SURFACE COATING POLLUTION PREVENTION REFERENCE GUIDE

Helping Surface Coaters Reduce Pollution at the Source and Avoid MACT Regulation

Colorado Department of Public Health and Environment

Colorado Department
of Public Health
and Environment

Air Pollution Control Division

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- CDPHE P2 Program
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CHAPTER 1
INTRODUCTION

Amendments to the Clean Air Act in 1990 introduced the universe of regulated businesses to numerous new hazardous air pollutants (HAP) and source categories. Specifically, the Clean Air Act Amendments (CAAA) direct the U.S. Environmental Protection Agency (EPA) to develop national emission standards for hazardous air pollutants that require the application of stringent air pollution reduction measures known as maximum achievable control technology (MACT).

New MACT standards will apply to facilities with surface coating operations that emit or have the *potential to emit* (PTE) more than the MACT standard thresholds of 10 tons per year (tpy) or more of any single HAP or 25 tpy or more of total HAPs (THAP). A facility's PTE is the quantity of emissions that would be generated at maximum capacity under a facility's physical or operational design. Facilities with emissions above the MACT standard threshold are designated *major* sources, and facilities with emissions under the threshold are designated *minor* sources (also known as *area* sources). Although many facilities may be operating in a manner that does not exceed the MACT standard thresholds (for example, because of limited operating shifts), the PTE may require compliance with MACT standards.

EPA is regulating HAP emissions from surface coating operations grouped into 12 source categories:

- ✓ Automobile and Light Duty Truck
- ✓ Boat Manufacturing
- ✓ Fabric Coating, Printing, and Dyeing
- ✓ Large Appliances
- ✓ Metal Can
- ✓ Metal Coil*
- ✓ Metal Furniture
- ✓ Miscellaneous Metal Parts and Products
- ✓ Paper and Other Webs*
- ✓ Plastic Parts and Products
- ✓ Reinforced Plastic Composites Manufacturing
- ✓ Wood Building Products

* These standards have been proposed as of September 2000. All standards are to be proposed by May 2001.

WHAT IS POLLUTION PREVENTION?

Pollution prevention (P2) is a process or raw material change that reduces the quantity or toxicity of an emission or waste *at the point of generation*. P2 is also known as "source reduction" and does not include controlling emissions or wastes after they are generated. For more about P2 in Colorado, refer to www.coloradop2.org.

The MACT standards that apply to these source categories will reduce emissions of pollutants through control technology; however, implementation will impose costs and resource allocation on both the State of Colorado and the private sector. For example, meeting MACT standards involves installing emissions controls and time-consuming monitoring, record keeping, and reporting. Moreover, facilities are required to comply permanently with MACT standards if they are considered a major source on the first compliance date (in other words, "once in, always in"). Finally, no exclusions to the MACT standards will be allowed after the first compliance date, including synthetic minor permits, and all HAP sources above MACT standard thresholds must obtain a Title V operating permit (except for area sources subject to MACT standards; Title V operating permit applications for area sources are due in 2004). Considering these complexities and the resources required to oversee MACT implementation in Colorado, the Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD) initiated a project to promote P2 strategies to surface coating facilities as a means of reducing HAP emissions below MACT thresholds.

This reference guide was developed to help surface coating facilities in Colorado improve compliance, offer P2 opportunities, and provide resources for additional information. This guide does not explicitly or implicitly endorse specific brand products or vendors and any graphics or examples contained herein are for illustrative purposes only.

This reference guide is an outcome of the first phase of APCD's efforts to understand the extent of surface coating operations in Colorado and promote P2 to these facilities (major and minor sources). Specifically, the reference guide presents a profile of surface coating facilities in Colorado (Chapter 2); describes, in general terms, basic steps in the surface coating process and P2 programs and opportunities for specialized surface coating operations (Chapter 3); and discusses P2 strategies that apply to a range of surface coating operations such as improving application efficiency (Chapter 4), powder coating (Chapter 5), and ultraviolet/electron beam (UV/EB) coating (Chapter 6). Chapter 7 contains general information on and references for energy efficiency (E2) for industrial applications. Finally, information about financing P2-associated process changes is included in Chapter 8.

NEED CAAA AND MACT BASICS?

General information about the CAAA and MACT standards:
www.epa.gov/ttn/uatw/epaprogs.html#CAA

A list of HAPs:
www.epa.gov/ttn/uatw/188polls.html

EPA's definition of PTE:
www.epa.gov/ttn/uatw/pte/ptepg.html

Timelines for MACT compliance for various source categories:
Completed:
www.epa.gov/ttn/uatw/mactfnl.html
Proposed:
www.epa.gov/ttn/uatw/mactprop.html
Upcoming:
www.epa.gov/ttn/uatw/mactupd.html

Information about obtaining a synthetic minor permit:
www.cdphe.state.co.us/ap/down/Ps97-001.pdf

OR

Contact Jean Terry in the CDPHE APCD at (303) 692-3255 or jean.terry@state.co.us.

COMMON ACRONYMS IN THIS REFERENCE GUIDE

AIRS	Aerometric Information Retrieval System
APCD	Air Pollution Control Division
CDPHE	Colorado Department of Public Health and Environment
E2	energy efficiency
HAP	hazardous air pollutant
MACT	maximum achievable control technology
P2	pollution prevention
PTE	potential to emit
SIC	standard industrial classification
TE	transfer efficiency
THAP	total (or sum) of hazardous air pollutants
tpy	tons per year

CHAPTER 2
PROFILE OF SURFACE COATING OPERATIONS IN COLORADO

APCD used its Aerometric Information Retrieval System (AIRS) database of reported emissions from industrial and commercial sources to identify major and minor facilities involved in surface coating operations in Colorado. Figure 1 illustrates the data filtering process used to identify 219 facilities in Colorado that are engaged in surface coating operations included in the 12 source categories proposed for regulation by EPA. Figure 1 also shows the numerical distribution of these facilities among the various source categories. Complexities associated with the data filtering process that limit a definitive characterization of the surface coating "sector" are discussed below.

- **Category Overlap.** Facilities are assigned to source categories by their standard industrial classification (SIC) code. EPA developed a list of SICs that comprise a source category (see Appendix A or www.epa.gov/ttnuatw1/coat/coat.html (from there, navigate to the category of interest and look in the preliminary industry classification report); however some SICs appear in more than one source category. As a result, 93 Colorado facilities identified from the AIRS database could be assigned to two categories, and 24 could be assigned to three categories (after the AIRS database was filtered to include only SICs for surface coaters and businesses that generate HAP emissions). Correct assignment of categories requires a time-intensive analysis of individual facility operations to identify the source category MACT that applies or, in some cases, whether more than one MACT may apply.

- **Potential to Emit**. The AIRS database contains emissions data reported by industrial facilities based on estimates derived from material balances or methods described in AP42 or similar emissions estimating protocols. These estimates are typically based on normal operating conditions, which may not represent maximum production capacity associated with a facility's PTE. Therefore, the AIRS database cannot easily be used to identify facilities with a PTE above MACT standard thresholds. For this reason, APCD created its list of possible major sources by filtering facilities in the AIRS database by half the MACT threshold (12.5 tpy THAP or 5 tpy single HAP).

MORE ABOUT PTE AND AP42?

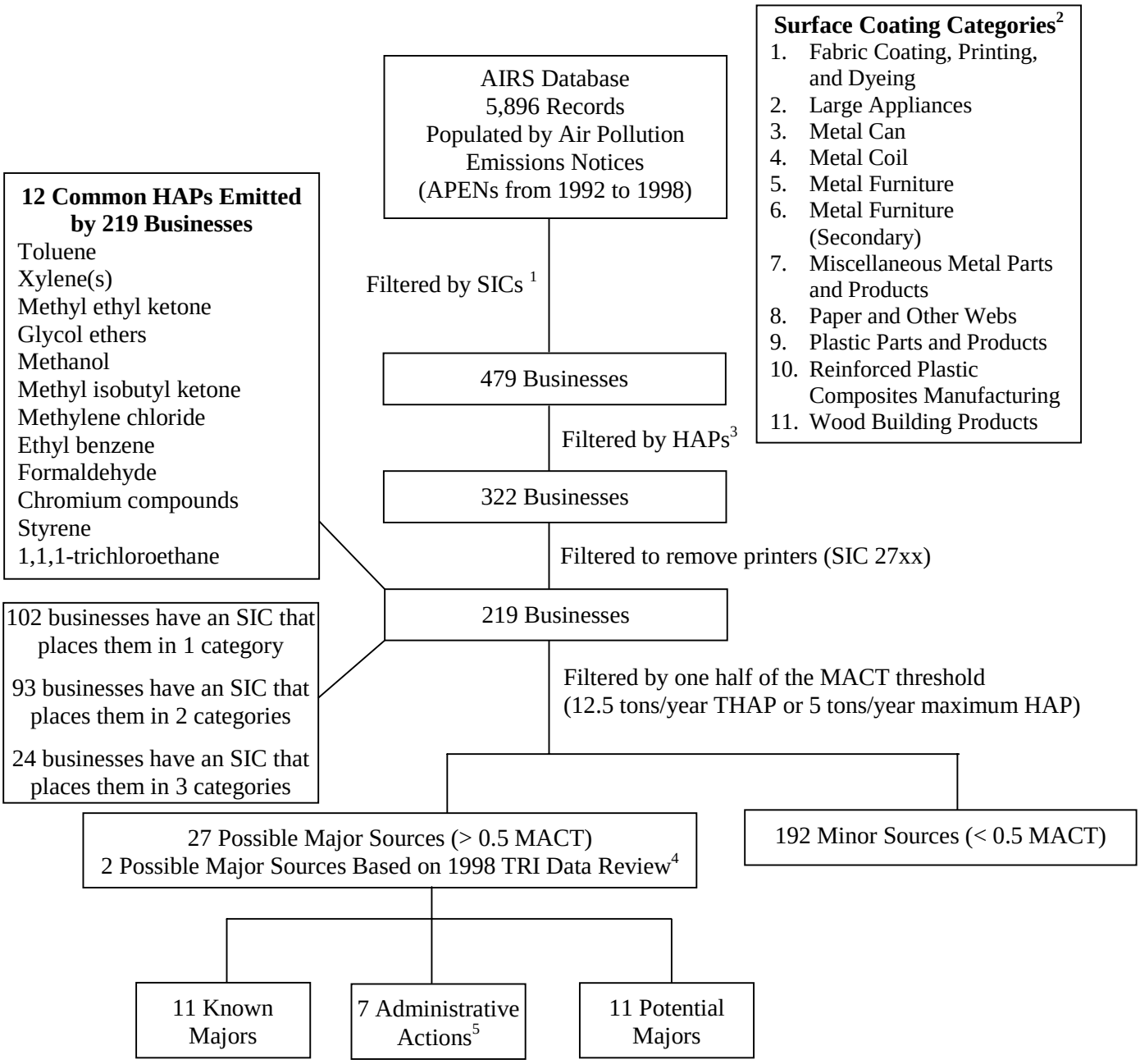
- Potential to Emit, A Guide for Small Business. EPA, Office of Air Quality Planning and Standards. EPA-456/B-98-003. October 1998.
- AP42 Fifth Edition, Compilation of Air Pollutant Emission Factors, Stationary Point and Area Sources. Office of Air Quality Planning and Standards and Office of Air and Radiation. Research Triangle Park. January 1995.

- **Data Age.** Industrial facilities submit emissions estimates to APCD via Air Pollution Emissions Notices (APEN). The APEN submittal dates are recorded in AIRS and range from 1992 to 1998, which introduces some uncertainty into the profile of surface coaters. Emissions at some facilities could have increased (as a result of higher production) or decreased (because of source reduction or lower production) since the facility's APEN was entered into the AIRS database.

APCD hosted a forum on July 12, 2000, to further its understanding of Colorado surface coating operations and to provide information about the impending MACT standards for surface coating. Eighteen people representing 14 companies with surface coating operations attended this meeting to discuss the surface coating MACT and strategies for avoiding it. In the weeks after the forum, APCD representatives visited companies present at the forum and others to obtain more detail on emissions reduction and control strategies and to record successful P2 efforts.

In addition to the forum and subsequent facility visits, APCD also used a geographic information system (GIS) to create a map showing the statewide distribution of surface coating facilities. An example GIS map showing the distribution of facilities by category is included as Figure 2. Other maps were generated that show distribution by source status (major and minor) and THAP. Most facilities are located in the metropolitan Denver area or in Colorado Springs.

FIGURE 1 SURFACE COATING EMISSIONS DATA PROCESSING



Notes

[1] 243 SICs are referenced by EPA's 12 surface coating categories.

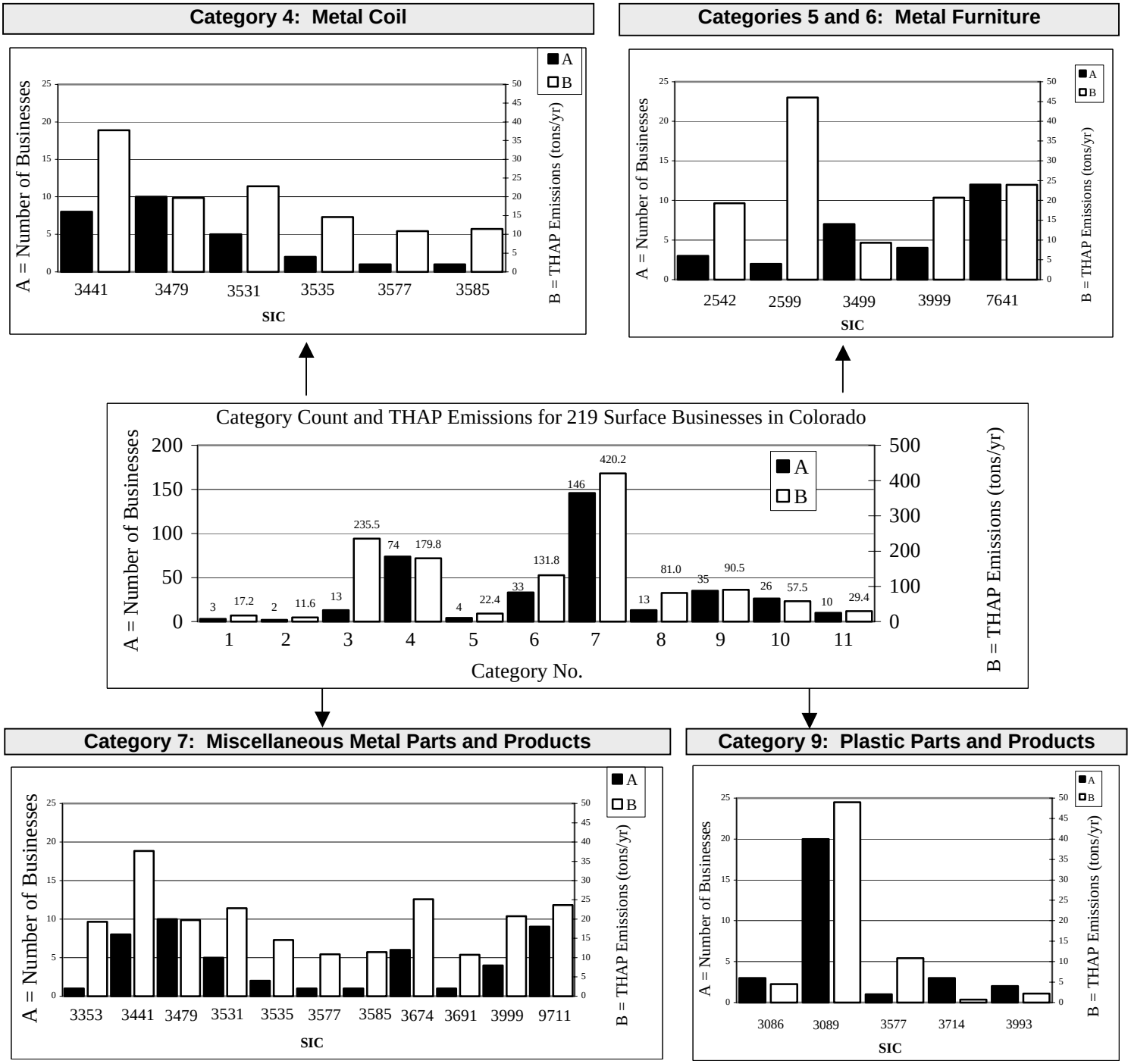
[2] This list differs from EPA's list of all surface coating categories because it represents the distribution in Colorado which has no boat or light duty automobile and truck manufacturers.

[3] 121 HAPs.

[4] The major sources identified in the 1998 TRI data review are not included in the 219 businesses from the AIRS database.

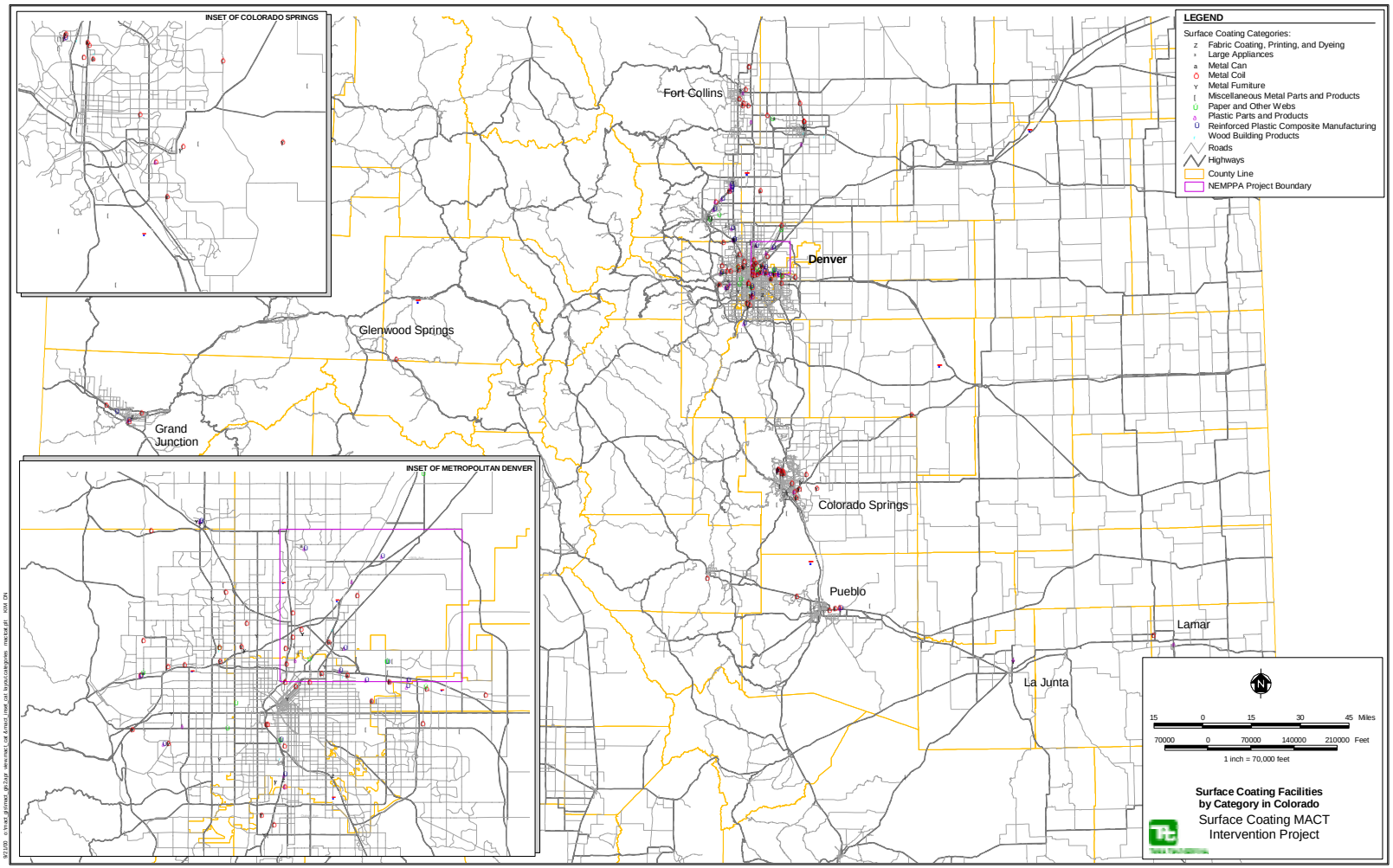
[5] "Administrative Actions" refers to facilities responding to MACT standards in an administrative manor, typically by filing for synthetic minor status.

FIGURE 1 SURFACE COATING EMISSIONS DATA PROCESSING (Continueed)



Note: Some SICs have been omitted from these charts based on low number of businesses or THAP emissions. The omitted SIC codes are provided in Appendix B.

FIGURE 2 DISTRIBUTION OF SURFACE COATING FACILITIES BY CATEGORY IN COLORADO



CHAPTER 3
SURFACE COATING OPERATIONS AND P2 OPPORTUNITIES

The 12 surface coating source categories (see Chapter 1) created by EPA encompass a broad range of surface coating processes that include decorative, protective, and functional coatings on diverse substrates (paper, plastics, and metals). Different coating formulations (for example, paints, adhesives, resins, and films) and application methods distinguish these processes; however, most surface coating processes share four basic steps: surface preparation, coating application, curing, and cleanup. This section briefly summarizes these four basic steps, introduces general P2 strategies for surface coating facilities, and discusses formal P2 assistance programs in Colorado and the extent to which surface coating facilities are involved with these programs. In addition, P2 references are provided for three categories common in Colorado: coil coating, reinforced plastic composites manufacturing, and plastic parts and products. Appendix C contains a table listing various P2 and E2 information sources for a wide range of surface coating processes and categories.

3.1 SURFACE COATING OPERATIONS

Surface Preparation. Surface preparation is typically carried out to clean the substrate before coating, improve adhesion of the coating, and correct surface flaws. Surface preparation may include solvent or aqueous cleaning, phosphating, chromating, abrasive blasting, or a variety of other methods depending on the substrate.

Coating Application. Numerous coating application technologies are used in surface coating operations. Factors that dictate the type of coating application technology used include the characteristics of the coating, physical dimensions of the part or substrate, and production rate. Three important process variables in a coating operation are (1) application method (spray, submersion, roller); (2) ventilation (enclosed versus open booths or areas); and (3) level of automation (from none to full).

Curing. Virtually all coatings require some time to cure. Traditional coatings are cured at room temperature or in ovens. During curing, residual volatile organic compounds (VOC) and HAPs used in the coating volatilize, thereby contributing to emissions. In general, coatings that cure at room temperature tend to release higher VOC/HAP emissions than those requiring a curing oven (in other words, there may be a tradeoff between emissions and energy use). Other curing methods such as ultraviolet (UV) and electron beam (EB) curing are discussed in Chapter 6.

Cleanup. Cleanup applies in all surface coating processes and involves cleaning coating application equipment and the booth or area where the coating is applied. Cleaning is typically a manual operation and usually involves solvents similar to those used to formulate or thin the coating.

3.2 P2 STRATEGIES FOR SURFACE COATING

P2 strategies that reduce HAP emissions in surface coating generally apply to the following three aspects of a coating process: coating formulation, coating application technology, and cleanup methods. General information about P2 strategies associated with these process aspects is summarized below. This section also includes P2 references for three surface coating categories common in Colorado: coil coating, reinforced plastic composites, and plastic parts and products. Additional details about specific, widely applicable P2 strategies related to optimizing coating application efficiency, powder coating, UV/EB coating, and E2 are provided in Chapters 4, 5, 6, and 7.

3.2.1 Coating Formulation

Solvent-based coatings have three major drawbacks: (1) solvents are toxic, (2) solvents are highly regulated, and (3) solvents increase risks of explosions and fire. Advancements in alternative, low- or no-solvent coatings such as water-based, hot-melt, UV- and EB-cured, and 100-percent solids are increasingly feasible replacements for solvent-based coatings. Conventional coatings typically contain 5 to 6 pounds of VOCs per gallon and most of these VOCs are also HAPs. In contrast, alternative coatings often contain less than 0.5 pound of VOCs per gallon. Reducing solvent content in coatings has three benefits. First, operation and maintenance and associated production downtime of pollution control devices are minimized or eliminated. Second, permitting, monitoring, record keeping, and reporting requirements are significantly reduced or eliminated. Finally, the elimination of solvent use improves the workplace environment.

High solids coatings are another alternative to conventional coatings that have lower emissions. Solvent-based coatings typically contain 30 to 40 percent solids and 60 to 70 percent solvent. Increasing the solids content of coatings has two benefits. First, less solvent is contained in the coatings on a per gallon basis. Second, the same surface area can be coated with fewer gallons of coating. These factors significantly reduce the air emissions generated. Higher solids coatings can also increase the speed of production lines because less solvent needs to be removed in the drying oven.

For additional information about alternative, low-solvent coating formulations, contact your coating vendor or review the following websites:

- http://cage.rti.org
- www.powdercoatingonline.com
- www.finishing.com
- www.ippmagazine.com
- www.paint.org
- www.powdercoating.org
- www.radtech.org

3.2.2 Coating Application Technology

Regardless of the type of coating, facilities involved in surface coating operations should evaluate opportunities for improving the efficiency of coating application. Some operations might be using application equipment that applies more coating than is required to meet product specifications. Improving control of coating application can reduce the quantity of coating needed to produce a quality product. Even a 5 or 10 percent reduction in coating use can lead to significant cost savings and emissions reductions. See Chapter 4 for more information about improving coating application efficiency for spray guns.

3.2.3 Process Equipment Cleanup

Solvents used for equipment cleaning can be a significant source of air emissions. P2 opportunities involve alternative, less toxic cleaning solutions (for example, water-based detergents or acetone in place of methyl ethyl ketone [MEK]), metering cleaning solvent to employees for use during cleanup, and recycling spent solvents using distillation equipment. Equipment cleanup emissions and wastes can also be minimized by reducing the frequency of coating changes through strategic work scheduling, mixing no more coating than necessary to complete the work, and dedicating mixing and application equipment to commonly used coatings.

P2 References for Plastic Parts and Products

1 Adhesives Age. *Environmental Legislation Aids Waterborne, Hot-Melt Adhesives Growth.* www.adhesives.org

2 "Pressure Sensitive Tapes and Labels: The Clean Air Act Amendments of 1990 and Pollution Prevention Opportunities," The Northeast Waste Management Officials' Association (NEWMOA), March 1999, www.newmoa.org.

3 Adhesives Sealant Council: www.ascouncil.com

4 Society of the Plastics Industry: www.socplas.org

5 For information on transfer efficiency see Chapter 4.

P2 References for Reinforced Plastic Composites

1 *CFA Emission Models/UEF Factors from the Open Molding Composites Industry.* www.cfa-hq.org

2 Composites Manufacturing Emissions. A Guide for: Composites Manufacturers, Communities, Regulators. www.cfa-hq.org

3 Composites Fabricators Association www.cfa-hq.org

P2 References for Coil Coating

1 In 1991, the National Coil Coaters Association published a study titled *Opportunities for Waste Minimization in the Coil Coating Industry.* In 1992, the association published a waste minimization study. An updated Waste Minimization study is due to be released late in 2000. See: www.coilcoaters.org

2 See Chapter 6 for more information on UV/EB technology.

3.3 P2 PROGRAMS IN COLORADO

Voluntary P2 programs represent an opportunity for a facility to obtain technical assistance with P2 efforts and benchmark their efforts to similar facilities. Many surface coating facilities are participating in these programs and, in doing so, benefit from technical assistance, public recognition, and a "yardstick" to measure progress. Nine programs are summarized in this section: the Governor's Challenge, the Colorado Environmental Leadership Program (CELP), CDPHE's confidential P2 assistance program, the Colorado State University (CSU) Industrial Assessment Center (IAC), ClimateWise, WasteWise, Northeast Metro Pollution Prevention Alliance, CDPHE Small Business Ombudsmen, and Colorado Materials Exchange. Participation in five of these programs by the 219 Colorado surface coating facilities identified from the AIRS database is summarized in the following table.

79 Colorado Surface Coating Facilities Participate in One or More Voluntary Programs				
Governor's Challenge	**CELP**	**CDPHE P2 Program**	**CSU IAC P2/E2 Assessment**	**ClimateWise**
11	3	9	72	9

3.3.1 Governor's Challenge

The CDPHE P2 Program administers the Governor's Challenge, which works with manufacturers to establish P2 goals. The Governor's Challenge covers all types of waste generation and pollution issues (air emissions, wastewater, solid waste, hazardous waste and energy efficiency); however, it focuses on the reduction of hazardous waste and Toxics Release Inventory (TRI) compounds. For more information about the Governor's Challenge call Parry Burnap at (303) 692-2975.

3.3.2 Colorado Environmental Leadership Program

The CDPHE Executive Directors Office administers the CELP, which "raises the bar" for environmental performance by recognizing businesses with environmental management systems (EMS) and innovative source reduction projects that provide mentoring and leadership in the businesses community and general public. Information about CELP can be found at www.cdphe.state.co.us/el/elphom.asp or by calling Tamera Bedford at (303) 692-3477.

3.3.3 CSU IAC P2/E2 Assessments

The CSU IAC is a U.S. Department of Energy (DOE) funded program designed to provide direct technical assistance to industrial facilities through P2/E2 assessments. The assessments are confidential and result in a report that summarizes a cost/benefit analysis of P2/E2 recommendations. The CSU IAC program is part of a national IAC network that tabulates outcomes in a database that contains results from more than 6,000 assessments. Information about the CSU IAC can be found at www.engr.colostate.edu/depts/me/program/outreach/iac or obtained by calling Mike Kostrzewa at (970) 491-7709.

3.3.4 CDPHE P2 Program P2 Assessments

The CDPHE P2 Program will complete free, on-site P2 assessments. The assessments are confidential and result in a report that summarizes a cost/benefit analysis of P2 recommendations. Information about the CDPHE P2 Program can be found at www.coloradop2.org.

3.3.5 ClimateWise

ClimateWise is an industry-focused voluntary partnership between businesses and EPA. Participating businesses agree to identify and implement P2 and E2 alternatives. Both EPA and DOE sponsor ClimateWise. The goal of ClimateWise is to help the U.S. honor international agreements to reduce greenhouse gas emissions. Businesses in ClimateWise receive E2 and P2 technical assistance from DOE and EPA, access to case studies of proven E2 and P2 technologies, a list of proven E2 technologies, tools to measure cost effectiveness, E2 and P2 facility assessments, and public recognition for involvement in the program. Information about ClimateWise can be obtained by calling 1-800-459-WISE or at www.epa.gov/climatewise.

3.3.6 WasteWise

WasteWise is a free, voluntary, EPA program that helps organizations eliminate costly municipal solid waste. WasteWise is a flexible program that allows partners to design a solid waste reduction program tailored to the individual businesses. WasteWise partners can save thousands or millions of dollars by reducing, reusing, and recycling solid waste. Information about WasteWise can be obtained by calling 1-800-EPA-WISE or at www.epa.gov/wastewise.

3.3.7 Northeast Metro Pollution Prevention Alliance

The Northeast Metro Pollution Prevention Alliance (NEMPPA) is a partnership of businesses, government agencies, and citizens in northeast metropolitan Denver. For more information about NEMPPA, call Dennis Creamer at (303) 286-5711.

3.3.8 CDPHE Small Business Ombudsman

The CDPHE Office of Customer Service has an air pollution small business ombudsman. Contact with the ombudsman is free, confidential, and nonregulatory. For more information, call Cathy Heald at (303) 692-2034 or (800) 886-7689.

3.3.9 Colorado Materials Exchange

The Colorado Materials Exchange (COMEX) is sponsored by the University of Colorado Recycling Services as a statewide clearinghouse of nonhazardous surplus and durable goods. Private and public sector groups as well as citizen and nonprofit organizations can to take advantage of COMEX as a means of finding low- or no-cost materials and minimizing waste. Information about COMEX can be found at www.colorado.edu/cure/COMEX/splash.html.

3.4 EXAMPLES OF P2 BY COLORADO SURFACE COATING FACILITIES

In addition to the participation in P2 programs in Colorado, APCD observed a number of P2 practices in place at surface coating facilities during facility visits. The following table summarizes some of the P2 practices noted during facility visits or telephone interviews.

FACILITY/ CONTACT	P2 PRACTICES	BENEFITS
Miscellaneous Metal Parts And Products		
Colorado Industrial Painting *Tracy Tormaschy (303) 371-6772*	• Operations consist of 92 percent powder coating, 7.5 percent liquid coating and 0.5 percent solvent coating. Three years ago, only 10 percent of operations included powder coating. Achieved increased percentage of powder coating by educating clients.	• Significantly reduced HAP emissions from decreased solvent-based liquid paint use
Lexmark International *Debra Brannum (303) 581-5184*	An established P2 program including: • Top management support and financial backing • Waste stream characterization, tracking, and charge-back to generating department • P2 Teams conduct routine assessments, implement and track P2 projects • Operator education, employee training, and procedure modification Example P2 projects include: • Use of recycled THF for tank cleaning in place of toluene	• Reduced drum solvent waste by 70 percent • 91 percent bulk solvent waste reduction • Reduced methanol use below 10,000 pounds • 99 percent particulate emissions reductions • Reduced natural gas usage and water additions to the steam system

FACILITY/ CONTACT	P2 PRACTICES	BENEFITS
	• Redesigned drum cleaning machine • Improved dust collection efficiency in toner manufacturing • Increased toner reuse in manufacturing • Currently researching supercritical CO_2 as a solventless cleaning method • Closed loop steam system	
Platte River Steel *Ted Woodard (970) 356-2326*	• Metal and wood recycling • Process optimization to reduce scrap metal	• Diversion of solid waste from landfill
Paper And Other Webs		
Eastman Kodak *Tom Dragano (970) 686-4389*	• P2 Team with established waste-specific subcommittees • Numeric goals for water conservation, energy conservation, hazardous waste generation, and chemical use • Develop annual waste minimization strategies for hazardous waste streams • Product reformulation and process improvements	• Decrease methanol use by 70 percent or 172,000 pounds per year in spite of 60 percent production increase • 35 percent reduction in energy use since 1993 • 47 percent reduction in water use
Intertape Polymer Group *Randy Putnam (303) 654-0500*	• Replaced motors on coaters with variable-frequency drives • Recycle cardboard, waste adhesive, cans, and condensate/cooling water • Collect and reuse waste film • Natural gas fire burners • Solvent recycling system	• Reusing and recycling cuts operating costs • Variable frequency drives reduce energy expenditures
Metal Coil		
Nichols Aluminum *Dennis Dumas (303) 654-8353*	• Replaced MEK used for coating additive and cleanup. Switched to ethyl acetate for cleaning the rollers and an 80/20 mix of acetone and isopropyl alcohol for cleaning floors • Dross (slag) from the melting furnace is reprocessed for aluminum recovery; recently switched from an external water-cooled system to a dross press	• Eliminated a HAP, although the substitutes contain VOCs • New aluminum recovery system eliminated about 2 tons per year of particulate fugitive emissions, as well as a small amount of water use. The new system allows for increased on-site aluminum recovery, resulting in a substantial annual savings.
Metal Can		
Metal Packaging International Inc. *Les Talmadge (303) 452-7007*	• Switched to water-based compound from hexane based	• Reduced emissions from 15.4 tons per year of hexane to 0 tons per year

FACILITY/ CONTACT	P2 PRACTICES	BENEFITS
Reinforced Plastic Composites		
C.F. Maier Composites, Inc. *Walter Thurner* *(719) 336-8745*	• Low styrene content resin (over 3 years increased from 0 to 60 percent of total resin used) • Chop gun	• 26 percent reduction in styrene emissions (12,376 lbs of VOCs) when normalized to production.
Large Appliances		
Trane Company *John Lawson* *(719) 585-3886*	• Driven by ISO 9000, instituted formal painter training program to address proper technique • In 1993, started conversion to water based coatings (epoxy and enamel); presently, much of the coating applied is water based • Recycle/rejuvenate machining coolants on site • Replaced solvent-based spray-on adhesive for insulation with self-stick backing	• Improved transfer efficiency and quality • Solvent emission reduction (73 percent reduction in xylene and 60 percent reduction in toluene) • 20 percent reduction in coolant disposal • Reduced solvent emissions by 90 percent

CHAPTER 4
SPRAY GUNS AND APPLICATION EFFICIENCY

VOC emissions from coating operations are indirectly proportional to how efficiently coating is applied to the part. In other words, the more efficient the coating application, the lower the VOC emissions. Total coating efficiency is a function of *transfer efficiency* (TE) and *build efficiency* (BE). This chapter discusses factors that affect TE and BE and how businesses that use spray guns can decrease VOC emissions, use less coating, and save money.

Electrostatic Painting

4.1 TRANSFER EFFICIENCY

Electrostatic Painting

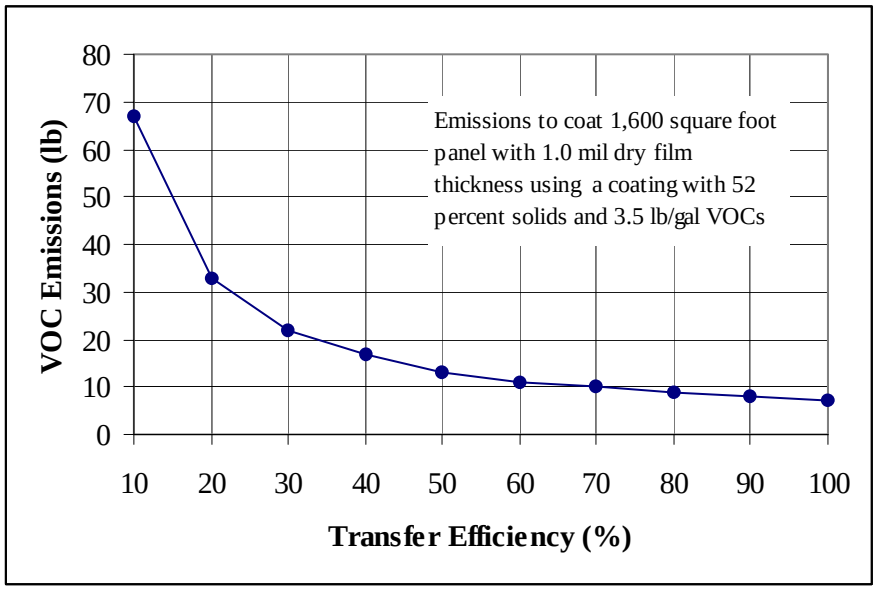
TE is expressed by the following equation:

$$TE = \frac{\text{Mass of Solids Deposited on Part}}{\text{Mass of Solids Sprayed}} x100\%$$

$$\text{or} = \frac{\text{Volume of Solids Deposited on Part}}{\text{Volume of Solids Sprayed}} x100\%$$

In plain terms, TE is a measure of how much coating is deposited on the part compared with the total amount sprayed, and is an indicator of the amount of wasted material in a coating operation (low TE = high waste).

TE affects emissions of VOCs, coating use rates, and production costs. Furthermore, low TE means higher waste disposal and maintenance costs. The following chart depicts the relationship between TE and VOCs emitted.[1]



The equation used to calculate emissions for the above chart is as follows:

$$\text{Emissions (pounds)} = \frac{\text{VOC (pounds / gallon)}}{\text{Volume of Solids x TE}}$$

Note that at low TE (less than about 45 percent), a small improvement significantly reduces emissions of VOCs.

Factors that affect TE can be grouped in five categories:[1]

Spray Gun or Booth Design
- Spray gun design and atomization method
- Orifice diameter of fluid tip or nozzle
- Air velocity and balance in spray booth
- Lighting in spray booth
- Space constraints in spray booth

Spray Technique
- Gun-to-target distance
- Overlapping successive spray gun passes
- Lead and lag triggering times
- Speed of spray gun travel

Operating Conditions
- Coating viscosity
- Fluid pressure
- Atomizing air pressure
- Ease of atomizing coating
- Part size
- Part geometry
- Spray pattern size
- Conveyor line speed
- Equipment maintenance
- Spray gun setup

Other
- Worker fatigue
- Worker attitude and training

For Electrostatics
- Coating conductivity or resistivity
- Part grounding
- Voltage potential between electrode and ground
- Proximity of other grounded objects to gun

Some of these factors are discussed in the following sections.

4.1.1 Spray Gun Design

The type of spray gun used in surface coating affects TE. A spray gun should be selected based on its effectiveness in atomizing a particular coating at a low-pressure setting. The following types of spray guns are listed in order of increasing TE, with all other factors being equal:

- Conventional air
- Airless
- Air-assisted airless
- High-volume, low-pressure (HVLP)
- Electrostatic

HVLP Spray Gun

Quantitative TE ranges that are forecasted for various spray gun designs can be misleading because many factors other than gun design affect TE (such as spray gun setup, application technique, and geometry of the part sprayed). TE is optimized for any spray gun when it is set up properly (see Section 4.1.2) and the coater is using good spray application technique (see Section 4.1.3). The cost of the spray guns is generally comparable and is typically dictated by the cost of the paint delivery equipment. Electrostatic technology can be applied to any of the spray guns (conventional air spray, airless, air-assisted airless, and HVLP). Different types of guns are used for powder coating; refer to Chapter 5, Advancements in Powder Coating, for a more detailed discussion of powder coating.

4.1.2 Spray Gun Setup

Proper spray gun setup depends on the type of spray gun, production speed, part size and geometry, operating pressures, fluid delivery rate, and viscosity of the coating[2]. Considering the complex interaction among these variables, the initial spray gun setup should be based on the manufacturers' recommendations and refinements identified through systematic experimentation.

Automatic Conventional Spray Gun

For air spray guns (conventional and HVLP), the fluid nozzles, needles, and air caps should be selected using the recommendations provided by the manufacturer. The owner's manual or vendor should provide an indication of the nozzle, needle, and air cap combination that will work for a specific coating viscosity and production rate. The nozzle size should be increased or decreased to refine the setup of the spray gun for a particular application. Pressure feed systems also require adjustment in the fluid pressure. In general, fluid pressure should be adjusted so that the gun delivers a 1- to 6-inch horizontal stream of fluid before the effect of gravity is evident.

Conventional Spray Gun

Airless and air-assisted airless spray guns are set up differently than air spray guns, but the approach to spray gun setup is basically the same. The fluid tip should be selected based on manufacturers recommendations to produce a spray pattern that best fits the parts to be coated. The size of the orifice also affects setup of the spray gun. Select an orifice size (considering viscosity and fluid pressure) to find the appropriate fluid delivery rate and degree of atomization. Begin by selecting an orifice size based on recommendations in the owner's manual for the spray gun. From there, experiment with the orifice size and fluid pressure. Do not make adjustments based on fluid pressure alone because the most efficient setup uses the lowest flow rate possible to coat the part. Use a systematic approach and keep records of changes and results while adjusting the setup.

Proper and regular maintenance of spray guns will reduce coating problems and maintain quality. Three basic maintenance practices should be included in the standard operating procedure for spray equipment:

- Clean the spray gun regularly to ensure optimum atomization and spray pattern.
- Clean equipment as specified by the manufacturer.
- Disassemble and inspect spray guns regularly.

4.1.3 Worker Technique

Worker technique is one of the most important and influential factors in application efficiency, but it is often overlooked because it is difficult to control. The Iowa Waste Reduction Center (IWRC) Spray Technique and Analysis Research (STAR) Program studied TE for a wide range of coating scenarios and identified the following "Top Six" variables that a well-trained coater can control to improve TE. These scenarios apply to both manual and automatic coating application.

- **Gun-to-target distance**. HVLP spray guns should be held 6 to 8 inches away from the part (some manufacturers recommend 4 to 6 inches). Air-assisted airless spray gun should be held 8 to 10 inches away from the part (8 to 12 inches if it is electrostatic, air-assisted airless). Airless spray guns should be held 12 to 14 inches away from the part. The distance from the spray gun to the part should be consistent. If the gun is too close to the target, the coating will be applied too heavily and run and sag. Holding the spray gun too far from the target causes excessive overspray, dry spray, a sandy finish, and low TE.
- **Air pressure and fluid pressure setting**. Air and fluid pressure should be set according to manufacturers recommendations and adjusted through a trial-and-error process (see Section 4.1.2).

HVLP Automatic Spray Gun

- **Overlap**. A 50-percent overlap over the previous strip of coating should be maintained.
- **Lead and lag**. The lead and lag (triggering before and after the part) should be minimized to the greatest extent possible without sacrificing the quality of the finish.
- **Spray gun angle**. The spray gun should be oriented so that the spray pattern is perpendicular to the part. For example, if coating a flat sheet, the spray gun should be moved from side to side, moving the arm or body, not by rotating or arcing the wrist.
- **Spray gun orientation**. The spray gun should be pointed directly at the part. A common misconception is that electrostatic guns need only be pointed in the general direction of the part. Although some particles will still adhere to the part, TE will increase significantly by directing the spray at the part.

4.2 BUILD EFFICIENCY

BE is the measure of how close and consistent the actual film applied to a part is to the desired dry film thickness. A BE of 100 percent is ideal; values greater than 100 percent represent wasted material and, consequently, excessive emissions of VOCs and production costs. For example, if the target dry film thickness for a part is 1 mil and 1.25 mils are actually applied (at a TE of 100 percent), the BE would be 125 percent, which results in 25 percent more material use and emissions than are necessary. The following example depicts the combined effect of low TE and high BE[3].

Hypothetical Scenario

Coating cost is $30 per gallon and contains 4 pounds of VOCs per gallon. Assume it takes 100 gallons of coating to coat 1,000 parts at 100 percent TE and 100 percent BE. In this scenario, it would cost $3,000 in material and 400 pounds of VOCs would be emitted.

Example

At a generous TE of 70 percent (30 percent of the material misses the target) and BE at 125 percent (25 percent more material is sprayed on the part than is needed), 179 gallons of coating would be needed to coat the parts. The cost for material would be $5,370 and 716 pounds of VOCs would be emitted.

BE is best controlled through good coating technique from well-trained applicators (see Section 4.1.3.)

These Techniques Really Work and Save Time and Money!

IWRC has been providing training on application techniques for more than a year to technical assistance personnel and small businesses nationwide. The following table provides actual results from a recent training conducted through the IWRC Painting and Coating Compliance Enhancement (PACE) Program:[4]

BEFORE TRAINING				
Operator	**Material Consumption (lbs)**	**Transfer Efficiency**	**Film Build Efficiency**	**Finish Quality: Number of visible defects (Major/Minor)**
1	0.913	41.5 percent	138 percent	6 major (excessive dry spray on all panels)/0 minor
2	0.749	44.4 percent	119 percent	3 major (dry spray)/7minor
3	0.633	49.5 percent	116 percent	0 major/9 minor
4	0.719	51.7 percent	135 percent	3 major/3 minor
POST-TRAINING				
1	0.404	60.7 percent	74 percent	6 minor
2	0.454	62.4 percent	82 percent	6 minor
3	0.433	61.5 percent	86 percent	4 minor
4	0.445	77.5 percent	98 percent	5 minor

In the training class, spray operators used a Graco Delta Spray HVLP spray gun fed by a pail-mount diaphragm pump. The training consisted of a 4-hour session that covers good spray technique and equipment operation using training videos, hands-on instruction, and the opportunity to practice the concepts taught. As a result of the training, the coaters' material consumption (and associated VOC emissions) was reduced by 32 to 56 percent. IWRC training staff were also tested to estimate a "benchmark" TE for the training exercise. Three trainers coated with a TE ranging from 78.4 to 88.9 percent and film BE ranging from 102 to 113 percent. The trainers used the same gun and setup as the operators in the training.

4.3 FINISH QUALITY

Finish quality is evaluated by its acceptability to the customer and is the most important consideration in application efficiency. The amount of care used to optimize TE and BE will not matter if an unacceptable finish is produced. Part rework causes excessive VOC emissions from stripping and refinishing and generates waste in discarded materials and parts. Poor finish quality costs companies money because of the waste of time, materials, and energy, as well as costs for waste disposal, maintenance, and the potential increased regulatory burden. Using good coating technique can decrease the reject rate of parts (see Section 4.1.3).

4.4 ADDITIONAL INFORMATION

The web sites listed in the following table contain information about spray guns, application efficiency, and other coating related P2 information. This table is not intended to be a complete representation of information sources or vendors, nor does it indicate any product endorsement.

NAME AND WEB ADDRESS	DESCRIPTION
P2 Information	
Coatings Alternatives Guide http://cage.rti.org	This web site is a P2 tool for paint and coating users sponsored by the EPA and Research Triangle Institute. The web site contains a guide to low-emissions products, a cost analysis tool, information about coating alternatives, information on application equipment, references, regulatory matters, related web links, and a searching function.
finishing dot com, "The Home Page of the Finishing Industry" www.finishing.com	This web site covers anodizing, plating, powder coating, and related surface finishing processes. It contains sections for interaction with other surface finishers, announcements of upcoming events, frequently asked questions, finishing books, organizations and societies, technical references, and web links.
Iowa Waste Reduction Center www.iwrc.org	The IWRC web site contains information on application efficiency issues. Also through this web site, users can sign up to receive PACE newsletters via e-mail.
National Paint and Coatings Association www.paint.org	The National Paint and Coating Association represents the paint and coatings industry. The web site contains industry information, links, information on meetings and events, a paint council network, and a search function.
Industrial Paint & Powder Magazine www.ippmagazine.com	Industrial Paint & Powder publishes its magazine on line. Current and past issues can be found through the web site. The web site also has product information, resources, events, links, and includes a search function.
Products Finishing www.pfonline.com	www.pfonline.com is the online component of Products Finishing Magazine. It has information about suppliers, products, articles, forums, experts, news, links, books, powder coating, environmental issues, and includes a search function.
The Society for Protective Coatings www.sspc.org	Viewing of this web site is limited to authorized users.
Spray Gun Manufacturers	
Vendor	**Web Site**
Binks	www.binks.com
Magnum Industries	www.magnumindustries.com
Sames	www.sames.com

4.5 REFERENCES

1. *Transfer Efficiency Revisited.* Metal Finishing. Joseph, R. June 2000.
2. *Benefits of Correct Gun Set Up*. Industrial Paint & Powder. Gedlinske, B. May 2000.
3. *The Cost of Application Inefficiency*. Industrial Paint & Powder. Gedlinske, B. June 2000.
4. *How Spray Operators Impact Application Efficiency*. Industrial Paint & Powder. Gedlinske, B. and Whiting, J. July 2000.

CHAPTER 5
ADVANCEMENTS IN POWDER COATING

Powder coating technology has been available in the United States since the middle of the 1950s. Today, it is the fastest growing industrial finishing method in North America (8 to 10 percent per year) and represents about 15 percent of the total industrial finishing market.[1] Although the general concepts and use of powder coating are widely understood in the industry, recent advances in materials and methods make powder coating a more viable option for many applications. Furthermore, powder coating is a good alternative to liquid painting because it significantly reduces emissions of HAPs and VOCs.

Automatic Powder Painting

5.1 OVERVIEW OF POWDER COATING

The process of powder coating involves using finely ground particles of pigment and resin that are electrostatically charged and sprayed onto electrically grounded parts. Charged particles adhere to the surface of the grounded parts until they are melted and fused to the part by a curing process. Powder coating involves three steps: pretreatment, powder application, and curing. Pretreatment is required to ensure an acceptable coating finish. The surface must be clean and dry before application of powder begins. Surface preparation usually involves alkaline cleaners, iron or zinc conversion coatings, and rinsing.

The powder application step uses four types of equipment:[1]

Powder Coating Material

- **Powder delivery system**. This system consists of a powder storage or feed hopper and pumping device to transport the powder to the spray gun.
- **Electrostatic spray gun**. There are two general types of guns: corona charging (the more common) and tribo charging.
- **Powder spray booths**. Most importantly, the spray booth should collect overspray and be easily cleaned for efficient color changeout.
- **Powder recovery and recycle systems**. There are two general types of recovery and recycle systems: cartridge and cyclone.

Powder coating is typically cured in a convection oven, infrared (IR) oven, or a combination of the two. Specially formulated powder coatings can also be cured using UV technology.

5.2 MATERIAL ADVANCEMENTS

There is a powder coating equivalent for nearly every liquid coating application. Specific advancements in powder coating include:[2]

Performance

- Weather, industrial pollution, and corrosion resistance
- Chalking resistance
- Heat resistance
- Thin film (0.8 to 1.2 mil)
- Low temperature cure (below 212 °F)
- Antibacterial
- Ability to be UV or infrared cured
- Ability to absorb and reflect ultraviolet, fluorescent, and incandescent light
- Not susceptible to degradation by UV rays
- Electro-conductive and electro-dissipative

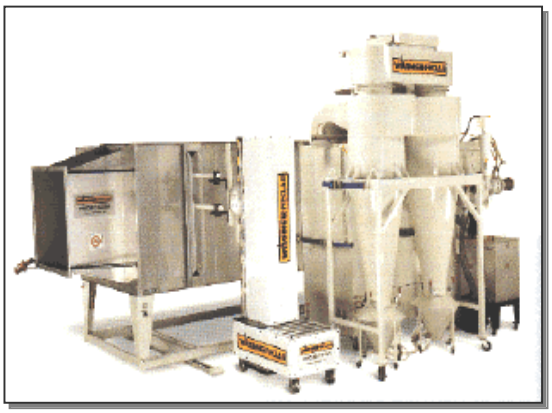
Appearance

- Decorative coating
- Clear appearance
- Various textures
- Matte finish
- Flat to high gloss appearance
- Fluorescent and iridescent appearance
- Metallic appearance
- Hammertones or veins

Some of these advancements are significant because they allow powder coating of materials other than metal. Specifically, low-temperature curing and UV and infrared-curable coatings have allowed for powder coating temperature-sensitive products such as wood and plastic.[1]

5.3 METHOD ADVANCEMENTS

In the area of powder coating methods, advancements have been made in applying the powder and improving application efficiency. Advancements have occurred in methods for curing, pre-assembly coating, process innovations, and powder coating wood products. The following table summarizes some of the process advancements in powder coating that affect industries to be regulated by the MACT standards for surface coating.[3]



Powder Coating Curing Unit

CURING	
Radiation curing allows for curing heat-sensitive substrates such as wood, plastic parts, and assembled components with heat-sensitive details. It can also be used with metal substrates and has the benefit of low energy and investment cost, shorter curing times and, thus, higher production rates.	
IR Curing	IR curing technology cures at a high heating rate. IR heats the coating, but not the entire substrate. IR curing can occur in as little as 30 seconds.
Near-IR Curing	Near-IR curing can cure specially formulated powders in several seconds. It uses high-energy light and high focusing reflector systems. Near-IR curing can be used for heat-sensitive substrates. It can also be used for metal substrates because there is no limitation on thickness of the film, especially with hard-to-cure colors such as red and yellow.
UV Curing	For UV curing, specially formulated powders must first be heated using IR or convection heat. The coating is then exposed to UV light. Photoionizers in the coating absorb UV energy, which causes chemical reactions that convert the coating into a solid, cured finish in seconds.

PRE-ASSEMBLY COATING	
Blank Coating	Powder coating allows for complete edge-wrap, uniform film thickness, and high transfer efficiency because blanks may be spaced inches apart on a coating line.
Coil Coating	Powder coating on metal coil can produce deep textures and unique visual effects on one or both sides of the sheets or strips in a single pass.
PROCESS INNOVATIONS	
Color Changes	Some powder coating systems can accommodate a color change in 15 minutes or less and booth cleanout in about an hour. Advancements include increasing transfer efficiency by optimizing air flow and electrostatic performance in the booth, using plastic walls and eliminating crevices where powder can lodge, including automatic vacuuming systems on the floor of the booth, and systems that provide powerful bursts of air to clean the pumps, hoses, and guns.
Electromagnetic Brush	Technology allows for application of powder coating to flat substrates at differing speeds and thicknesses. Ferromagnetic particles are directed at the substrate through a magnetic brush. The substrate passes the brush, an electromagnetic field is turned on, and the substrate becomes coated. Electromagnetic brushes may be used for coating metal coil, blanks, and wood.
WOOD PRODUCTS	
Medium-Density Fiberboard	Medium-density fiberboard (MDF) currently has the greatest application in wood product powder coating. MDF is used in office furniture, ready-to-assemble furniture for home and office, kitchen and bathroom cabinets, and store fixtures and displays. Other wood with sufficient moisture content may be powder coated as well. Wood products are cured with IR, IR and convection ovens, UV light and IR, or UV light and convection ovens.

5.4 COST CONSIDERATIONS

A cost comparison among coating systems should consider capital costs, labor costs, material costs, energy use, rework rate, and other associated costs such as cleanup time, waste generated, maintenance time, and filter cost.[4] To normalize for the differences in coating types, each of these factors should be evaluated with a common denominator such as cost per square foot coated or total annual cost.

Powder Coating Pays

In one example, the ***applied material cost*** per square foot of substrate coated varied as follows:[1]

Low-solids:	$\$0.0770/ft^2$
High-solids:	$\$0.0534/ft^2$
Waterborne:	$\$0.0748/ft^2$
Powder:	$\$0.0501/ft^2$

The capital investment for coating systems ranges from $165,000 (powder coating) to more than $500,000 (electron beam, see Chapter 6). Capital investment is lowest for powder coating systems; therefore, powder coating equipment is the most economical choice for new equipment. The following bullets describe some cost issues associated with powder coating technology.

- **Material costs** of powder coating when comparing dollars per square foot coated are the lowest of all materials because the recycle rate for the powder can be 99 percent. This feature is especially important because material costs represent two-thirds or more of the total annual operating costs of any finishing system.[1]

- **Energy use** for powder coating is slightly above average when comparing total energy costs (including spray booth exhaust, flash tunnel exhaust, and solvent incineration). The higher cost is due to the high curing temperature for powder coating.

- The **rework rate** for powder coating is significantly less than for liquid coating because there is no dripping or sagging. Furthermore, a powder-coated part can be stripped with an air gun and recoated if a flaw is noticed before curing.

- Powder coating is less expensive than liquid coating because **less maintenance** is required for powder coating units than for liquid coating units. Lower maintenance requirements are typical because powder coating units have fewer moving parts or mechanical pumps to feed the applicators and less frequent filter changes.

Powder Coating Pays

In one example, the ***energy cost*** (total gas energy costs per hour) varied as follows:[1]

Low-solids:	$11.21/hour
High-solids:	$6.92/hour
Waterborne:	$7.21/hour
Powder:	$8.03/hour

Overall, in terms of cost per square foot coated (not including capital investment), powder coating is the least expensive surface coating alternative and typically yields the greatest annual savings and shortest payback period.

5.5 ADDITIONAL POWDER COATING RESOURCES

The following table contains resource information on powder coating. There are many powder-coating vendors for many different aspects of powder coating (pretreatment, equipment, material, and oven, for example). For information about vendors, refer to the following web sites.

NAME AND WEB ADDRESS	DESCRIPTION
Powder Coating Institute www.powdercoating.org	The Powder Coating Institute sponsors this web site, which contains information about powder coating, information for consumers and industry, and information about the Powder Coating Institute.
Powder Coating Online www.1-800-9powder.com	This web site is aimed at providing powder coating resources such as supplier listings, product information, literature, powder coating jobs, a place to purchase powder coating products, links to other web sites, and a searching function.
PowderNet.com "Networking the Entire Powder Coating Industry" www. powdernet.com	This web site mainly consists of links in the categories of suppliers, custom coaters, classified advertisements, a site search, and other pages related to powder coating such as a bookstore, original equipment manufacturer (OEM) listings, and industry news.
Coatings Alternatives Guide http://cage.rti.org	This web site is a P2 tool for paint and coating users sponsored by the EPA and Research Triangle Institute. The web site contains a guide to low-emissions products, a cost analysis tool, information about coating alternatives, information about application equipment, references, regulatory matters, related web links, and a search function.

NAME AND WEB ADDRESS	DESCRIPTION
finishing dot com "The Home Page of the Finishing Industry" www.finishing.com	This web site covers anodizing, plating, powder coating, and related surface finishing processes. It contains sections for interaction with other surface finishers, announcements of upcoming events, frequently asked questions, finishing books, organizations and societies, technical references, and web links.
Iowa Waste Reduction Center www.iwrc.org	Through this web site, users can sign up to receive Pollution Prevention for Painting and Coating Compliance Enhancement (PACE) newsletters via e-mail.
National Paint and Coatings Association www.paint.org	The National Paint and Coating Association represents the paint and coatings industry. The web site contains industry information, links, information on meetings and events, a paint council network, and a search function.
Industrial Paint & Powder Magazine www.ippmagazine.com	Industrial Paint & Powder publishes its magazine on line. Current and past issues can be found through the web site. The web site also has product information, resources, events, links, and a search function.
Products Finishing www.pfonline.com	This is the online component of Products Finishing Magazine. It has information about suppliers, products, articles, forums, experts, news, links, books, powder coating, environmental issues, and a search function.
The Society for Protective Coatings www.sspc.org	Viewing of this web site is limited to authorized users.

5.6 REFERENCES

1. *Powder Coating – A Pollution Prevention Alternative from the Powder Coating Institute*. March 1999.
2. *Powder Coating Material s- Offer a World of Colors, Textures, and Effects*. Products Finishing Magazine. Bocchi, G. July, 2000.
3. *Powder Application Methods*. Products Finishing Magazine. Bocchi, G. July, 2000.
4. *Powder Coating Tasks*. Products Finishing Magazine. Palmer, J. July, 2000.

CHAPTER 6
UV/EB

UV/EB technology may be used in place of conventional paints, coatings, inks, and adhesives, eliminating emissions of common HAPs such as toluene, MEK, ethylene glycol, and glycol ethers. The result is a surface coating that performs as well as or better than conventional solvent-based coatings, with no HAP emissions.

6.1 APPLICABILITY

Because UV/EB technology uses the same resins as solvent-based coatings, almost any resin used in solvent-based products can be converted to UV/EB curable oligomers (low-molecular-weight polymers). Many industries that will be affected by the MACT standards for surface coating are good candidates for considering UV/EB including: wood building products, plastic parts and products, metal can, metal coil, and paper and other webs. Advantages of UV/EB technology include:[1]

- **No thermal curing ovens**. Thermal curing ovens are not used for UV/EB technology. Not using thermal curing ovens saves fuel and floor space and eliminates air emissions from the heating ovens and from burning fuels to heat the curing ovens.
- **High-speed curing**. Cure time using UV/EB technology is reduced to seconds.
- **Greater productivity**. Conventional solvent-based coatings often become more viscous during use due to VOC volatilization. Increased coating viscosity results in increased labor and production time. No solvents are used in UV/EB coating, therefore no increase in coating viscosity occurs during coating application.
- **No add-on controls**. Pollution control equipment is unnecessary because no emissions are generated in the UV/EB coating process.

> Coors Brewing Company switched its production of more than 4 billion beer cans per year entirely to UV curing on the exterior of the can. The company reduced emissions from external coating from 115.9 tons per year using a water-based enamel to 6.7 tons per year for a UV-cured acrylic and then to 0.9 tons per year for a UV coated epoxy enamel.[2]

Some examples of the applications of UV/EB technology applications include metal cans, metal coils, ready-to-assemble furniture, pressure-sensitive tape, fishing rods, golf club heads, automotive wheels, headlights, windshields, and wide-web-rolled paperboard.[3] A good application for UV technology would involve powder coating cured by UV technology in a job shop (miscellaneous metal parts and products and plastic parts and products). EB technology has the greatest application among coil coaters and ready-to-assemble furniture. EB technology is also effective in applying adhesive to pressure-sensitive tapes.

UV Curing Unit

6.2 TECHNOLOGY

UV and EB technology allow instantaneous curing of coatings that change from a liquid to a solid (polymerize) when irradiated with UV light or accelerated electrons.

6.2.1 UV Technology

A lamp is used in UV technology to emit bright, visible light, invisible UV light, and infrared energy for curing. UV curing is fast and relatively cool if the infrared component of the lamp is shielded, allowing for use on heat-sensitive substrates. UV curing occurs in two stages. Photoinitiators are included in the coating mixture, which break down under UV light, generating free radicals that attack acrylic double bonds and cause polymerization. UV curing offers many advantages, including.[3]

- Abrasion- and solvent-resistant finish
- Decreased production waste
- High-gloss finish
- In-line processing
- Instant curing, increased productivity
- Low energy requirements
- Low thermal stress on substrate
- Minimal floor space
- Minimal manufacturing steps
- No solvent emissions
- Interstation drying capability

Some disadvantages of UV technology include:

- UV light must "see" photoinitiators to cure the coating.
- In some cases, UV technology may not cure thick or opaque colors as thoroughly as EB technology, reducing adhesion because the coating does not cure through to the substrate surface.
- There is limited application to heat-sensitive substrates because heat is generated using UV technology.

6.2.2 EB Technology

EB technology uses accelerated electrons for curing. The process works by exposing an oligomer/monomer mixture to a stream of electrons, causing copolymerization that forms a solid coating. The process produces secondary radiation in the form of x-rays. EB has the ability to cure thick and opaque wet coating films or through opaque coatings because of the ability of the accelerated electrons to penetrate matter.

EB Curing Unit

EB offers all of the advantages of UV (except for interstation drying capability) and the following advantages:[3]

- Accurate, repeatable control of cure
- Curing through opaque materials
- Coolest curing process
- Cure of thick pigmented coating
- High line speeds to increase productivity
- Long pot and shelf life
- New and unique products possible
- Superior coating properties
- Elimination of photoinitiators and their odors and emissions

Adhesive on tape can be cured using EB technology.

Some disadvantages to EB technology include:

- High capital investment (see cost considerations).
- Limited applicability (no three-dimensional parts).
- May not be cost effective for applications less than 18 inches wide.
- New technology for surface coaters; no long-term testing of coating performance or industry confidence established.

6.3 COST CONSIDERATIONS

The capital investment for a UV curing system is about $100,000 and is three to five times of less than an EB processor that is comparable in speed. (Prices are decreasing; EB equipment priced in the $800,000 range 4 years ago can be purchased for $500,000 to $600,000 today.[3]) The high capital investment in EB is commonly cited as a barrier to the technology. Some EB systems are available for as low as $100,000 and as much as $1.5 million, depending on size and application. However, EB vendors claim 60 to 90 percent utility savings (water, electricity, and natural gas) over conventional liquid coating technology. A 60 to 90 percent savings in utility costs can lead to a payback in less than 1 year. EB technology presents a good opportunity for performance contracting, which some vendors offer. The price range for UV and EB curable coatings is $25 to $40 per gallon and the coatings are 100 percent solids. They can be expected to coat 1 pound per thousand square feet wet with optimum properties (smooth, glossy, and protective). There is a general misconception that UV and EB curable coatings are more expensive than liquid coating. The following example demonstrates the lower cost of UV coating compared with liquid coating.[2]

Liquid, Thermoplastic Paint	Energy Cured (UV/EB) Paint
32.62 percent solids by volume	99.69 percent solids by volume
$13.67 per gallon	$35 per gallon
$0.0262 per square foot per dry mil	$0.0219 per square foot per dry mil
In this example, cost for energy-cured paint is 17 percent lower than for liquid paint.	
Assumptions: Transfer efficiency is the same for both coatings (liquid and energy cured) and the same coating thickness will be applied.	
Constant: 1,604 square feet per gallon per mil.	

Other cost factors to consider are space, energy consumption, and productivity. UV and EB equipment are about 10 percent of the size of a conventional drying oven. The energy consumption for UV and EB technology is also lower. In terms of productivity, not only is the UV and EB curing process significantly faster than conventional technology, but they also require less maintenance. The coatings do not skin over in the applicator; therefore, no cleanup is required at the end of shifts or before the weekend, and the startup procedure is faster. Finally, the faster cure time allows fewer particles to contaminate the surface finish, which relates directly to rework and scrap costs.

6.4 ADDITIONAL UV/EB TECHNOLOGY RESOURCES

NAME	DESCRIPTION
INFORMATION	
RadTech International North America www.radtech.org	RadTech's main purpose is to promote use and development of UV/EB technology. The web site contains technical information about UV and EB technologies, publications, events, and links to vendors.
UV/EB TECHNOLOGY VENDORS	
VENDOR	**WEB SITE**
Coating Material Suppliers	
BASF Corp.	www.basf.com
Ciba Specialty Chemicals	www.cibasc.com
Clariant Corp.	www.clariant.com
Equipment Suppliers	
Energy Science Inc. (EB and UV Technology)	www.ebeam.com
Advanced Electron Beam (EB Technology)	no web site, call (978) 458-8600
Fusion UV Systems	www.fusionuv.com
Ultraviolet Systems and Equipment Inc.	www.ultravioletsystems.com

6.5 REFERENCES

1. Breezing Through Clean Air Permitting with UV/EB Coatings, A Users Guide. RadTech International North America. Date unknown.
2. Information obtained from a web site. www.radtech.org/About_UV_EB/Misconceptions.html
3. *UV, EB, and Aqueous Coatings: Technical Basics*. GATF World. Griese, E. May/June 1998. pp. 33-36.

CHAPTER 7
ENERGY EFFICIENCY

Using energy-efficient products and equipment reduces pollution associated with power generation and transmission and can be surprisingly cost effective. Many organizations and programs exist to inform businesses about energy-efficiency and to assist businesses in completing a cost analysis for switching to energy-efficient products. This chapter describes some E2 resources available to businesses.

Energy Efficiency Tips:

- Replace filters regularly to prevent clogs that restrict air flow, increase workload on fans, and reduce energy efficiency.
- Use outside air for compressor intake. Outside air, on the average, is cooler and denser and therefore requires less energy to compress.
- Fix air leaks in compressed air lines. Air leaks require the compressor to work harder; a few small (eighth-inch) leaks can cost thousands of dollars in energy bills annually.
- Use radiant heating systems.
- Insulate and reduce air leaks around dock doors.
- Install high-efficiency lighting with T-8 and electronic ballasts.
- Upgrade metal halide lighting systems to a lower wattage system.
- Replace the standard V-belt drives on exhaust fans with synchronous belt and sprocket drives to reduce electrical usage.
- Analyze flue gas from boilers every 2 months to monitor and increase boiler efficiency.
- Insulate piping from the boiler to reduce heat loss.
- Include variable frequency drives on fan motors, and air economizers and thermostat set backs on heating, ventilation, and air conditioning (HVAC) systems.
- Use evaporative cooling for roof top chillers.

Energy Star®. Energy Star® is an EPA-sponsored initiative with many E2-related programs. Two programs within Energy Star® relevant to businesses in Colorado are the Partnership and Small Businesses programs. Energy Star® partnerships are voluntary agreements between EPA and U.S. businesses. These businesses agree to identify and implement energy-efficient alternatives. In exchange, businesses involved in the partnership have access to extensive information about E2 opportunities including compact fluorescent light bulbs, office equipment, transformers, windows, and exit signs. Energy Star® also provides technical assistance, tools for promoting the business's involvement in Energy Star® to the public, technical manuals, workshops, presentations, and software for completing a comprehensive energy and economic analysis of E2 opportunities.

The EPA Energy Star® Small Business program focuses specifically on businesses that work in buildings smaller than 100,000 square feet. This program is similar to the partnership, but is tailored to E2 opportunities for smaller buildings. Information about Energy Star® can be obtained by calling 1-800-STAR YES or at www.energystar.com.

ClimateWise. See Chapter 3 for a description of ClimateWise.

Federal Energy Management Program (FEMP). FEMP's primary mission is to provide E2 assistance to federal agencies. However, FEMP publishes E2-related technical information and offers training courses that are available to businesses and the public as well. Information about FEMP can be obtained by calling 1-800-DOE-EREC or at www.eren.doe.gov/femp.

Alliance to Save Energy. The Alliance to Save Energy (ASE) is a coalition of business, government, environmental, and consumer leaders who promote E2. ASE has many E2 programs including one for industry alternatives and cost analysis tools for E2 alternatives. Information about ASE can be obtained by calling (202) 857-0666 or at www.ase.org.

American Council for an Energy-Efficient Economy (ACE^3). ACE^3 is a nonprofit organization dedicated to advancing E2 as a means of achieving both economic prosperity and environmental protection. ACE^3 compiles business case studies for E2 and P2, holds conferences, and tracks legislative issues relevant to P2 and E2. For information about research and conferences, call (202) 429-8873. For publications, call (202) 429-0063 or visit the web site at www.aceee.org.

Energy Information Administration (EIA). EIA is a statistical agency in the U.S. Department of Energy. EIA's mission is to develop energy data and analyses that help enhance understanding of energy issues on the part of business, government, and the general public. EIA offers information related to various energy sources including petroleum, natural gas, coal, nuclear, electricity, renewable energy, and alternative fuels. Information about EIA can be obtained by calling (202) 586-8800 or at www.eia.doe.gov.

Wind Power in Colorado. Wind power is available for purchase nearly everywhere in Colorado. More information about wind power can be found at www.cogreenpower.org/index.htm.

National Lighting Product Information Program (NLPIP). NLPIP is an independent organization sponsored by government and electric utilities. Its goal is to distribute information on energy-efficient lighting products. NLPIP maintains a library of information related to energy-efficient lighting and a database of manufacturer-specific product information. Information about NLPIP can be found at www.lrc.rpi.edu/nlpip/online.

Lighting Research Center. The Lighting Research Center is part of Rensselaer Polytechnic Institute's School of Architecture. It is the world's largest university-based center for lighting education and research. The Lighting Research Center maintains information about energy efficient lighting opportunities for commercial facilities and offers free publications. Information about the Lighting Research Center can be obtained by calling (518) 687-7100 or at http://lighting.lrc.rpi.edu.

CHAPTER 8
FINANCIAL ASSISTANCE

In addition to the technical feasibility of a P2 opportunity, businesses must also consider capital investment costs, annual savings, and the payback period or return on investment. Many resources are available to assist businesses in completing a cost analysis and in securing funds for the capital investment to implement P2 opportunities. For businesses in Colorado, the *Pollution Prevention Financing Guide* provides information about, and references for, completing a total cost analysis, background information on borrowing money from lenders, case studies about P2 projects and costs involved, and a list of various types of financing options. The financing guide can be ordered through CDPHE P2 Program or is available at: www.coloradop2.org/cdphefin/(1)cover.htm.

Further information about total cost analysis and making decisions about funding options can be found in the financing technology toolbook at the following web site: www.oit.doe.gov/toolbook. The web site is monitored by the U.S. Department of Energy Office of Industrial Technologies and is intended to provide a step-by-step guide to financing and technical assistance.

The *Pollution Prevention Financing Guide* and the DOE financing technology toolbook website provide detailed descriptions of financing sources available. The following table summarizes P2 financing information that is relevant to surface coaters in Colorado.

FINANCING SOURCE	DESCRIPTION
National Industrial Competitiveness Through Efficiency: Energy, Environment, and Economics ($NICE^3$) DOE Golden Field Office: (303) 275-4728	This grant program provides funding to state/industry partnerships for projects that develop and demonstrate advances in E2 and clean production technologies.
Small Business Administration (SBA) Loan Guarantee Program Contact: Charles Brown (303) 844-3461 ext. 222	The SBA 7(a) Loan Guaranty Program facilitates loans to small businesses that are unable to secure financing on reasonable terms through normal lending channels.
Colorado Housing and Financing Authority (CHFA) Contact: Steve Johnson (303) 297-7673	CFHA offers a fixed-interest program that helps Colorado businesses involved in waste diversion to obtain financing.
CHFA Colorado Business and Industry Colorado Business and Industry Program Contact: Steve Johnson (303) 297-7673	This CHFA program focuses on rural manufacturing and industrial businesses.
CHFA Colorado Credit Reserve Contact: Steve Johnson (303) 297-7673	The Colorado Credit Reserve provides loans and lines of credit for any business purpose.

FINANCING SOURCE	DESCRIPTION
CDPHE Environmental Leadership Pollution Prevention Revolving Loan Fund (RLF) Contact: Tamera Bedford (303) 692-3477	This RLF program is designed to assist participants or potential participants in the Colorado Environmental Leadership Program with financing for projects that reduce pollution below the levels required by regulations.
Office of Economic Development RLF Program Contact Depends on Region; see the *Pollution Prevention Financing Guide*	This RLF program provides loans to existing or startup businesses in rural areas of Colorado.
Energy Performance Contracting with Energy Service Companies Rebuild Colorado Colorado Office of Energy Conservation Contact: Linda Smith (303) 620-4292 www.state.co.us/oec/rebuildco	In performance contracting, the capital investment is paid off by future energy savings. Rebuild Colorado, a program of the Colorado Office of Energy Conservation, assists businesses in all steps of performance contracting. Services range from providing sample contracts to providing an on-site expert in performance contracting to help monitor the energy improvements.
Business Capital of Colorado, Inc. (BCC) Contact: David Ammann (303) 832-8647 www.bcc-colorado.com	BCC makes loans to businesses that do not have sufficient collateral to secure a conventional bank loan. The loans are available to businesses in Adams, Arapahoe, Boulder, Denver, Douglas, and Jefferson counties.
CDPHE Small Business Ombudsman Contact: Cathy Heald (303) 692-2034 or (800) 886-7689	The CDPHE Small Business Ombudsman is available to assist small businesses in obtaining and understanding financial resources.

Many other type of loan and business assistance programs exist that are not related to capital investments for P2 technology (for example, business venture funds). Details about such programs are found in the *Pollution Prevention Financing Guide* and the DOE financing technology toolbook website.

APPENDIX A

PRIMARY AND SECONDARY SIC CODES BY SOURCE CATEGORY

APPENDIX A
PRIMARY AND SECONDARY SIC CODES BY SOURCE CATEGORY

SOURCE CATEGORY	PRIMARY SIC CODE	SECONDARY SIC CODE
Automotive and Light Duty Truck Manufacturing	None in Colorado	
Boat Manufacturing	None in Colorado	
Fabric Coating, Printing, and Dyeing	2211, 2221, 2231, 2241, 2261, 2262, 2269, 2273, 2295, 2296, 2297, 2298, 2299	
Large Appliances	3631, 3632, 3633, 3639, 3585, 3589	
Metal Can	3411, 3479, 3466	
Metal Coil	3412, 3421, 3423, 3425, 3429, 3431, 3432, 3433, 3441, 3442, 3443, 3444, 3446, 3448, 3449, 3451, 3452, 3462, 3463, 3465, 3466, 3469, 3471, 3479, 3482, 3483, 3484, 3489, 3491, 3492, 3493, 3494, 3495, 3496, 3497, 3489, 3499, 3511, 3519, 3523, 3524, 3531, 3532, 3533, 3534, 3535, 3536, 3537, 3541, 3542, 3543, 3544, 3545, 3546, 3547, 3548, 3549, 3552, 3553, 3554, 3555, 3556, 3559, 3561, 3562, 3563, 3564, 3565, 3566, 3567, 3568, 3569, 3571, 3572, 3575, 3577, 3578, 3579, 3581, 3582, 3585, 3586, 3589, 3592, 3593, 3594, 3596, 3599	
Metal Furniture	2514, 2522, 2531, 2542	2514, 2522, 2531, 2542, 2599, 3429, 3469, 3495, 3499, 3645, 3464, 3821, 3843, 3999, 7641
Miscellaneous Metal Parts and Products	3312, 3313, 3315, 3316, 3317, 3321, 3322, 3324, 3325, 3351, 3353, 3354, 3355, 3356, 3357, 3363, 3364, 3365, 3366, 3369, 3399, 3412, 3421, 3423, 3425, 3429, 3431, 3432, 3433, 3441, 3442, 3443, 3444, 3446, 3448, 3449, 3451, 3452, 3462, 3463, 3465, 3466, 3469, 3471, 3479, 3482, 3483, 3484, 3489, 3491, 3492, 3493, 3494, 3495, 3496, 3497, 3489, 3499, 3511, 3519, 3523, 3524, 3531, 3532, 3533, 3534, 3535, 3536, 3537, 3541, 3542, 3543, 3544, 3545, 3546, 3547, 3548, 3549, 3552, 3553, 3554, 3555, 3556, 3559, 3561, 3562, 3563, 3564, 3565, 3566, 3567, 3568, 3569, 3571, 3572, 3575, 3577, 3578, 3579, 3581, 3582, 3585, 3586, 3589, 3592, 3593, 3594, 3596, 3599, 3612, 3613, 3621, 3624, 3625, 3728, 3743, 3751, 3761, 3764, 3769, 3792, 3795, 3799, 3911, 3914, 3931, 3944, 3949, 3961, 3964, 3991, 3993, 3995, 3996, 9711	
Paper and Other Webs	2653, 2657, 2671, 2672, 2673, 2674, 2675, 2679, 2711, 2721, 2731, 2732, 2741, 2752, 2754, 2759, 2761,2771, 2782, 2789, 2791, 2796, 3074, 3081, 3083, 3291, 3497, 3861, 3955, 3996	
Plastic Parts and Products	3086, 3089, 3537, 3571, 3573, 3577, 3578, 3579, 3643, 3647, 3711, 3713, 3714, 3715, 3716, 3751, 3799, 3799, 3821, 3931, 3942, 3944, 3949, 3961, 3993	
Reinforced Plastic Composite Manufacturing	3732, 3081, 3082, 3084, 3085, 3086, 3087, 3088, 3089	
Wood Building Products	2426, 2429, 2431, 2435, 2436, 2939, 2451, 2452, 2493	

APPENDIX B

SICS OMITTED FROM FIGURE 1

APPENDIX B
SICS OMITTED FROM FIGURE 1

CATEGORY	SIC	NO. OF FACILITIES	SUM OF THAP
Metal Coil	3423	1	10.09
Metal Coil	3429	1	0.01
Metal Coil	3444	6	5.97
Metal Coil	3446	2	1.13
Metal Coil	3449	3	2.14
Metal Coil	3469	1	6.32
Metal Coil	3471	11	9.68
Metal Coil	3499	7	9.33
Metal Coil	3519	1	0.03
Metal Coil	3537	1	0.49
Metal Coil	3544	1	3.39
Metal Coil	3545	1	0.54
Metal Coil	3549	2	0.86
Metal Coil	3552	1	0.11
Metal Coil	3555	1	0.37
Metal Coil	3559	1	0.52
Metal Coil	3565	1	1.29
Metal Coil	3569	1	0.90
Metal Coil	3571	1	0.21
Metal Coil	3572	1	5.03
Metal Coil	3589	1	0.18
Metal Coil	3599	1	4.18
Metal Furniture	2514	1	3.18
Metal Furniture Secondary	2514	1	3.18
Metal Furniture Secondary	3429	1	0.01
Metal Furniture Secondary	3469	1	6.32
Metal Furniture Secondary	3645	1	1.66
Metal Furniture Secondary	3646	1	1.44
Miscellaneous Metal Parts and Products	3312	3	19.22
Miscellaneous Metal Parts and Products	3317	1	8.29
Miscellaneous Metal Parts and Products	3321	3	10.29
Miscellaneous Metal Parts and Products	3325	1	3.58
Miscellaneous Metal Parts and Products	3423	1	10.09
Miscellaneous Metal Parts and Products	3429	1	0.01
Miscellaneous Metal Parts and Products	3442	2	6.84
Miscellaneous Metal Parts and Products	3443	3	7.56
Miscellaneous Metal Parts and Products	3444	6	5.97
Miscellaneous Metal Parts and Products	3446	2	1.13
Miscellaneous Metal Parts and Products	3449	3	2.14
Miscellaneous Metal Parts and Products	3469	1	6.32
Miscellaneous Metal Parts and Products	3471	11	9.68
Miscellaneous Metal Parts and Products	3499	7	9.33
Miscellaneous Metal Parts and Products	3519	1	0.03
Miscellaneous Metal Parts and Products	3537	1	0.49
Miscellaneous Metal Parts and Products	3544	1	3.39
Miscellaneous Metal Parts and Products	3545	1	0.54

APPENDIX B
SICS OMITTED FROM FIGURE 1

CATEGORY	SIC	NO. OF FACILITIES	SUM OF THAP
Miscellaneous Metal Parts and Products	3549	2	0.86
Miscellaneous Metal Parts and Products	3552	1	0.11
Miscellaneous Metal Parts and Products	3555	1	0.37
Miscellaneous Metal Parts and Products	3559	1	0.52
Miscellaneous Metal Parts and Products	3563	1	1.85
Miscellaneous Metal Parts and Products	3565	1	1.29
Miscellaneous Metal Parts and Products	3569	1	0.90
Miscellaneous Metal Parts and Products	3571	1	0.21
Miscellaneous Metal Parts and Products	3572	1	5.03
Miscellaneous Metal Parts and Products	3589	1	0.18
Miscellaneous Metal Parts and Products	3599	1	4.18
Miscellaneous Metal Parts and Products	3612	1	0.34
Miscellaneous Metal Parts and Products	3613	1	0.00
Miscellaneous Metal Parts and Products	3621	1	0.03
Miscellaneous Metal Parts and Products	3624	1	0.12
Miscellaneous Metal Parts and Products	3634	1	16.50
Miscellaneous Metal Parts and Products	3645	1	1.66
Miscellaneous Metal Parts and Products	3646	1	1.44
Miscellaneous Metal Parts and Products	3661	1	0.07
Miscellaneous Metal Parts and Products	3672	4	2.24
Miscellaneous Metal Parts and Products	3679	5	5.69
Miscellaneous Metal Parts and Products	3699	2	0.70
Miscellaneous Metal Parts and Products	3711	1	13.00
Miscellaneous Metal Parts and Products	3714	3	0.74
Miscellaneous Metal Parts and Products	3715	1	6.71
Miscellaneous Metal Parts and Products	3716	1	2.76
Miscellaneous Metal Parts and Products	3728	3	9.46
Miscellaneous Metal Parts and Products	3743	2	7.42
Miscellaneous Metal Parts and Products	3761	1	0.03
Miscellaneous Metal Parts and Products	3764	1	9.20
Miscellaneous Metal Parts and Products	3914	1	0.98
Miscellaneous Metal Parts and Products	3949	1	0.04
Miscellaneous Metal Parts and Products	3993	2	2.23
Miscellaneous Metal Parts and Products	3995	1	1.89
Plastic Parts and Products	3537	1	0.49
Plastic Parts and Products	3571	1	0.21
Plastic Parts and Products	3711	1	13.00
Plastic Parts and Products	3715	1	6.71
Plastic Parts and Products	3716	1	2.76
Plastic Parts and Products	3949	1	0.04

APPENDIX C

SOURCES FOR SURFACE COATING P2 AND E2 INFORMATION

APPENDIX C

SOURCES FOR SURFACE COATING P2 AND E2 INFORMATION

Sources	Categories	SIC Codes	Information Sources	Comments
Air and Waste Management Association	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.awma.org	The AWMA website has a wide variety of information on air pollution control and waste management. AWMA publishes monthly periodicals and quarterly newsletters which can be viewed on-line. Website focuses on regulatory issues in the environmental field. Technical publications can be searched by function
Adhesives Age	Plastic Parts and Products	30, 35, 36, 37, 38, 39	www.adhesives.org	Website contains current news information within the adhesives industry. Describes recent industry trends and provides links to other
Adhesives and Sealants Council (ASC)	Plastic Parts and Products	30, 35, 36, 37, 38, 40	www.ascouncil.com	The website contains a small list of publications; however, it appears that most publications and resources can be accessed only
Aluminum Extruders Council	Miscellaneous Metal Parts and Products (aluminum extruders with paint lines)	33	www.aec.org	This website is focused mainly on aluminum extruders in the miscellaneous metal parts and products category. It contains current news, industry events, and technical discussions on
Aluminum Association	Metal Can, Metal Coil, Metal Furniture, Large Appliances, Misc. Metal Parts and Products	25, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.aluminum.org	This website contains industry facts, publications, up-to-date news, recycling technology, environmental issues, and a calendar of events. Publications can be
American Electroplaters and Surface Finishers Society	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.aesf.org	The website provides a list of documents, upcoming conferences, and general information on industry news, current trends, and technical assistance. However, many of the publications can be viewed only by members
Association of Industrial Metallizers, Coaters and Laminators	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.aimcal.org	The website contains industry news, industry-related links, technical information, publications, and past issues of its newsletters.
Coatings Alternatives Guide	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 98	http://cage.rti.org	This website is a pollution prevention tool for paint an coating users sponsored by the Research Triangle Institute and the U.S. Environmental Protection Agency (EPA). The web site contains low-emissions products guide, a cost analysis tool, information about coating alternatives, application equipment
Composites Fabricators Associations	Reinforced Plastic Composites	37	www.cfa-hq.org	The website contains technical resources, annual convention/seminar events, monthly magazines/publications, regulatory and compliance issues, and product information

APPENDIX C
SOURCES FOR SURFACE COATING P2 AND E2 INFORMATION

Chemical Coaters Association International	Metal Can, Metal Coil, Metal Furniture, Large Appliances, Misc. Metal Parts and Products	25, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.powdercoatingonline.com	The website focuses mainly on suppliers of powder coating technologies and resources for businesses within the industry. Within the supplier directory there is a description of various powder coating equipment and a list of suppliers. The business resources section includes topics, such as, pollution prevention,
finishing dot com "The Home Page of the Finishing Industry"	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.finishing.com	The website covers anodizing, plating, powder coating, and related surface finishing processes. It contains sections for interaction with other surface finishers, upcoming event announcements, frequently asked questions,
Industrial Paint and Powder Magazine	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 98	www.ippmagazine.com	Industrial Paint & Powder magazine publishes its magazine on line. Present and past issues can be found through the website. The website also has product information, resources, events,
Iowa Waste Reduction Center (IWRC)	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 99	www.iwrc.org/pubs_frame.html	The IWRC website contains information regarding application efficiency issues. Also, through this website, users can sign up to receive Pollution Prevention for Painting and
National Coil Coaters Association	Metal Coil	32, 33, 34, 35	www.coilcoaters.org	The website includes industry news and publications, including a waste minimization study, that can be purchased on-line. The
National Paint and Coatings Association	Metal Can, Metal Coil, Metal Furniture, Large Appliances, Misc. Metal Parts and Products	25, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.paint.org	The National Paint and Coating Association represents the paint and coatings industry. The website contains industry information, links, meeting and event information, a paint council
Pressure Sensitive Tape Council	Paper and Other Webs	26, 27, 30, 32, 34, 38, 39	www.pstc.org	Viewing the Pressure Sensitive Tape Council website is limited to members; however, there is a resource library that can be accessed by
Products Finishing	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.pfonline.com	www.pfonline.com is the online component of Products Finishing Magazine. It has information about suppliers, products, articles, forums, experts, news, links, books, powder
Powder Coating Institute	Metal Can, Metal Coil, Metal Furniture, Large Appliances, Misc. Metal Parts and	25, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.powdercoating.org	Website provides consumer information and a list of technical publications that can be ordered on-line.
RadTech International North America	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.radtech.org	RadTech's main purpose is to promote the use and development of UV/EB technology. The website contains technical information about UV and EB technologies, publications, events,

APPENDIX C

SOURCES FOR SURFACE COATING P2 AND E2 INFORMATION

Society of the Plastics Industry	Plastic Parts and Products	30, 35, 36, 37, 38, 39	www.socplas.org	The website contains reports on legislative, regulatory, business development/outreach, and environmental issues. There is also a search
Specialty Steel Industry of North America	Metal Can, Metal Coil, Metal Furniture, Large Appliances, Misc. Metal Parts and Products	25, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.ssina.com	Specialty Steel Industry is an organization sponsored by its members. The website contains information on steel suppliers, publications, current news, a calendar of events, and links to
Steel Manufacturers Association	Metal Can, Metal Coil, Metal Furniture, Large Appliances, Misc. Metal Parts and	25, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.steelnet.org	This website provides a list of suppliers of steel, a calendar of events, and an online library.
Tennessee Valley Authority Environmental Waste Management Process and Prevention	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39,	www.tva.gov/orgs/iwr	Provides waste reduction guides for various technologies.
The Society for Protective Coatings	All	22, 24, 25, 26, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 76, 97	www.sspc.org	Viewing this web site is limited to authorized users.