborne, and powder coatings, short-wave technology (0.7–2.0- micron wavelength) has performed more effectively and is being used more often by original equipment manufacturers for drying and curing, thereby setting a new product standard that refinishers must match. As evidenced by the large number of IR equipment manufacturers active in this market, a large number of auto body shops are already using short-wave IR drying equipment.

Cost and Electrical Requirements

A basic short-wave IR spot heater or panel heater with two or three quartz emitters generally costs $1000–$2500. Custom-designed ovens cost between $10,000 and $250,000.

IR ovens typically cost 10–20% less than gas convection ovens for the same application and features. This is primarily because fewer control systems are required (e.g., air-handling equipment and gas-related safety features).

Curing Times (in minutes)*

Coating Type	Infrared	Oven	Air Dry
Etch	6	12	20
Primer	8	35	120
Hi-Build	10	45	180+
Topcoat	12	40	240
Waterborne Primer	8	30	60+

Outdoor Lighting

Basic Principle

Many small businesses benefit from enhanced outdoor lighting through reduced potential for crime, increased employee safety, and improved visibility and attractiveness of the facility.

These benefits are obtained for a relatively small operating cost because, in most cases, outdoor lighting does not contribute to a facility's peak electrical demand. This means that the average energy cost for outdoor lighting (in terms of cents/kWh) is typically less than the energy cost of other improvements.

Typical Outdoor Lighting Applications

Type of light	Exterior Signage	Parking Garages	Parking Lots/ Driveways	Walkways	Facade and Landscaping
Incandescent	■			■	■
Compact Fluorescent		■		■	■
Fluorescent	■	■		■	■
Metal Halide		■	■	■	■
High-Pressure Sodium			■		
Mercury Vapor			■		

Note: Additional applications are possible for each of the lighting types, but the chart identifies the most efficient applications for each of the light sources. Low-pressure sodium lamps are not normally used in small businesses because of their poor color quality.

There are three principal methods for using outdoor lighting in small businesses:

1. Signage on the exterior of the building or illuminated signs near the building to generate attention for the building or the small business

2. General lighting in parking lots, driveways, parking garages, and walkways

3. Facade lighting to increase the visibility of the structure and surrounding architectural features and landscaping

Different lighting technologies are typically used for different applications. Existing lighting systems can often be retrofitted or replaced by energy-efficient lighting systems. In addition, existing lighting systems can be supplemented with new lighting systems to increase safety, security, visibility, and name recognition.

System Description

Mercury vapor, high-pressure sodium (HPS), and metal halide lamps are referred to as high-intensity discharge (HID) lamps. Metal halide lamps and HPS lamps provide approximately 100 and 140 lumens per watt, respectively, while mercury vapor lamps provide up to 60 lumens per watt. Mercury vapor lamps emit a bluish green light while HPS lamps emit a yellow orange light. Metal halide lamps emit a predominately white light. Most HID lamps require a spacing-to-mounting height ratio of 1.0–1.9, which means that the spacing is roughly one to two times the pole height.

Each HID lamp requires a specific ballast to drive the lamp; however, some manufacturers offer metal halide and HPS lamps that can be operated by a mercury vapor lamp ballast. This allows easier conversion from inefficient mercury vapor lamps to higher-efficiency metal halide and HPS lamps. HID lamps are available in a variety of wattages from 35–1500. The HID ballast adds approximately 8–15% to the wattage of the lamp.

Fluorescent lamps are also used as outdoor lighting sources for small businesses. Conventional 4-foot and 8-foot tubes are used in many parking garages and covered walkways. Compact fluorescent lamps are also becoming popular as replacements to incandescent lamps in stairways. Newer T-8 lamps and electronic ballasts are approximately 30% more energy efficient than older 40-watt T-12 lamps with magnetic ballasts.

Incandescent lamps are the least efficient form of outdoor lighting. However, incandescent lamps are still used as spot lights on signs and as flood lights on building facades and landscaping. The short lifetime of incandescent lamps often has a bigger impact on operating costs than does the additional energy use.

Common controls used for outdoor lighting systems include time clocks, photocells, and programmable controllers.

Typical Lamp Characteristics for Outdoor Applications

Type of Lamp	Typical Wattages	Initial Lumens/Watt	Avg. Rated Life (h)
Incandescent	60–1,500	15–24	750–2,500
Compact Fluorescent	12–35	25–75	8,000–12,000
Fluorescent	20–215	50–100	9,000–20,000
Metal Halide	175–1,500	69–115	10,000–20,000
High-Pressure Sodium	35–1,000	51–140	7,500–24,000
Mercury Vapor	40–1,000	24–60	12,000–24,000

Note: Initial lumens/watt includes ballast losses.

Advantages

Well-designed outdoor lighting systems can offer the following advantages:

- Increased perception of comfort and friendliness
- Increased security for customers and employees
- Reduced accidents in driveways, parking areas, and walkways
- Increased visibility for the facility and the small business

Disadvantages

Other than installation and operating costs, there are no overall disadvantages of outdoor lighting. However, specific lamps do have weaknesses:

- HID lamps require 2–7 minutes to warm up before reaching full output.
- Metal halide lamps require up to 15 minutes to cool before restrike.
- Special low-temperature fluorescent lamps are required in cold climates to maintain a relatively constant lumen output below freezing.

Commercial Status

All of the lamps described above are readily available from a variety of manufacturers. However, mercury vapor and older T-12 fluorescent lamps are being phased out of production.

Gradual improvements have been made in the efficiency of outdoor lighting systems. In addition, color-corrected HPS lamps are available, as well as improved metal halide lamps that contain incandescent or fluorescent lamps that come on if the power is interrupted.

EPRI Information

Additional information on lighting technologies is available from the EPRI Lighting Information Office, (800) 525-8555.

Electric Infrared Space Heating

Basic Principle

Heat is transferred in three ways: convection, conduction, and radiation. In most space heating systems, convection and conduction are the principal heat transfer mechanisms. Infrared (IR) space heating is accomplished through electromagnetic radiation. Natural gas, propane, and electricity are the fuels commonly used by IR heaters. Although these heaters are referred to as "space heaters," they do not directly heat the space; they heat the objects in the space which in turn eventually heat the space. The term "infrared space heating" is used to distinguish comfort heating applications from IR process heating.

Electric IR heaters have two basic components, an IR heating element and a reflector. The IR heating element is composed of a resistor material (or radiator) that gives off electromagnetic energy in the IR portion of the spectrum when excited by an electric current. The resistor material is partially enclosed in the reflector, a fixture that reflects the radiation toward the object to be heated. Resistor materials include tungsten wire in a quartz tube, nickel chromium alloy in a quartz tube, tungsten wire in a reflector lamp, and nickel chromium alloy in a metal rod. In space heating applications, the IR radiation is normally directed toward the people in the area. However, the radiation also strikes other objects, such as the floors, walls, equipment, and furnishings. These objects then retransmit the heat they receive, through secondary convection, conduction, and radiation. In this way, IR heaters can be used to warm the air in a room to a set temperature, much like a conventional heating system.

Tungsten wires in quartz lamps and reflector lamps operate at filament temperatures of about 4050°F and radiate energy in the "near-infrared" portion of the spectrum. These lamps have the added advantage of providing visible light of approximately 8 lumens per watt. This can help illuminate work areas. The potential downside is that when heating is not needed, the extra light is missing. Other lamp elements, such as metal sheath, open wire, and ribbon elements, operate between 1200°F and 1800°F and emit in the "far-infrared" portion of the spectrum.

Applications

IR heaters are used in a variety of applications, including golf driving ranges, storage rooms, fire station garages, loading docks, covered walkways, warehouses, commercial/industrial plants and shops, outdoor restaurants, hotels and motels, shopping centers, and store entrances. The most cost-effective applications are in areas exposed to the outdoors or areas that require high ventilation rates.

An IR system can be designed to maintain an air temperature of over 70°F in an enclosed room. In this case, the overall efficiency of the system approaches 100%, but as little as 50% of the radiated energy actually reaches the people or objects. The ideal application is an area maintained at 50°F in which IR heaters are used to warm the people. An example is a large warehouse watched over by a stock person near the main door. IR heaters could be installed where the stock person spends the most time, providing the stock person heating comfort irrespective of the warehouse temperature overall.

System Description

IR lamps and fixtures are available in a variety of shapes and sizes. They are normally hung from or attached directly to the ceiling, in a manner similar to a lighting system, with careful attention to the maximum height of forklifts, trucks, cranes, etc. that operate in the area. The IR-system designer determines the desired energy levels for the different parts of the facility and then estimates the equipment wattage required to produce the desired energy levels. The fixtures are typically available in 120-, 240-, 277-, and 480-volt systems. Simple switches, time clocks, timers, and thermostats are used to control fixture output.

The lamp efficiency depends on the material of the resistor or radiator. Clear quartz lamps have an efficiency of about 96%. Tungsten wire and quartz tubes have efficiencies of 60–80%. Metal rods have lamp efficiencies as low as 50%. The overall efficiency of the IR system depends on the type of IR element in the lamp, the absorptivity of the people and equipment near the lamp, and the efficiency of the fixture (including the reflectivity of the reflector and the directional efficiency of the fixture). Other factors to consider in selecting an IR element include amount of visible light output, time required to develop full output, vibration resistance, and color of light. The life expectancy of any IR lamp is about 5000 hours or more.

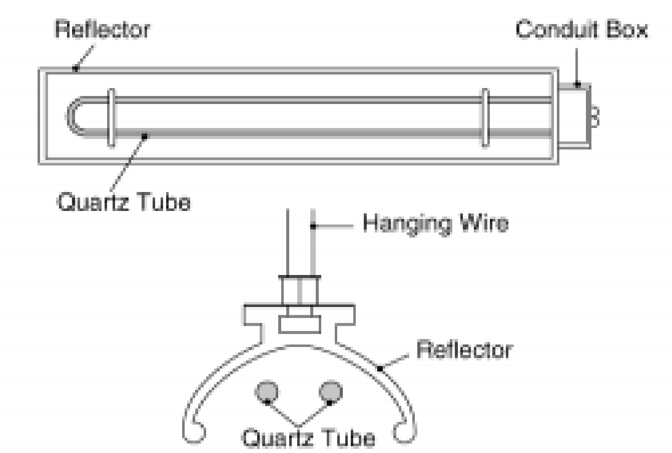
Advantages

- Relatively inexpensive and easy to install compared to conventional HVAC systems

- Keeps people comfortable in relatively open areas such as bus stops, covered breezeways, loading docks, outdoor restaurants, and garages
- Reduces the overall energy required to heat an area by allowing a background temperature of 50–60°F
- Simple to lay out, control, and maintain
- Can be used to heat "trouble spots" such as lobby areas, hallways, and entrances
- Less complicated than gas heating because there is no gas piping or ventilation of combustion by-products

Disadvantages

- If systems are used to maintain space temperatures of 68–70°F, the overall efficiency is no better than conventional resistance heating.
- Mounted at ceiling heights of over 30 feet, IR lamps do not keep people warm.
- People need to be radiated from both sides to feel comfortable. That is, enough lamps must be installed to produce a criss-cross pattern.



Electric Infrared Space Heating

Commercial Status

Electric IR space heaters are available from several manufacturers in a variety of shapes, sizes, voltages, and radiant output. They come in both conventional fixtures and radiant wall and ceiling panels. A manufacturer's sales representative normally assists in estimating the required energy output and planning unit locations. Sales representatives can also assist in performing a simple heat loss calculation for the facility or area to be heated.

Cost and Electrical Requirements

The cost for electric IR systems varies significantly depending on the complexity of the unit and the number of fixtures used. For example, a simple loading dock application with four fixtures and an on/off switch costs under $2000. However, a large industrial application with specialized controls and fixtures costs over $100,000.

The electrical requirements are very straightforward. Once the supply voltage is decided, the individual wattages of the lamps required to produce the desired results can be estimated. The total electrical requirements are simply the total wattage of the lamps installed on a particular electrical circuit in the facility. For example, a facility using four fixtures at 7 kW (total) for 8 h/d (2000 h/yr) would require 56 kWh/d (14,000 kWh/yr) of electricity.

Electric Infrared Heating Fixture Characteristics

Dimensions	Length: 15–58" Width: 8–32" Height: 4–13" Weight: 9–55 lb
Power Rating	0.5–13.5 kW
Minimum Mounting Height	10–14 ft
Key Inputs	
Power	Electricity
Other	Infrared lamp replacements
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effluent	None
Cost	
Purchase	Small: $100–$3000 Large: $2,000–$100,000
Installation	Minimal
Other Supplies	$40–$160 per 1–3 years

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RESOURCES

This section contains three lists: (1) equipment suppliers for the electrotechnologies profiled in this guidebook, by equipment type; (2) EPRI information resources on efficiency technologies; and (3) auto body trade associations. Information used to compile these lists was based on a combination of a telephone survey, published reports, directories, buyer's guides, and technical journals. The information was current at the time of publication and is expected to change over time.

Short-Wave IR Drying and Curing

Equipment Suppliers

Aitken Products Inc.
P.O. Box 151, 566 North Eagle St., Geneva, OH 44041
(216) 466-5711, fax: (216) 466-5716

Americure, Inc.
2353 W. Lincoln St., Phoenix, AZ 85009
(602) 253-3130

Argus International
P.O. Box 38-M, Hopewell, NJ 08525
(609) 466-1677, fax: (609) 466-4111

BGK
4131 Pheasant Ridge Dr. N.E. Minneapolis, MN 55449
(612) 784-0466, fax: (612) 784-1362

Cleveland Process Corp.
127 S.W. Fifth Ave. Homestead, FL 33030
(800) 241-0412, fax: (305) 248-4371

Dry-Clime Corporation
P.O. Box 146, State Rd. 46 W. Greensburg, IN 47240
(812) 663-4141, fax: (812) 663-4202

Edwin Trisk Systems
670 New York Street, Memphis, TN 38104
(800) 261-7976, fax: (901) 274-8355

Eraser Company, Inc.
Olivia Drive, P.O. Box 4961, Syracuse, NY 13221
(315) 454-3237, fax: (315) 454-3090

Future Cure
29313 Clemins, Westlake, OH 44145
(800) 722-4664, fax: (216) 835-1578

Fostoria Industries, Inc.
1200 N. Main St. Box 986, Fostoria, OH 44830
(419) 435-9201, fax: (419) 435-0842

Glenro, Inc.
39 McBride Ave. Paterson, NJ 07501
(800) 922-0106, fax: (201) 279-9103

Infratech Corporation
1634 Industrial Park St. Covina, CA 91722
(818) 331-9400

Infratrol Manufacturing Corporation
646 S. 29th St. Milwaukee, WI 53234
(414) 671-7140, fax: (414) 671-5088

IRT Systems
89 Connie Crescent Concord, Ontario L4K 1L3, Canada
(800) 387-3639, fax: (905) 669-1171

Prime Heat
1946 John Towers El Cajon, CA 92020
(619) 449-6623, fax: (619) 449-9844

Process Thermal Dynamics
304 G 50th Ave. Alexandria, MN 56308
(612) 762-2077, fax: (612) 762-1319

Radiant Energy Systems
458 Hamburg Turnpike Wayne, NJ 07470
(201) 942-7767, fax: (201) 942-5581

Solaronics
704 Woodward Rochester, MI 48307
(810) 651-5333, fax: (810) 651-0357

Tech Systems
1030 N. Lincoln St. Greensburg, IN 47240
(812) 663-4720, fax: (812) 663-4799

Watlow Electric Manufacturing Company
12001 Lackland Rd., St. Louis, MO 63146
(314) 878-4600, fax: (314) 878-6814

Outdoor Lighting

Equipment Suppliers

Bairno Corp.
2251 Lucien Way, No. 300, Maitland, FL 32751
(407) 875-2222

Bieber Lighting Corp.
970 W. Manchester Blvd. Inglewood, CA 90301
(213) 776-4744, fax: (213) 776-0235

Bulbtronic Inc.
45 Banfi Plaza Farmingdale, NY 11735
(800) 647-2852, (516) 249-2272, fax: (516) 249-6066

Carlon (Lanson & Sessions Co.)
25701 Science Park Dr. Cleveland, OH 44122
(216) 831-4000, fax: (216) 831-5579

Cooper Lighting Group
400 Busse Rd., Elk Grove Village, IL 60007-2195
(708) 956-8400

Crouse-Hinds Co.
Lighting Production Div., P.O. Box 4999, Syracuse, NY 13221
(315) 477-8185

Doane, L.C., Co.
55 Plains Rd., P.O. Box 975, Essex, CT 06428
(203) 767-8295, fax: (203) 767-1397

Duro-Test Corp.
9 Law Dr. Fairfield, NJ 07004
(201) 808-1800, fax: (201) 808-6622

Federal APD Inc., Federal Signal Corp.
24700 Crestview Court Farmington Hills, MI 48335
(800) 521-9330, (313) 477-2700, fax: (313) 477-0742

Gardco Lighting
2661 Alvarado St. San Leandro, CA 94577
(510) 357-6900, fax: (510) 357-3088

G.E. Company
3135 Easton Turnpike Fairfield, CT 06431
(800) 626-2004, fax: (518) 438-2527

Hapco Div. of Kearney-National Inc.
P.O. Box 547, Abington, VA 24210
(703) 628-7171

ITT Outdoor Lighting
A Unit of the Lighting Fixture Div. Southaven, MS 38671
(601) 342-1545

Litetronics International
4101 W. 123rd St. Alsip, IL 60658
(708) 389-8000 ext 195, fax: (708) 371-0627

Mason, L.E. Co.
98 Business St. Boston, MA 02136
(617) 361-1710

Philips Lighting Co.
200 Franklin Sq. Dr. Somerset, NJ 08875
(908) 563-3000, (800) 631-1259, fax: (908) 563-1259

Rig-A-Light
P.O. Box 12942, Houston, TX 77217
(713) 943-0340, fax: (713) 943-8354

Sterner Lighting Systems
351 Lewis Ave Winisted, MN 55395
(612) 485-2141, fax: (800) 328- 3635

Sylvania Lighting Equipment
Lighting Special Production
465 Devon Park Dr. P.O. Box 500, Devon, PA 19333
(508) 678-3911

Unique Solution/Manville
515 McKinley Ave. Newark, OH 43055
(614) 349-4194

Electric Infrared Space Heating

Equipment Suppliers

Aitken Products Inc.
P.O. Box 151, 566 North Eagle St. Geneva, OH 44041
(216) 466-5711, fax: (216) 466-5716

Chromalox Industrial Heating Products
641 Alpha Dr. Pittsburgh, PA 15238
(412) 967-3800

Fostoria Industries, Inc.
1200 N. Main St. Box 986. Fostoria, OH 44830
(419) 435-9201, fax: (419) 435-0842

Spectrum Infrared, Inc.
246 East 131 St. Cleveland, OH 44108
(216) 451-6666, fax: (216) 451-2510

Zimco Inc.
24-45 Little Neck Blvd. Bayside, NY 11360
(718) 224-2699, fax: (718) 229-5597

Information on Efficiency Technologies

This list provides EPRI resources on efficiency technologies identified in this guidebook. Copies of publications can be ordered through the EPRI Distribution Center, (510) 934-4212.

Adjustable Speed Drives

Medium-Voltage Adjustable Speed Drives: A Basic Specification Guide, BR-104420, 1995.

Adjustable Speed Drives: Application Guide, TR-101140, December 1992.

Adjustable Speed Drive Directory, Third Edition, CU-7544, December 1992.

Assessment of Electric Motor Technology: Present Status, Future Trends and R&D, TR-101264, December 1992.

Proceedings: Advanced Motors and Drives R&D Planning Forum, TR-191288, December 1992.

Environmental Benefits of Adjustable Speed Drive Applications, TR-100200, July 1992.

Energy-Efficient HVAC

Electric Chiller Handbook, TR-105951, February 1996.

Space-Conditioning System Selection Guide, TR-103329, December 1993.

Packaged Terminal Heat Pump Assessment Study, CU-6777, March 1990.

Information on HVAC is also available from the EPRI HVAC&R Center, (800) 858-3774.

Energy-Efficient Lighting

Proceedings—Efficient Lighting 1993: A Lighting Symposium for Electric Utility Lighting and DSM Professionals, TR-105963, January 1996.

Electronic Ballasts, BR-101886, May 1993.

High-Intensity Discharge Lighting, BR-101739, May 1993.

Advanced Lighting Technologies Application Guidelines: *1990,* TR-101022-R1, May 1993.

Lighting Fundamentals Handbook, TR-101710, March 1993.

Commercial Lighting Efficiency Resource Book, CU-7427, September 1991.

Information on lighting is also available from the EPRI Lighting Information Office, (800) 525-8555.

Trade Associations

Automotive Service Association
P.O. Box 929, 1901 Airport Freeway, Bedford, TX 76095-0929, (817) 283-6205,
(800) 272-7567, fax: (817) 685-0225

Members are businesses providing automotive service in mechanical, auto body, transmission, and other fields.

Automotive Service Industry Association
25 Northwest Point Blvd. 4th Floor, Elk Grove Village, IL 60007-01035
(708) 228-1310, fax: (708) 228-1510

Members are manufacturers, remanufacturers, manufacturers' representatives, distributors, and jobbers in seven divisions, including paint/body equipment.

Inter-Industry Conference on Auto Collision Repair
3701 W. Algonquin Rd. Suite 400, Rolling Meadows, IL 60008-3118
(800) 422-7872, fax: (800) 590-1215

Members are major auto manufacturers; insurance companies; auto collision repair shops; tool, equipment, and supply manufacturers; and related industry and trade associations.

National Association of Auto Trim Shops
6255 Barfield Road, Suite 200, Atlanta, GA 30328
(800) 241-9034, fax: (404) 252-4436

Members specialize in enhancing the appearance of cars and other vehicles.

Paint, Body, and Equipment Association
9140 Ward Parkway, Kansas City, MO 64114
(816) 444-3500, fax: (816) 444-0330

Members are distributors of automotive paint and other repair products and affiliate manufacturer suppliers.

Society of Collision Repair Specialists
131 N. Tustin Ave., Suite 210, P.O. Box 3765, Tustin, CA 92680
(714) 835-3110, fax: (714) 835-3118

Members are owners and managers of auto collision repair shops in the United States, Canada, Australia, and New Zealand. The organization distributes technical information, develops and maintains industry standards, and conducts seminars and workshops on collision repair facility management.