EPA-600/R-97-101
September 1997

Powder Coat Applications

Final Report

by

Michael J. Docherty and Fredrick J. Mulkey
Concurrent Technologies Corporation
1450 Scalp Avenue
Johnstown, PA 15904

EPA/DOD IAG DW97936814
DOD Contract: DAAA21-93-C-0046

U.S. EPA Project Officer:
J. Kaye Whitfield
National Risk Management Research Laboratory
Air Pollution Prevention and Control Division
Research Triangle Park, NC 27711

Prepared for:
U.S. Environmental Protection Agency
Office of Research and Development
Washington, DC 28460

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before compl

1. REPORT NO.	2.	3
EPA-600/R-97-101		PB98-108624

4. TITLE AND SUBTITLE	5. REPORT DATE
Powder Coat Applications	September 1997
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Michael J. Docherty and Fred J. Mulkey	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Concurrent Technologies Corporation 1450 Scalp Avenue Johnstown, Pennsylvania 15904	11. CONTRACT/GRANT NO. EPA/DOE IAG DW97936814 DOD DAAA 21-93-C-0046
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
EPA, Office of Research and Development Air Pollution Prevention and Control Division Research Triangle Park, NC 27711	Final; 12/95 - 12/96 14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES APPCD project officer is J. Kaye Whitfield, Mail Drop 61, 919/541-2509.

16. ABSTRACT The report discusses an investigation of critical factors that affect the use of powder coatings on the environment, cost, quality, and production. The investigation involved a small business representative working with the National Defense Center for Environmental Excellence (NDCEE), operated by Concurrent Technologies Corporation (CTC), through the EPA's Environmental Technology Initiative. The investigation demonstrated that powder has the potential to provide unique and valuable benefits when considering each of these areas. (NOTE: Powder coating is an organic finishing technology that offers users the potential to reduce volatile organic compound (VOC) emissions to zero. Due to ever-increasing VOC emission restrictions placed on manufacturers, powder coating production and use have been growing dramatically over the past few years. Powder coating has been accepted by such manufacturing communities as automotive, appliance, furniture, and equipment. However, small business manufacturers have difficulty investigating new technologies due to size and budget restrictions.)

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Pollution Prevention	13B
Powder (Particles)	Stationary Sources	14G
Coatings	Volatile Organic Compounds (VOCs)	11C
Volatility		20M
Organic Compounds		07C
Emission		

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release to Public	Unclassified	67
	20. SECURITY CLASS *(This page)*	22. PRICE
	Unclassified	

EPA Form 2220-1 (9-73)

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and groundwater; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

E. Timothy Oppelt, Director
National Risk Management Research Laboratory

ABSTRACT

Powder coating is an organic finishing technology that offers users the potential to reduce Volatile Organic Compound (VOC) emissions to zero. Due to ever-increasing VOC emission restrictions placed on manufacturers, powder coating production and use have been growing dramatically over the past few years. Powder coating has been accepted by such manufacturing communities as automotive, appliance, furniture, and equipment. However, small business manufacturers have difficulty investigating new technologies due to size and budget restrictions. Through the EPA's Environmental Technology Initiative, the National Defense Center for Environmental Excellence (NDCEE), operated by Concurrent Technologies Corporation (*CTC)*, has worked with a small business representative to demonstrate the applicability of powder coating. During the project, critical factors that affect the cost, quality, and production were investigated. The investigation demonstrated that powder has the potential to provide unique and valuable benefits when considering each of those areas.

CONTENTS

ABSTRACT iv

LIST OF FIGURES vii

LIST OF TABLES vii

METRIC EQUIVALENTS viii

EXECUTIVE SUMMARY ix

INTRODUCTION 1

- Project Background 1
- Project Objectives 1

APPROACH 1

- Identification of a Small Business Representative 1
- Facility Baseline Survey 1
- Powder Coating Technology Feasibility Testing 2
- Powder Coating Technology Optimization Testing 2
- Powder Coating Validation Demonstrations 2
- Technology Transfer Activities 2

PROJECT RESULTS 2

- Identification of Small Business Project Partner 2
- Baseline Survey of The Bilco Company's Flowcoat Finishing Operation 3
  - Methodologies Used 3
    - On-site Survey 3
    - Survey Questionnaire 3
    - Follow-up Phone Interviews 3
  - Bilco Process Description 4
    - General Process Descriptions of Manufacturing and Coating Operations 4
  - Equipment Description 4
  - Material and Utilities Usage 4
    - Material Usage 4
    - Utilities Usage 4
  - Production Flow Rates 4
  - Procedures and Practices 5
    - Surface Preparation 5
    - Coating Application and Mixing Process 5
    - Coating Performance Testing 6
  - Waste and Emissions Summary 6
  - Regulatory Profile 6
  - The Clean Air Act, as Amended in 1990 (CAA) 7
    - National Ambient Air Quality Standards (NAAQS) 7
    - State of Connecticut 7
    - The Resource Conservation and Recovery Act (RCRA) 7
    - D007 Hazardous Waste (Paint Sludge) 8

Powder Coating Alternative Process Description 8
Powder Coating Equipment Used for this Project Descriptions 9
Controls and Data Collection 9
Conveyor System 9
Pretreatment 9
Dry-off and Cure Ovens 9
Automatic Powder with Manual Touch-up 9
Material and Utilities Usage 9
Pretreatment Process Selection Background 9
Pretreatment Materials 10
Powder Coating and Topcoating Materials 10
Procedures/Practices 11
Surface Preparation 11
Coating Application 11
Coating Performance Testing 11
Waste and Emissions Summary 11
Liquid Wastes 11
Solid and Hazardous Wastes 11
Air Emissions 11
Regulatory Profile 12
The Clean Water Act (CWA) 12
Future Considerations 12
Local POTW Requirement 14
Requirements of the New Haven Code 14
Prohibited Discharges 15
Requirements for Wastewater Discharge Permits 15
Other Considerations 15
Feasibility Demonstrations 15
Pretreatment System and Powder Coating System Conditions 16
Feasibility Laboratory Testing Results 16
Primer to Metal Performance Data 16
Primer to Topcoat Performance Data 16
Feasibility Demonstration Major Lessons Learned 16
Optimization Demonstrations 17
Pretreatment System and Powder Coating System Conditions 19
Racking Considerations 19
Iron Phosphating Pretreatment Considerations 19
Powder Coating Considerations 19
Optimization Trial Laboratory Testing Results 19
Supplemental Powder Coat/Topcoat Compatibility Trial 20
Optimization Demonstration Major Results 20
Validation Trials 20
Parts Processing 20
Process Operating Conditions 20
Material, Utility and Labor Usage 21
Laboratory Results 21
Powder Coat Primer to Metal Performance Data 21
Basement Door Parts Thickness Profile Data 22
Major Results Summary From Validation Testing 22
COST ANALYSIS 22
Environmental Analysis 26

Regulatory Comparisons 26
Quality Analysis Summary 27
Primer to Metal Performance Category 27
Primer to Topcoat Performance 27
Additional Process Quality Considerations 27
CONCLUSIONS 28
REFERENCES 29
APPENDIX A 30
Facility Baseline Survey Questionnaire 30
APPENDIX B 46
Material Safety Data Sheets for Bilco Primer and Solvent Thinner 46

LIST OF FIGURES

Figure 1 Exploded Top View Of Bilco Basement Door System 3
Figure 2. Exploded Bottom View Of Bilco Basement Door System 3
Figure 3. Process Flow Diagram 5
Figure 4. *CTC* Line & Overall Process Schematic 9
Figure 5. Average Thickness Profile On Front Surface 23
Figure 6. Average Thickness Profile On Back Side Surfaces 23

LIST OF TABLES

Table 1. Flowcoating Process Equipment 4
Table 2. 1995 Primer And Solvent Usage In Bilco Flowcoating Process 4
Table 3. Summary Of Energy Usage By The Bilco Company 4
Table 4. Bilco Basement Door Primer Specifications 6
Table 5. Waste And Emissions Summary For The Bilco Flowcoating Process 6
Table 6. Iron Phosphate Process Materials Summary 10
Table 7. Summary Of Powder Coating And Topcoating Materials 13
Table 8. Iron Phosphate Process Summary 13
Table 9. Scope Of Coatings Testing For Technology Demonstration Trials 14
Table 10. Iron Phosphate Pretreatment System Conditions 16
Table 11. Powder Coating System Conditions 16
Table 12. Feasibility Testing Results For The Primer Only And Primer / Topcoat Specimens 18
Table 13. Optimization Testing Results For The Powder Primer And Primer / Topcoat Specimens 20
Table 14. Supplemental Intercoat Adhesion Data For Topcoats And Powder Coats 21
Table 15. Validation Trial Material And Utility Usage Summary 22
Table 16. Validation Trial Inventory Of Parts For AM And PM Shifts 24
Table 17. Validation Trial Process Operating Conditions Summary 24
Table 18. Validation Testing Results For The Primer And Primer / Topcoat Specimens 25
Table 19. Total Capital Cost 26
Table 20. Operating Cost Summary 26
Table 21. Life Cycle Cost Comparison 26
Table 22. Bilco Basement Door Primer Specifications 27

METRIC EQUIVALENTS

This report combines metric and nonmetric units as the need arises. Readers who are more familiar with metric units may use the following factors to convert to that system.

NON-METRIC	MULTIPLIED BY	YIELDS METRIC
°F	5 / 9 (°F-32)	°C
ft	0.3048	m
ft^2	0.0929	m^2
ft^3	28.32 (or 0.02832)	L (m^3)
gal	3.785	L
lb	0.4536	kg
in	2.54	cm
mil	0.0254	mm
psi	6.895	kPa

EXECUTIVE SUMMARY

This document summarizes the results of a National Defense Center for Environmental Excellence (NDCEE) task conducted by Concurrent Technologies Corporation (*CTC*). The task, "Powder Coat Applications," is an Environmental Technology Initiative project funded by the US Environmental Protection Agency (EPA). The task objective is to demonstrate powder coating technology as a method of eliminating volatile organic compounds (VOCs) from coating operations in small business.

Small business manufacturers often do not have the resources to investigate new technologies such as powder coating. This task leveraged the existence of the NDCEE Technology Demonstration Factory to test and evaluate powder coatings for small business applications. A small business manufacturer, The Bilco Company, was selected to participate in the project. Bilco, located in West Haven, CT, manufactures steel basement doors and coats these with a solvent-based primer.

Environmental analysis of the alternative, powder coating, demonstrated the potential to eliminate VOC emissions. Currently, approximately 39 tons per year of VOCs are produced by the current system. These VOCs are sent to a catalytic incinerator destruction system that is nearing the end of its useful life and will need to be replaced in order to meet regulations if the current coating system is kept. This VOC destruction system reduces the amount of VOCs emitted into the atmosphere to 2.5 tons per year.

During quality analysis, powder coating demonstrated the potential to dramatically improve upon performance of the current coating system. Performance characteristics such as salt spray corrosion resistance, impact resistance, and hardness were improved with the use of powder coating. With increased coating performance, Bilco could investigate the possibility of offering an extended warranty on its products.

Powder coating systems can be designed to meet Bilco's present and future production requirements. Automatic and manual powder equipment presently exists that can be configured to meet Bilco's present 235 door/day production level.

Using the NIST Building Life Cycle Cost program with a study period of 15 years, it was calculated that through powder coating, Bilco can save over $142,000 each year in operating costs when compared to using the current coating system with increased VOC controls. In addition, a Life Cycle Cost savings of over $280,000 can be obtained with powder.

Bilco's current finishing system, flow coating, is a high-transfer efficiency coating process resulting in a low cost per part. As a result, it is estimated that an investment in powder coating equipment will not realize payback until year 7 after investment. This payback period is much longer than observed when powder systems have replaced liquid spray coating technologies in industry. However, benefits such as increased part quality and reduced use of hazardous materials are difficult to quantify. Powder coating, while offering a payback period of 7 years, has the potential to increase product quality and provide a cleaner, healthier workplace.

INTRODUCTION

New environmental regulations continue to place tighter restrictions on how manufacturers can coat parts by limiting the amount of volatile organic compounds (VOCs) that can be released. A reduction in VOC emissions can be achieved by technologies such as higher-efficiency spray equipment, e.g., high-volume, low-pressure (HVLP) and electrostatic equipment. In addition, a process material change can reduce VOC emissions by eliminating VOCs from coating formulations. Coatings manufacturers offer a range of technologies such as high-solids paint, waterborne, and powder coating materials to lower VOC emissions.

Powder coating, invented in the early 1950s, is an environmental technology with near-zero-VOC emissions. Although powder coatings have been in existence for over 40 years, they have not gained widespread acceptance until the recent introduction of strict VOC emission regulations. Powder coating manufacturers have continually refined their formulations and now offer coatings that match or exceed performance characteristics of previously-used liquid spray coatings.

Although powder coating technology has been adopted by large industries such as automotive, appliance, and furniture manufacturing, small businesses often do not have the resources to investigate new technologies. To successfully transition a new technology, a company must be able to investigate all aspects of a new technology that affect:

- cost,
- environmental impact,
- part quality, and
- production.

Once these areas are evaluated, an informed decision can be made regarding the implementation of new technology.

Project Background

The US Environmental Protection Agency (EPA), through its Environmental Technology Initiative, has funded the National Defense Center for Environmental Excellence (NDCEE) to work with a small business to demonstrate powder coating and identify opportunities for its use by these businesses.

This project focused on commercially-available powder coating materials that could potentially be implemented into small business manufacturing. These powder coatings have been developed for and used by larger manufacturers and the Department of Defense (DOD) but have performance characteristics similar to those required by smaller businesses. Working with the EPA and the Powder Coating Institute (PCI), a project plan was developed to meet this objective.

Project Objectives

The project objectives, as stated in the original Statement of Work (SOW) and Project Plan, are as follows:

- work with a small business partner who is presently using a solvent-based coating system to conduct technology demonstrations and process simulations involving the application of powder coatings on sample production parts
- gather technical, economic, and environmental data to determine the feasibility of converting from a solvent-based coating system to a powder coating system for a small business project partner
- derive lessons learned that are applicable to the conversion of powder coating by other businesses using solvent-based finishes
- conduct technology transfer activities to small businesses on powder coating.

APPROACH

The approach used by the project consists of six major steps as described in this section.

Identification of a Small Business Representative

- Collaborate with the DOD, EPA, PCI, and the Small Business Association (SBA) to identify a candidate small business for direct participation in the Powder Coating Applications project. The basic requirement for selecting a small business candidate was that the candidate had to be using solvent-based liquid finishing technologies as a major component of their manufacturing process and have an interest in transitioning to powder coating technology.

Facility Baseline Survey

- Establish a baseline for the process economics, technical requirements, and environmental aspects for the small business candidate's current finishing operation by conducting an on-site facility survey, prepare a detailed survey questionnaire to be completed by the small business, and perform follow-up telephone conversations with the small business.

- Use this information to prepare life cycle cost, environmental, and technical performance comparative analyses of the candidate's present finishing process to the powder coating alternative process.

Powder Coating Technology Feasibility Testing

- Prior to conducting full-scale powder coating technology demonstrations and formal economic and product performance data collection, perform initial feasibility testing to determine if powder coating technology is appropriate for the parts manufactured by the small business. The primary objective of this activity is to demonstrate that powder coatings show promise in terms of coating performance data for meeting existing coating requirements.

Powder Coating Technology Optimization Testing

- Following the successful feasibility demonstration of powder coating, perform an optimization trial. The optimization phase is intended to accomplish the following goals:

  - focus on those aspects of the powder coating process that demonstrate a need for further refinement based on process engineering lessons learned and/or laboratory testing results from the feasibility trial
  - demonstrate that current coating requirements could be maintained after optimization process changes were made
  - serve as a technical preparation phase for the final technology validation demonstration trials.

Powder Coating Validation Demonstrations

- Following completion of the optimization testing, conduct a final powder coating validation demonstration. The goals of the validation testing are as follows:

  - using the process parameters and lessons learned from prior trials, prove-out the ability of powder coating technology to successfully coat parts under simulated production conditions
  - make any final process engineering observations that would translate into powder coating process implementation recommendations
  - collect "on-line" technical, economic, and quality data for powder coating the selected candidate's parts.

Technology Transfer Activities

- One of the primary objectives of the Powder Coating Applications project is to provide information to the small business community demonstrating that powder coating can be a cost-effective methodology to replace liquid processes while yielding improved product quality, reduced life cycle production costs, and reduced hazardous air emissions.

- Complete the following technology transition activities:

  - distribute this report to other small businesses through the EPA, PCI, SBA, and trade publications
  - conduct classroom, factory, and laboratory hands-on training sessions in powder coating.

PROJECT RESULTS

Identification of Small Business Project Partner

The first project activity identified a small business project partner. To maximize the impact of the program, demonstration of powder coating technology on real parts from a small business manufacturer was critical. A meeting was first held, attended by:

- the EPA project sponsors
- DOD technical monitors
- PCI Executive Director
- industry consultants
- in-house technical and business personnel.

During the meeting, the type of small business participation was discussed. Small businesses, as categorized by the SBA, consists of any manufacturer with 500 or fewer employees. To select a manufacturer for the project that would produce sufficient data that would be widely applicable to many of the small manufacturers currently performing liquid coating operations, the decision was made by the meeting attendees to work with a manufacturer that at least had a conveyorized paint line.

After an extensive search, the Bilco Company in West Haven, CT, was identified. Bilco is currently coating its products with a solvent-based coating system and is interested in investigating powder coating. Because of Bilco's small size, an investigation of this nature was not feasible without external support. This project offered Bilco a way to accomplish that investigation while expending little resources and avoiding any production interruptions.

Bilco is a small manufacturer of exterior basement doors. Bilco currently has approximately 110 employees at its manufacturing site. Approximately half of the employees work producing doors in the factory. The remaining employees work in administrative and sales areas.

Figures 1 and 2, show the type of product that Bilco manufactures. These parts are produced using hot-rolled steel and are coated with a solvent-based primer at the manufacturing site. The doors may be topcoated later by an installation contractor in the field. The primer that Bilco

currently applies is a solvent-based coating that contains 3.99 pounds of VOCs per gallon as supplied. However, to properly coat the parts, Bilco adds additional solvent to the primer at an average yearly ratio of approximately 3:4. This produces a high level of VOCs from the coating process.

If the current paint system is kept, Bilco faces replacement of their current VOC control system with a new $380,000 VOC incinerator to comply with the VOC emissions limit. The current equipment is nearing the end of its useful life. This type of 'end-of-pipe' VOC control is typically expensive to purchase and operate.

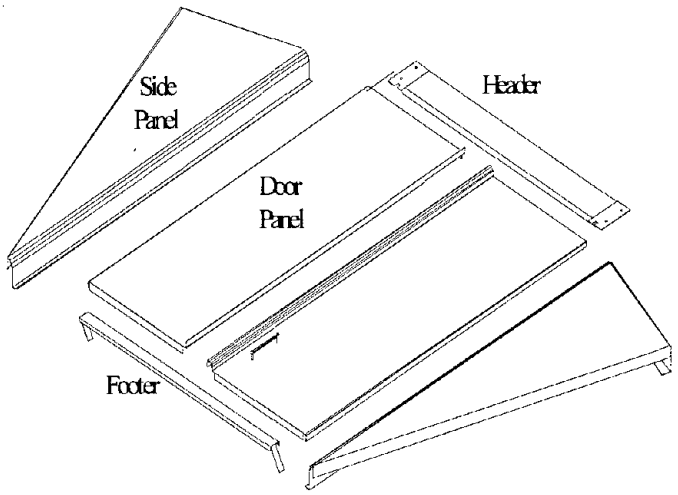


Figure 1. Exploded Top View of Bilco Basement Door System

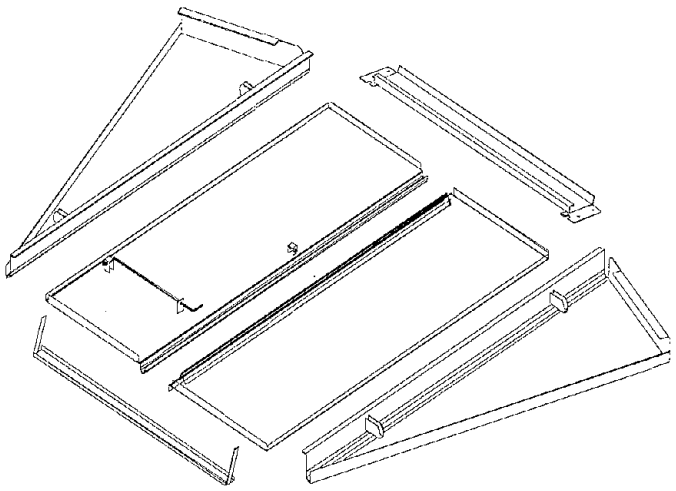


Figure 2. Exploded Bottom View of Bilco Basement Door System

Baseline Survey of The Bilco Company's Flowcoat Finishing Operation

This section presents the methods used to collect information and describes the coating process for Bilco's finishing operations.

Methodologies Used

Three techniques were used to collect information about Bilco's finishing process. These were:

- an initial on-site survey,
- a facility questionnaire, and
- follow-up phone interviews.

On-site Survey

An initial project kick-off meeting and brief survey of Bilco's finishing operation was conducted in December 1995. Contractor personnel and an NDCEE program representative from the Armament Research Development and Engineering Center (ARDEC) worked with Bilco staff to collect information.

During a one-day meeting, Bilco representatives led the survey team on a tour of its manufacturing facility. The tour included receiving, cutting, stamping, forming, welding, coating, packaging, and storage. During the tour, information was collected about Bilco's process equipment, procedures, and material usage. Bilco provided the team with process material safety data sheets (MSDSs), material usage volumes, and coating details.

The most detailed information, however, was collected from the survey questionnaire and follow-up phone interviews.

Survey Questionnaire

As a follow-up to the initial on-site facility baseline survey, a 15-page questionnaire was prepared and completed by Bilco personnel. A sample questionnaire is located in Appendix A. The questionnaire requested information on Bilco's process operating data, quality assurance practices, environmental practices, and operating costs.

Follow-up Phone Interviews

The information collected from the on-site survey and the follow-up questionnaire was supplemented as necessary by conducting phone interviews with Bilco personnel throughout the duration of the project.

The input received from all three data collection techniques forms the basis of the information reported below for Bilco's finishing process.

Bilco Process Description

The following is an overview of Bilco's current process. For relevancy, detailed discussion will be limited to those portions of Bilco's manufacturing that directly affect the coating process.

General Process Descriptions of Manufacturing and Coating Operations

Bilco receives hot-rolled steel in sheets to manufacture the doors and steel rods to manufacture the handle and locking assemblies. All necessary cutting, stamping, bending, and welding are performed on-site by Bilco personnel. Following welding, the parts are hung on a conveyor and sent to the flow-coater where a one-coat primer is applied.

In flowcoating, the parts are sprayed with paint from the top, bottom, and sides with high-pressure spray nozzles. The paint that does not adhere to the part falls through the bottom of the flowcoater and is recirculated through the system's large paint reservoir. All required paint and solvent are added to this reservoir. The overall transfer efficiency of this type of system is very high, similar to that of powder coating, but the paint currently used is high in VOC content.

Following application of the primer, it is dried in a baking oven connected to the flow coater. Once the coating is dried, the parts are packaged and sent to storage for shipment. Figure 3 shows a schematic process flow diagram of Bilco's facility.

An important factor to note about Bilco's current paint system is that there is no cleaning or pretreatment of the parts prior to painting. With solvent-based paint systems and low levels of oily soils, this can sometimes work. Apparently, Bilco's solvent-based paint system is able to accommodate the low levels of soils present on its products.

Equipment Description

Table 1 lists Bilco's current flowcoating equipment size, capacity, pollution control, and other information.

Table 1. Flowcoating Process Equipment

Unit	Details
OVERALL	
Process Footprint	15' x 125'
VOC CONTROL	
Catalytic Incinerator	Installed 1985, 93-94% destruction efficiency
COATING SYSTEM	
Flowcoater Booth	90 gallon tank, 6' x 10' x 30'
Baking Oven	Gas fired oven, 6' x 10' x 30'

Material and Utilities Usage

Material Usage

In the single-step flowcoating process used by Bilco, the only material inputs are the primer coating and a solvent used to reduce the viscosity or thin the primer. There are no other parts cleaning or metal pretreatment steps. The door components enter the flowcoater directly after fabrication. The primer is listed by the coating vendor as being a red oxide primer. The thinner is a mixture of aromatic hydrocarbon solvents.

In addition to reducing the primer, the solvent is used periodically to clean the spray nozzles in the flowcoater. The total annual (1995) usage and the major hazardous constituents as listed on the MSDSs are shown in Table 2. The complete MSDSs are in Appendix B.

Table 2. 1995 Primer and Solvent Usage in Bilco Flowcoating Process

Material	Annual Usage, gallons	Hazardous Components
Low VOC Red Oxide Primer 10.773 lbs/gal (3.99 lb/gal VOC)	5,740	Ethylamine Alkylolammonium Salt Petroleum Hydrocarbons 1,2,4, Trimethylbenzene Naphthalene Cobalt Manganese
Aromatic 100 Solvent 7.3 lbs/gal	7,560	Trimethylbenzenes Xylene Cumene Ethylbenzene

Utilities Usage

The Bilco flowcoating process primarily uses natural gas and electricity. The utility usage details are summarized in Table 3.

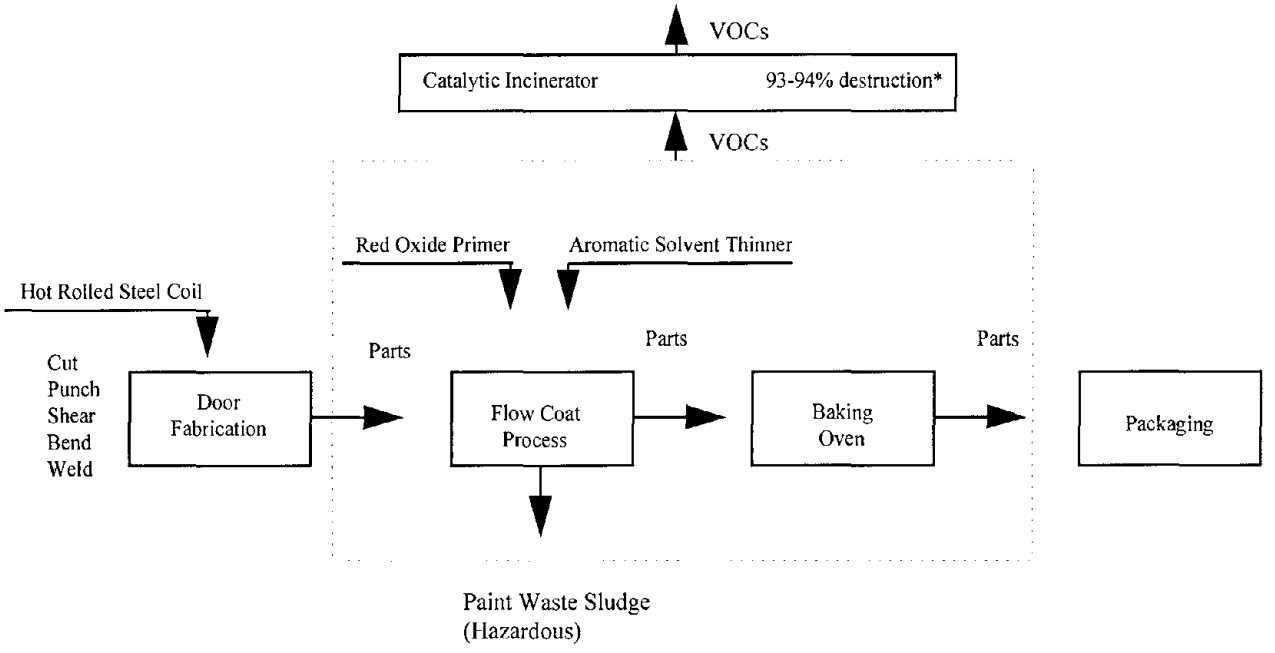
Table 3. Summary of Energy Usage by the Bilco Company

ENERGY	QUANTITY
Electricity	23,107 kW-hr/yr
Natural Gas	2,149,600 ft^3/yr

Production Flow Rates

Bilco operates one 8-hour production shift per day, 5 days per week, 249 days per year. A total of eight operators and one supervisor work in the finishing area, which includes flowcoating, packaging, and distribution operations.

Per shift, Bilco manufactures and flowcoats approximately 235 complete hot rolled steel basement door systems, which come in four standard sizes. Each door consists of two



* capture efficiency not available

Figure 3. Process Flow Diagram

rectangular door panels, two triangular side pieces, a rectangular header piece, and a rectangular footer piece, for a total of six major components. The doors and side pieces also have various hinges and latches attached for operation of the doors. On a typical production day, therefore, Bilco manufactures 470 door panels, 470 side pieces, 235 headers, and 235 footers. Average annual total production equates to 50,000 to 60,000 complete doors per year.

The average total surface area per complete door system (six main panels with subassemblies) is approximately 91 ft^2. Assuming equal production of all standard door sizes, 21,385 ft^2 of surface area are coated with primer each shift, and over 5.3 million ft^2 of surface area are coated annually.

Procedures and Practices

Surface Preparation

After fabrication of the hot rolled steel into panels and welding of various subassemblies such as handles, rods, and hinges onto the appropriate panels, the parts are sent directly to the flowcoating booth.

There are no additional surface preparation steps such as blasting, cleaning, conversion coating, or scale removal. The physical and/or chemical action of the primer and solvent mixture is relied upon to maintain film integrity and adhesion. Bilco does perform a visual inspection of the hot rolled steel prior to flowcoating to check for the presence of excessive scale or oil. Upon close visual inspection, weld spots and other small, random metal surface imperfections and contamination such as dust may occasionally be observed in the Final Coating Film.

Coating Application and Mixing Process

The flowcoating operation is conveyorized and requires little manual attendance during coating and baking other than loading and unloading of the parts. The door components are racked individually onto the conveyor so that the parts for one complete basement door assembly exit the baking booth as a group. The racking configuration would not be described as being high density.

The primer and solvent are mixed to achieve the viscosity recommended by the vendor which is 20-22 seconds in a Zahn #2 cup. The parts are automatically coated as they pass through the flowcoating booth. A reservoir collects any unvolatilized primer/thinner overspray as well as any solvent used to periodically clean the spray nozzles. The contents of the reservoir are continuously recycled with virgin coating material during production and sprayed back onto the parts.

When applied and cured according to the coating supplier's instructions, the dry film thickness of the primer should range from 0.5-1.5 mils. The theoretical coverage of the primer,

when thinned as prescribed, is 636 ft^2/gallon. Actual coverage varies based on actual viscosity, process operating, environmental conditions, and coating thickness. Based on the 55,740 gallons of primer used annually by Bilco and the stated coverage for the coating, the calculated surface area coated annually by Bilco is approximately 3.6 million ft^2 at a film thickness of 1 mil. However, based on Bilco's production data of 235 doors per day, which equates to about 5.3 million ft^2 of coated surface annually, Bilco is achieving a yield that is on the higher end of the expectation boundary. This may indicate, as do the panels tested, that Bilco is applying films at the lower end of the film thickness range.

Coating Performance Testing

Bilco reports that it performs visual inspections and dry film thickness quality checks on its parts after baking and that there are few if any rejects after these checks. The coating supplier is responsible for any primer raw materials checks and for periodic testing for salt spray corrosion resistance.

Bilco has a performance specification sheet for its basement door primer. Table 4 summarizes the overall primer requirements as found in Bilco's written specification and as determined through discussion with Bilco representatives.

Table 4. Bilco Basement Door Primer Specifications

ITEM	REQUIREMENTS
Corrosion Resistance	• 175 hours ASTM B117 salt spray • Resist rust to a rating of 10 according to ASTM D610 • No blisters according to ASTM D714
Environmental Compliance	• VOC compliant in the State of Connecticut
Appearance and Thickness	• Smooth finish when applied to hot rolled steel weldments • Complete coverage, no bare spots, drips or sags • Red oxide color • 0.7 to 1.1 mils thickness
Topcoating	• Compatible with a finish coat of alkyd enamel applied in the field after installation • Alternative topcoats acceptable as long as these have equal field performance and customer appeal

Waste and Emissions Summary

The flowcoating process produces two waste streams: a D007 paint sludge waste and VOC air emissions. The paint sludge waste comes from the primer/thinner recycling reservoir at the bottom of the flowcoater booth. This sludge must be removed and periodically disposed off-site. Although this waste stream is primarily paint related along with oils and other surface contaminants removed during the coating step, according to environmental regulations it must be listed as D007 due to the possible presence of chromium from the steel parts being coated. There are no other operations, such as cleaning or maintaining equipment, or replacing filters, that generate additional solid wastes.

Air emissions are generated as the result of VOCs in the primer and thinner. There are minimal fugitive emissions reported for the process. The only opening in the process booths other than the exit slit from the bake oven and the openings for the emission stacks is the narrow entrance slit for the parts. The spray segment occurs well enough inside the flowcoating booth to minimize fugitive emissions. All emissions are assumed to travel through the interconnected emission stack system above the flowcoating and bake oven booths to a catalytic incinerator that reduces the amount of VOCs entering the atmosphere by 93-94%. Secondary air contaminants may be generated during the incineration process and result in the release of additional air emissions. These secondary air contaminants can include nitrogen oxides, carbon monoxide, carbon dioxide, and sulfur dioxide.

Table 5 summarizes the waste streams generated and the amounts of each reported by Bilco.

Table 5. Waste and Emissions Summary for the Bilco Flowcoating Process

Waste Stream	Quantity
D007 Hazardous Paint Waste Sludge	11,000 lbs/yr
VOC Air Emissions	39 tons/yr before incineration 2.5 tons/yr after incineration
Nitrogen Oxides	140 lb/million cubic feet gas fired*
Carbon Monoxide	35 lb/million cubic feet gas fired*
Carbon Dioxide	120,000 lb/million cubic feet gas fired*
Sulfur Dioxide	0.6 lb/million cubic feet gas fired*

*(Estimated values based on information found in EPA document *AP-42* for uncontrolled small industrial boilers[1].)

Regulatory Profile

This section describes the legislative and regulatory requirements at the federal, state, and local level that relate to the management of hazardous waste and the control of VOC emissions as they impact Bilco's current flow coating operation.

The flow coating operation is a two-step process. The first step includes the application of the coating (primer) itself. The second step is a curing process where the primer is dried and the VOC emissions are captured for incineration.

The regulatory analysis that follows is based on the following data reported by Bilco:

- Bilco currently emits less than three tons of VOCs per year from its flow coating operation (after incineration).
- Bilco generates approximately 11,000 lbs/yr (5,000 kg/yr) or 416 kg/month of D007 hazardous waste (paint sludge).

Based on these facts, the primary regulations impacting Bilco at this time are the Clean Air Act and the Resource Conservation and Recovery Act.

The Clean Air Act, as Amended in 1990 (CAA)

National Ambient Air Quality Standards (NAAQS)

Under Title I of the Clean Air Act, as amended in 1990 (CAA), the EPA is required to establish national ambient air quality standards (NAAQS) for criteria pollutants, such as ozone, sulfur dioxide, nitrogen dioxide, particulate matter, carbon monoxide, and lead. NAAQS establish certain levels of criteria pollutants that may not be exceeded in the ambient air of specified geographical areas. Each state is responsible for adopting and enforcing the NAAQS. An area where the quality of the ambient air fails to meet any of the NAAQS for a given pollutant is referred to as a non-attainment area.

Ozone non-attainment areas are classified into one of the following five categories based on the extent of non-attainment: marginal, moderate, serious, severe, and extreme. Each classification has its own date by which attainment is required and its own major source threshold based on a source's potential to emit a certain number of tons of VOCs per year. Sources located in ozone non-attainment areas classified with a greater extent of non-attainment generally require more stringent controls.

Because Bilco generates VOCs that are considered to be a precursor to ozone, Bilco's conventional flowcoating process is primarily affected by the NAAQS pertaining to ozone. Bilco is located in New Haven, Connecticut, which is in a geographical area that has been designated as a serious non-attainment area for ozone. In serious ozone non-attainment areas, a major source is defined as a source that emits 50 tons or more of VOCs per year. Therefore, Bilco does not qualify as a major source emitter of VOCs.

State of Connecticut

Control of VOC Emissions - Emissions Standards

The state of Connecticut has established regulations to control emissions of organic compounds. These regulations can be found in 22 (Connecticut Code) CT Code part 174, section 20 (i.e., Section 22a-174-20). The regulations include emission standards to control VOC emissions related to "miscellaneous metal parts and products," which includes the following industrial categories:

- fabricated metal products (metal covered doors, frames, etc.) and
- any other industrial category which coats metal parts or products under the Standard Industrial Classification (SIC) Code of Major Group 34 (fabricated metal products).

The regulation prohibits facilities engaged in the surface coating of miscellaneous metal parts and products from operating a coating application system that emits VOCs from any coating in excess of the following amounts:

1. 4.3 pounds per gallon (lb/gal) of coating, excluding water and exempt VOCs, delivered to a coating applicator that applies a clear coat
2. 3.5 lb/gal of coating, excluding water and exempt VOCs, delivered to a coating applicator in a coating application system that is air dried or forced warm air dried at temperatures up to 90 degrees C
3. 3.5 lb/gal of coating, excluding water and exempt VOCs, delivered to a coating applicator that applies extreme performance coatings
4. 3.0 lb/gal of coating, excluding water and exempt VOCs, delivered to a coating applicator for all other coatings, adhesives, fillers, or sealant and coating application systems
5. 6.3 lb/gal of coating, excluding water and exempt VOCs, delivered to a coating applicator which applies high performance architectural aluminum coatings.

Item No. 2, in particular, is relevant to Bilco's operation.

The Resource Conservation and Recovery Act (RCRA)

Subtitle C of the federal Resource Conservation and Recovery Act (RCRA) authorizes the EPA to regulate the management and disposal of hazardous wastes. The designation of a waste as hazardous subjects all those charged with managing that waste to the stringent "cradle-to-grave" requirements of RCRA Subtitle C. The state of Connecticut has been authorized to administer its own hazardous waste program and enforce hazardous waste law.

If wastes from the Bilco process qualify as hazardous under RCRA, Bilco is considered a hazardous waste generator subject to the RCRA requirements for hazardous waste generators, such as hazardous waste manifesting of wastes and reporting. A generator is defined as "any person, by site, whose act or process produces hazardous waste identified or

listed in [40 CFR] part 261..... or whose act first causes a hazardous waste to become subject to regulation."
Hazardous wastes are designated as either (1) a solid waste that is specifically listed as being hazardous, or (2) a solid waste that exhibits hazardous characteristics (e.g., ignitability, corrosivity, reactivity, or toxicity). This report assumes that the paint sludge generated in the flow coating process at Bilco is a characteristic hazardous waste (D007). According to the EPA, chromium occurs in the paint sludge because metal chips or flakes from the treated steel substrate contain chromium. The EPA defines a D007 waste as a waste that contains 5.0 mg/L of chromium in the extract from a toxicity characteristic leaching procedure (TCLP).

D007 Hazardous Waste (Paint Sludge)
The process wastes from Bilco's flowcoating operation include hazardous waste paint sludge, EPA identification number D007, due to the potential to contain heavy metals (chromium). Bilco generates approximately 11,000 lbs/yr (5,000 kg/yr), or 416 kg/month, of this hazardous waste. Based on this quantity, Bilco is classified as a *small quantity generator,* subject to the requirements for small quantity generators. A small quantity generator is defined as a facility that generates more than 100 kilograms of hazardous waste per month, but less than 1,000 kilograms per month.

Powder Coating Alternative Process Description

The EPA has targeted powder coating as a potential alternative coating technology due to its elimination of VOC emissions. In addition, the process is less hazardous, less expensive, and can provide a healthier work environment for employees.

Any powder coating operation, whether a large multi-million-square-foot-per-year production line or a small custom shop has three main components:

- cleaning/pretreatment
- powder application
- powder cure.

Many other sub-processes are involved such as racking, process control, and shop environmental controls, but these are all in support of the three main areas and will be described as such.

Adequate cleaning and pretreatment is perhaps the single most important aspect to consider when designing any new paint system, whether it is a powder system or not. The most common reason for paint failures is improper cleaning prior to painting. Although a coating's performance is dependent on its final application, even the most expensive, high performance coating will fail if applied over a contaminate, or improperly prepared substrate, particularly in highly corrosive environments.

There are many different types of pretreatments available for steel parts prior to powder coating ranging from a high-performance 6- to 7-stage zinc phosphate system to a 1-stage cleaner/phosphator solution. If the 1-stage system provides adequate performance for the product, then the more expensive system is not necessary unless product performance suffers or an improvement is desired.

For this project, an iron phosphate material was selected because of its low cost, few stages (2), and performance that met requirements.

Following pretreatment, the parts are dried in a convection oven to remove excess water. An infrared oven (IR) can also be used for this purpose and may reduce operating costs even further.

Once the parts are dried, the powder can be applied. Although there are several methods of powder coating, electrostatic spray is the most commonly used and is the method that was used for this study.

Electrostatic spray offers a high degree of control, is easily automated, and can coat a variety of different part shapes and sizes. In the electrostatic powder application process, powder is electrically charged at the gun tip and applied to a grounded part.

An overview of *CTC's* powder coating process is shown in Figure 4. After cleaning and pretreatment, parts are conveyed to the powder booth. Powder is loaded into a fluidizing hopper and delivered to the spray guns using a pneumatic pump system. Any powder that does not reach the part is pulled into the reclaim module and can be filtered and re-sprayed.

Following application of the powder, the parts are sent to a curing oven. Here, the powder is taken past its melting point where it flows evenly over the part, cross-links, and cures.

Convection ovens are popular for curing because of their versatility and cost. IR ovens are gaining widespread acceptance because of their increased efficiency and process flow rate. IR ovens cannot, however, cure every type of part. Since IR is a light-wave radiation process, line-of-sight exposure to IR is required, so a part with hidden areas will not cure. IR ovens are also valuable when combined with a convection oven to speed up the cure process.

The *CTC* powder coating system is capable of applying powder coating manually or automatically using up to 10

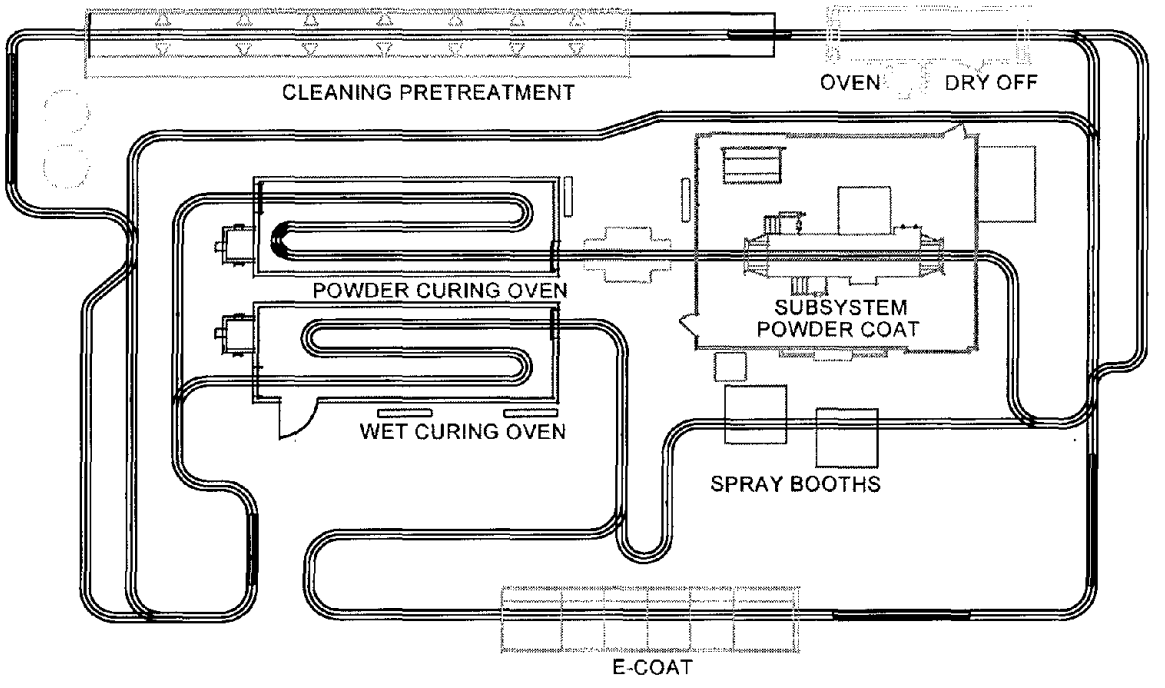


Figure 4. *CTC* Line & Overall Process Schematic

electrostatic guns. A variety of part configurations can be accommodated up to dimensions of 3'x4'x4' and up to 250 pounds per part.

The system is Programmable Logic Controller (PLC)-controlled and tied into a Factory Data Integration System that collects process and ambient data during each run.

Powder Coating Equipment Used for this Project Descriptions

Controls and Data Collection

The controls and data collection were briefly discussed in the previous section and played a major part in this program. The PLC control system allowed one to experiment with a variety of process settings in order to find the optimum setup for Bilco's parts.

Conveyor System

The conveyor system uses a power-and-free overhead conveyor system with a total of 5 separate chains. Parts can travel from 5 to 40 feet per minute through the system. A power and free system was selected because it provides the maximum amount of process flexibility and versatility in a small space.

Pretreatment

The pretreatment system consists of a 7-stage spray washer with variable temperature, pressure, and flow controls at each stage. A variety of chemical pretreatment solutions can be demonstrated because of the system's unique flexibility.

Dry-off and Cure Ovens

The dry-off oven and cure ovens used at *CTC* are direct gas-fired convection ovens. In addition, an IR oven was used for testing.

Automatic Powder with Manual Touch-up

CTC's powder coating system is capable of manual application or automatic application using two banks of automatic guns on vertical reciprocators.

Material and Utilities Usage

Pretreatment Process Selection Background

To apply powder coatings to steel, the metal parts should first be pretreated to create a surface which will accept the organic coating with good appearance, adhesion and corrosion resistance properties. Phosphating processes are common pretreatment steps used on steel before powder coating. Two major types of phosphating include zinc phosphating and iron phosphating. There are economic, quality and operational tradeoffs associated with each process that factor into selection of one for use.

Zinc phosphating, while often giving superior adhesion and corrosion resistance when compared to iron phosphating typically will have more process stages, be more costly to

install and operate, require greater effort to control chemically, and produce a zinc metal contaminated solution.

Iron phosphating provides the requisite finished product performance in many applications and typically consists of fewer process stages with less chemical constituents to monitor in the phosphating stage. The iron phosphating process would thus be expected to have less expensive startup and operating costs and be simpler to operate and control. In addition, the desired iron oxide and iron phosphate (FeO and $FePO_4$) sites on the metal surface are created using iron inherent in the base metal, eliminating heavy metals arising from the phosphating chemicals.

A one-step cleaner/coater iron phosphate process followed by a city water rinse was chosen as the pretreatment technology for demonstration due to anticipated operational, life cycle cost and environmental advantages. After selection of this process, two technical challenges required further attention: a) applying an iron phosphate pretreatment to hot rolled steel and b) the level of surface cleanliness of the parts after fabrication. The first challenge results from the buildup of mill-scale, or unwanted iron oxides, from the action of oxygen with steel at higher temperatures during the making of the hot rolled steel raw material. This issue is addressable by operating the phosphating process at sufficiently low pH to remove any scale (unwanted oxides) through acidic dissolution while simultaneously depositing the desired phosphate layer. It should be noted that the hot rolled raw material Bilco uses is reported to contain minimal scale, further mitigating this potential problem. With respect to the latter concern, surface cleanliness, the required approach is to ensure that parts are in contact with the phosphating/cleaning stage for a long enough period to remove any oils and smut.

Pretreatment Materials

The materials required for the iron phosphating process used for this project are summarized in Table 6. The phosphating stage consists of the phosphating chemical and an additive to enhance detergency for cleaning of the parts. The only chemical control requirements are a titration for total acid content and pH measurement which was recorded by an in-line meter. The titration was used to maintain the total acid at a level which required control between 6.0 to 14.0 milliliters, or points, of the vendor supplied titrant. To increase the concentration of the chemical for tank replenishment purposes, 0.5 gallons of fresh chemical is added per 100 gallons of tank volume for each point of desired concentration increase. To maintain the concentration at 10.0 +/- 0.5 points required the addition of approximately 9-14 gallons of fresh chemical at the start of each day of experimentation. It should be noted that a pretreatment system which has been explicitly designed and optimized for two or three stage iron phosphating would be expected to operate more efficiently with respect to chemical consumption.

Table 6. Iron Phosphate Process Materials Summary

Material	Purpose	Active Chemical Components
Parker Amchem Prep-n-Coat 700	Phosphating	Monosodium Phosphate Surfactants Hydrofluoric Acid
Parker Amchem Parco Cleaner 3140	Cleaning Additive	Ammonium Hydroxide Nonionic Surfactants
Parker Amchem Caustic Soda	pH adjustment	Sodium Hydroxide
Parker Amchem Parcolene 6	pH adjustment	Phosphoric Acid
Rinse Stage	Parts Rinsing	City Water

Powder Coating and Topcoating Materials

A key component of this project is to demonstrate that powder coating materials are commercially available which meet Bilco's existing primer performance requirements including:

- corrosion resistance (175 hours salt spray),
- environmental compliance (VOC compliant),
- appearance (smoothness, coverage and color), and
- the ability to be topcoated (adhesion and appearance).

Of Bilco's criteria, the greatest technical challenge by far is applying a liquid topcoat to a cured powder coating and achieving adequate adhesion. Because powder coatings tend to be extremely durable and chemical resistant, it is sometimes difficult for a topcoat to "bite" into the surface to achieve good adhesion. There are a number of powder coat primer/liquid topcoat systems that work well and Bilco will need to consider this when selecting a material for production.

Potential powder coating candidates were identified through discussions with vendors. Based on the discussions with major vendors of powder coatings that considered Bilco's primer criteria as well as product availability, a red oxide, thermosetting urethane polyester material was chosen as the baseline powder coating. A VOC-compliant alkyd enamel product was chosen as the baseline topcoating material. A summary of all the powder coating and topcoating materials used for this project is shown in Table 7.

Procedures/Practices

Surface Preparation

As stated above, an iron phosphating process was used for all metal pretreatment needs. Two processing stages, one for phosphating and one for a city water rinse were required. The chief technical challenges were to establish suitable process operating conditions such as for exposure times, temperatures, chemical concentration and to keep the parts wet after phosphating to avoid flash rusting. The vendor of the pretreatment chemicals assisted with process optimization through preliminary pretreatment runs in its laboratories and through on-site consultation. The iron phosphate process operating conditions used for this project are summarized in Table 8.

Coating Application

An automated powder coating process with manual touchup was necessary to deliver powder to all surfaces of the parts. Two banks of four guns each were programmed for automatic spray, while an organic finishing technician used a hand-held gun for manual touchup.

Coating Performance Testing

The objectives of coating performance testing were to:

- generate quantitative and qualitative baseline comparison data on the flowcoat and powder coat primers
- determine the minimum product quality achieved during each project phase

Laboratory and shop floor testing were performed to determine the primer to metal and topcoat to primer performance properties. Tests were performed on 4" x 12" cold rolled and hot rolled steel coupons and on actual basement door parts in each of the three major technology demonstration phases of the project (feasibility, optimization, and validation).

Commercially obtained cold rolled steel coupons were used where the heavier gauge of Bilco's hot rolled steel interfered with the testing requirements. These panels, because of their increased thickness, could not be used for standard ASTM impact and flexibility tests. Table 9 summarizes the various test procedures used for this project. Actual results for the testing programs conducted during each phase of the project may be found in the appropriate discussion for the particular phase.

Waste and Emissions Summary

The following waste and emissions practices are observed for the pretreatment and powder coating process used for this study. The Pennsylvania Department of Environmental Protection (DEP) has determined that all air emissions sources associated with this facility's powder coating operation, except the burn-off oven, do not require air operating permits. The DEP's decision not to require the facility to obtain air operating permits for these sources was made because the powder coating operation emits extremely low (de-minimis) quantities of air contaminants. The quantities of emissions generated during the various powder coating demonstration projects are significantly under state reportable amounts

Liquid Wastes

Non-hazardous aqueous wastes are generated as a result of metal cleaning and phosphating pretreatment operations for technology demonstration and validation purposes. Projects involve strictly batch type operations of varying scope. The facility does not directly discharge liquid pretreatment wastes to a body of water or to a Publicly Owned Treatment Works (POTW). Phosphating wastes are placed into totes for on-site recycle/recovery purposes and returned to the pretreatment process or are placed into drums and sent off-site to a permitted wastewater treatment facility.

Water from rinsing stages is fed directly to an atmospheric evaporator for volume reduction. The non-hazardous sludge remaining in the evaporator is removed and taken off-site for disposal periodically by a permitted waste disposal company.

Solid and Hazardous Wastes

The only solid wastes generated by the pretreatment and powder coating processes are the sludges from the phosphating pretreatment line and atmospheric evaporator discussed above and any excess raw powder coating material that is not recycled. Currently, excess powder coating material is considered, by the DEP, as residual waste and can be disposed at a sanitary landfill. There may also be additional solid wastes generated if pretreatment solutions become contaminated and need to be replaced.

There are no hazardous wastes associated with the demonstration facility's pretreatment and powder coating processes.

Air Emissions

There are air emissions associated with the phosphating pretreatment system, the pretreatment dry-off oven, the curing oven and the atmospheric evaporator. However, because the quantities of these air emissions are very low, the DEP has not require the facility to obtain air operating permits for these sources. There is also a burn-off oven associated with the powder coating operation. This burn-off oven is used periodically to remove coatings from the conveyor system's hooks and racks. The DEP has not made a final determination regarding the need for an air operating permit for this oven.

Regulatory Profile

This section describes the federal, state and local requirements that Bilco should be aware of as it considers the merits of the proposed powder coating operation. The powder coating operation would include a three step process:

1. substrate pretreatment with an aqueous phosphate process
2. application of the powder coat to the phosphated parts
3. baking and curing.

A changeover to powder coating from flowcoating will virtually eliminate the use of solvents, and therefore the production of VOCs, and paint sludge wastes. However, a powder coating system will generate contaminated phosphating and rinse waters. The primary regulations applicable to the phosphating process are the Clean Water Act and local discharge regulations.

The Clean Water Act (CWA)

Phosphating and rinse waters from Bilco would be considered an indirect discharge under the Clean Water Act (CWA) if it discharges waste water from the pretreatment lines of the proposed powder coat operation to a local publicly owned treatment works (POTW). As a general rule, facilities that discharge wastewater to POTWs must pretreat their wastes to specified levels prior to discharging to a POTW system. Indirect discharges are not required to obtain a National Pollutant Discharge Elimination System (NPDES) permit; however, the POTWs they discharge to are covered by the NPDES system. POTWs may impose certain discharge limitations (e.g., local pollutant limits) on facilities to ensure that the POTW will not violate its NPDES permit. (For further information about local POTW limits, see Section entitled Local POTW Requirements.)

As an indirect discharger, Bilco may be subject to the national industry-wide pretreatment standards for the metal finishing (MF) industry. These standards, which are also called national categorical pretreatment standards, contain specific numeric limitations which are used by POTWs in setting pretreatment limits. These standards, which can be found at 40 CFR part 433, establish limits for:

- cadmium
- chromium
- copper
- lead
- nickel
- silver
- zinc
- cyanide
- total toxic organics

The pretreatment standards for metal finishers apply to 46 different operations ("covered operations"). If Bilco decides to install a powder coating line, it may operate one of these 46 covered operations - conversion coating. For Bilco to be subject to the MF pretreatment standards, it must perform at least one of the following six covered operations: 1) conversion coating, 2) electroplating, 3) electroless plating, 4) anodizing, 5) chemical etching and milling, and 6) printed circuit board manufacturing. If Bilco does not perform one of these six operations it will not be covered under the MF regulation. If Bilco performs one of these six operations, it may be subject to the MF regulation for that operation plus any of the other 40 covered operations present. These other 40 covered operations include electrostatic painting.

Future Considerations

The EPA has proposed standards to regulate a new category under the CWA called the Metal Products and Machinery (MP&M) category. Facilities currently covered under 40 CFR part 433 may be subject to the new MP&M regulation in the future, if certain criteria are satisfied. The MP&M regulation is a broader regulation and it may cover Bilco even if Bilco is not currently covered under the MF regulation.

The MP&M category is intended to regulate wastewater from facilities that "manufacture, maintain, or rebuild finished metal parts, products or machines." The regulation will establish technology-based limits for the discharge of pollutants into POTWs by new and existing facilities.

The regulation of the MP&M category will be accomplished in two phases: Phase I and Phase II. Phase I of the MP&M regulation was proposed on May 30, 1995 (see 60 Fed. Reg. 28209). The second phase of the regulation is not expected to be proposed by the EPA until December 1997.

Phase I of the MP&M category targets seven industrial sectors, and one of these categories is "hardware." Typical products produced by the hardware industry are the following:

- fabricated metal products
- fabricated structural metal.

EPA has identified 47 unit operations typically performed by MP&M facilities. These operations include the following:

- chemical conversion coating
- painting
- metal spraying
- corrosion preventive coating (other than conversion coating).

Table 7. Summary of Powder Coating and Topcoating Materials

Vendor	Vendor Product Description	Color	Purpose
Powder Coatings			
O'Brien	Aromatic Urethane Polyester	Red Oxide	Baseline Powder Coating
Morton	Corvel Zinc Rich Epoxy	Gray	Powder - Topcoat Adhesion Data
PPG	Envirocron Polyester	Black	Powder - Topcoat Adhesion Data
Top Coatings			
Sherwin Williams	Industrial Alkyd Enamel VOC Complying	Gray	Baseline Topcoating
Sherwin Williams	DTM Waterborne Acrylic	Gray	Powder - Topcoat Adhesion Data
Sherwin Williams	High Solids, Low VOC Polyurethane	Gray	Powder - Topcoat Adhesion Data
Sherwin Williams	Metalatex Acrylic Multiple Surface Coating	Gray	Powder - Topcoat Adhesion Data

Table 8. Iron Phosphate Process Summary

Material	Purpose	Parameter	Setpoint
Phosphating Tank			
Parker Amchem Prep-n-Coat 700	Phosphating	Tank Capacity	1,290 gal
		Initial Charge	70 gal
		Subsequent Charges for Demonstration Trials	9-14 gal/day
		Total Acid (6.0 - 14.0 titrant points)	10.0 points
		pH	4.6
		Time	60 sec
		Temperature	150°F
		Nozzle Pressure	10 psi
Parker Amchem Parco Cleaner 3140	Cleaning Additive	Concentration	0.25% by tank volume
Parker Amchem Caustic Soda	pH adjustment	Desired pH	As Needed
Parker Amchem Parcolene 6	pH adjustment	Desired pH	As Needed
Rinse Tank			
City Water Rinse	Parts Rinsing	Tank Capacity	950 gal
		Time	30 sec
		Temperature	110°F
		Nozzle Pressure	
		A Side	15.5 psi
		B Side	9.0 psi
Dry Off Oven			
	Post-Rinse Water Removal	Time	6 minutes
		Temperature	275°F

Table 9. Scope of Coatings Testing for Technology Demonstration Trials[2,3,4]

Title of Test	Procedure Reference	Application	Units/ Rating Scales
coating weight	Parker Amchem	iron phosphate pretreatment coating	mg/ft^2
visual inspection	N/A	appearance check of phosphate, primer and topcoat layers	qualitative
coating thickness	ASTM B499 (magnetic) ASTM D4138 (tooke gage)	dry film thickness of primers and topcoats	0.001" (mils)
tape adhesion (cross-hatch & x-cut)	ASTM D3359	adhesion of primers to metal surface	0-5 scale
intercoat adhesion	ASTM D3359	adhesion of topcoat to primer layer	0-5 scale
salt spray	ASTM B117	corrosion resistance of primers	175 hours
	ASTM 610	degree of rusting	0-10 scale
	ASTM 714	degree of blistering	0-10 scale
reverse impact	ASTM D2794	impact resistance of primers	0-160 in-lbs
direct impact	ASTM D2794	impact resistance of primers	0-160 in-lbs
conical mandrel bend	ASTM D522	flexibility of primers	1/8" diameter check for cracking
gloss consistency	ASTM D523	gloss of primers and topcoats	0-100
color consistency	ASTM D2244	color of primers and topcoats	CIE Scale
pencil hardness (gouge resistance) (scratch resistance)	ASTM D3363	hardness of coating	6B - 8H softer - harder

Local POTW Requirement

Bilco may be subject to requirements imposed by the New Haven Water Pollution Control Authority (WPCA). Local POTW limits are imposed to protect a POTW from discharges that would inhibit or disrupt the POTW's operation or cause the POTW to violate its NPDES permit.

Local POTWs may adopt and enforce their own requirements for industrial facilities that discharge wastewater to the POTW. The New Haven WPCA recently started its own pretreatment program. The New Haven WPCA's limitations are reflected in agreements between the WPCA and its industrial users.

The New Haven WPCA can be contacted at the following address:

Attention: Mr. Bill Root
New Haven Water Pollution Control Authority (WPCA)
345 East Shore Parkway
New Haven, CT 06512

Requirements of the New Haven Code

The New Haven Code requires anyone who wishes to connect and discharge to the New Haven WPCA to apply to the general manager for a permit authorizing the connection. The discharge application must be made on forms supplied by the WPCA. The general manager may require the discharger to:

1. File a discharge report which includes the following information:
   - nature of the process
   - volume
   - rate of flow
   - production quantities.
2. Submit a plan showing the location and size of on-site sewers, sampling point, pretreatment facilities, and city sewers.
3. Describe activities, facilities and plant processes proposing to discharge waste water.
4. name the types of products produced, amounts, and rate of production.
5. Name the chemical components and quantities of liquid or gaseous material bulk stored on-site, even though they may not normally be discharged into New Haven's sewer system.

Prohibited Discharges
The discharge of the following materials into the city sewer is prohibited by the New Haven Code:

- any liquid or vapor having a temperature higher than 150 degrees Fahrenheit
- any waste water containing grease, oil or other substances in excess of 100 mg/l that will solidify or become discernibly viscous at temperatures between 32 degrees and 150 degrees Fahrenheit
- solid or viscous substances capable of causing obstructions to the flow in sanitary sewers or interference with the proper operation of the treatment works, such as metal, shavings, paint residues, and chemical residues.

The New Haven Code also prohibits waste water discharges to the city sewer containing:

- free or emulsified oil and grease exceeding an average of 100 mg/l of either or both, or a combination of, free or emulsified oil and grease, if the waste:
  - obstructs the sewer
  - overloads the grease handling equipment
  - cannot be treated
  - adversely affects the treatment process.
- acids or alkalies that attack or corrode the sewers or sewage disposal structures, equipment and/or personnel, or have a pH value lower than 5.5 or higher than 9.5, or which may be reduced or changed with age or by sewage to produce acid or alkaline reactions
- any metallic ions and salts of the heavy metals that exceed specified concentrations
- excessive discoloration
- unusual biological oxygen demand, chemical oxygen demand, or chlorine requirements
- unusual concentrations of solids.

Requirements for Wastewater Discharge Permits

Wastewater discharge permits may specify the following:

- allowable average and maximum strengths, characteristics, or constituents of the waste water discharge
- limits on the rate and time of discharge or requirements for flow and equalization
- requirements for the installation of inspection and sampling facilities
- pretreatment requirements (e.g., Bilco may be required to adjust the pH of its waste water before discharge.)
- requirements for monitoring programs, such as sampling locations, frequency and method of sampling, number, types and standards of tests, and reporting schedules
- requirements for the submission of technical or discharge reports
- requirements for maintaining plant records on waste water discharges.
- Bilco must comply with all permit requirements established by the WPCA.

Other Considerations
The powder coat booth typically does not have an emission point; therefore, a permit is not required. In addition, the curing oven for the proposed powder coat operation will emit volatile organics to the atmosphere. Generally, these emissions are so low (0-4% by weight) that an air operating permit will not likely be required. Typically, the VOC content of the powder used is low or nonexistent. However, some powders contain listed HAPs which may be regulated.

Feasibility Demonstrations

The primary objective of the feasibility trial was to powder coat an initial short run of coupons and basement doors to demonstrate that this technology shows promise for meeting Bilco's primer performance requirements. Feasibility work also allowed the project team to accomplish the following:

- establish initial process operating parameters for the entire powder coating process including iron phosphate pretreatment, dry off, parts racking, powder application and powder curing
- establish a product quality baseline for powder coating primer on Bilco's hot rolled steel substrate
- establish a product quality baseline for flowcoating primer on hot rolled steel coupons prepared and submitted by Bilco.

Leading up to the formal feasibility demonstration several cold rolled and hot rolled steel coupons were pretreated with iron phosphate for process check and adjustment purposes. Also, several coupons and basement door parts were temperature profiled using a Datapaq temperature logging device to determine the optimum cure oven settings for the powder coating material.

For the feasibility trial, one complete basement door assembly (consisting of the 6 individual parts), 20 Bilco hot rolled steel coupons, and 20 cold rolled steel coupons were iron phosphated and powder coated with the O'Brien red oxide powder primer. Following powder coating, several powder coated door parts and coupons were top coated with the Sherwin-Williams alkyd enamel material for topcoat compatibility assessment.

Specimens from each stage of the coating process (pretreatment, powder coating, and topcoating) were then tested in the laboratory to determine a quality baseline for the powder coating process. In addition, coupons of flowcoated hot rolled steel received from Bilco were tested in the laboratory to determine a flow coating product quality baseline. The laboratory data allowed comparison of the two processes (powder coating to flow coating) according to Bilco's primer performance criteria.

Pretreatment System and Powder Coating System Conditions

The iron phosphate pretreatment and powder coating system conditions used for the feasibility demonstration, arrived at through material vendor input and project team process engineering expertise, are shown in Table 10 and Table 11 respectively.

Table 10. Iron Phosphate Pretreatment System Conditions

Parameter	Setpoint
Conveyor Speed	4.8 ft/min
Iron Phosphate Cleaner	
Coater Stage	
Total Acid	10.0 titration points
pH	4.6
Nozzle Pressure	10 psi
Temperature	145°F
Time	1 min
Misting Risers Pressure (to keep parts wet between stages)	Riser 1 - 7.0 gals/min Riser 2 - 4.5 gals/min
City Water Rinse Stage	
Total Acid Carryover	< 0.5 titration points
Temperature	110°F
Time	1 min
Nozzle Pressure	
A Side	15.5 psi
B Side	9.0 psi
pH	6.0
Chemical Usage	
Prep-n-Coat 700	70 gals initial charge 36 gals additional needed to maintain conditions through preliminary setup trials
Parco Cleaner 3140	3.5 gals (0.27% total tank volume)
Caustic Soda Neutralizer	1 gal
Dry Off Oven	
Time	6 minutes
Temperature	275°F
Iron Phosphate Coating Weight Achieved	76 mg/ft^2

Table 11. Powder Coating System Conditions

Parameter	Setpoint
Conveyor Speed	12 ft/min
Automatic Spray Gun Configuration	
No. of Spray Guns	4 per side
Stroke Speed	14 cycles per 30 seconds
Kilovolts	100 kV/gun
Fluidizing Air	14 psi
Atomizing Air	20 psi
Manual Touchup	not used for feasibility
Cure Oven (Optimized from Datapaq Trials)	
Time	27 min
Temperature	425°F

Feasibility Laboratory Testing Results

Primer to Metal Performance Data

Laboratory testing was performed for the powder coated and flowcoated primer specimens and for topcoated specimens of each primer according to Bilco's primer performance requirements. The most obvious performance difference in the primer to metal performance data for the two primers is significantly better corrosion resistance for the powder coated specimens. Gloss, impact resistance and dry film thickness values are the only other significant differences in primer to metal performance for the two primers materials. The test data results performed on 4" x 12" coupons for the primered and topcoated specimens are summarized in Table 12.

Primer to Topcoat Performance Data

The Bilco topcoat compatibility performance requirement was assessed through the use of a semi-quantitative scribe and tape pull intercoat adhesion test. An x-cut scribe is made through the topcoat just down to the primer coat layer. Tape is uniformly applied to the x-cut and then rapidly removed at a 180° backward angle. The specimen is then visually inspected for loss of coating along the x-cut scribed area, which is also measured in fractions of an inch from the scribe, and in the regions between the lines of the scribe. The flowcoated primer provided an adequate surface for adhesion of the topcoat by exhibiting no loss of coating using this test method. Some of the powder primed specimens completely failed the test exhibiting a loss of coating on the scribe and in between the lines of the x-cut scribed region. After additional testing, successful combinations of powder primers and liquid topcoats were identified.

Feasibility Demonstration Major Lessons Learned

The following lessons learned were obtained from the feasibility work efforts:

- a two stage iron phosphate pretreatment can be successfully applied to Bilco's specific base material

- powder coating can be successfully applied to Bilco's parts, however some manual touchup is required
- based on laboratory testing, powder coating materials can meet Bilco's primer to metal performance criteria
- all basement door parts are able to be racked successfully using the existing holes punched into the products which was a concern to the small business participant.

Sufficient success was achieved during feasibility testing to warrant proceeding to optimization trials which not only focus on product performance, but also on additional process engineering and life-cycle cost issues. Additional powder coating and topcoating materials were investigated for data completeness.

Optimization Demonstrations

The powder coating technology optimization trial primarily focused on refinement and tailoring of the powder coating systems for Bilco's basement door parts based on lessons learned from the feasibility demonstration. The optimization trial also aided refinement of operating data collection practices such as material and energy usage and served as a preparation run for the technology validation phase. The following processes were changed or optimized from the feasibility trial based on process engineering observations and expertise:

- iron phosphating pretreatment
- parts racking
- powder coating application.

The optimization trial consisted of using the O'Brien red oxide material to powder coat two carriers of cold rolled and hot rolled steel 4" x 12" coupons for lab quality testing and two complete basement door assemblies (12 total components). One complete powder coated door assembly and several coupons were then coated with the alkyd enamel topcoat. The following sections summarize the activities and results from the optimization trial.

Table 12. Feasibility Testing Results for the Primer Only and Primer / Topcoat Specimens

Test or Evaluation	Flowcoated Primer Only Coupon Baseline Data	Powder Coated Primer Only Coupon Baseline Data
Visual Appearance *		
Smoothness	smooth, except in areas of substrate defects	smooth except in areas of substrate defects some orange peel effect
Coverage	complete coverage on coupons	complete coverage on coupons areas requiring manual touchup observed on basement door parts
Color	no significant numerical differences among specimens determined by spectrophotometer no noticeable differences to the naked eye	no significant numerical differences among specimens determined by spectrophotometer no noticeable differences to the naked eye
Gloss	3.6 at 60°	39.9 at 60°
Coating Thickness	0.5 mils average	1.6 mils average
Corrosion Resistance * Salt Spray - 175 Hours		
ASTM D610 Rusting	0-1 (50-100% rusted area)	8-9 (< 0.10% rusted area)
ASTM D714 Blistering	6 (1% affected area)	8 (< 0.10% affected area)
Physical Properties		
Pencil Hardness (Scratch Toughness)	2H	2H
Pencil Hardness (Gouge Toughness)	> 8H	> 8H
Direct Impact	passes to 44 in/lbs	passes > 160 in/lbs
Reverse Impact	passes to 100 in/lbs	passes > 160 in/lbs
Conical Mandrel	pass 1/8" bend	pass 1/8" bend
Tape Adhesion (X-cut)	5 - no failure	5 - no failure
Tape Adhesion (Cross-cut)	5 - no failure	5 - no failure
	Flowcoated Primer with Alkyd Enamel Topcoat Coupon Baseline Data	**Powder Coat Primer with Alkyd Enamel Topcoat Coupon Baseline Data**
Visual Appearance	smooth, even coverage uniform color and gloss	smooth, even coverage uniform color and gloss

*Denotes specific Bilco Performance Requirement.

Pretreatment System and Powder Coating System Conditions

This section describes the changes or refinements to the powder coating process for the optimization trial.

Racking Considerations

To ensure clearance of the largest of the Bilco basement door components through the pretreatment system and to properly adjust the positions of the automatic powder guns, several of the basement door parts were run through the entire powder coating line while it was off-lined. Measurements were taken to provide for the proper racking distance between the tops of the parts to the conveyor system. For the powder coating system used, a minimum carrier to part distance of about 19.5 inches was required.

Any seams or places where oils or other contamination from the steel manufacturing or door fabrication process could become trapped had to be oriented vertically so that the contaminants would drain thoroughly from the parts in the cleaner / coater pretreatment step. Retention of oils would prevent proper adhesion of the powder coating in these places. This was particularly critical for one area along a seam on the larger triangular side panels where two strips of metal overlap.

It was also necessary to devise "S" shaped hooks to rack the parts, and in some cases to add bolts to existing holes in some of the parts to attach the hooks. This racking approach was necessary to avoid drilling additional holes in the parts solely for racking purposes which would not be used in the final assembly of the door systems.

Iron Phosphating Pretreatment Considerations

The time of exposure in the pretreatment cleaner/coater phosphating stage had to be increased to allow for better cleaning of the hot rolled steel parts based on the visual appearance of the parts exiting the washer stage. This was accomplished by decreasing the conveyor speed through the washer system from 4.8 ft/min to about 4 ft/min. Parts remained in the phosphating stage approximately 75 seconds instead of 60 seconds as used for the feasibility trial. Iron phosphate coating weight, determined from a weigh-acid strip-weigh procedure, averaged 75 mg/ft^2 which compared favorably to the feasibility trials (76 mg/ft^2).

Due to the multi-purpose configuration of the test/demonstration powder coating line as opposed to one which would be built for a single manufacturing purpose, a carrier delay of three minutes between each rack of parts had to be utilized. This delay prevented the parts from remaining in the phosphating stage too long while carriers just ahead were being held for 6 minutes in the dry off oven. In an actual manufacturing setting, the system design would not require such a carrier delay. Approximately 13 gallons of fresh Prep-n-Coat 700 chemical was required to recharge the phosphating stage from the feasibility trial. All other pretreatment process conditions, such as temperatures, concentrations and pressures were kept the same as for the feasibility trial shown in Table 10.

Powder Coating Considerations

Several changes were made in the powder coating application process. The most significant change was the addition of a manual touchup step, with other adjustments consisting of changes to the spray gun settings. It was determined from the feasibility trial that the dry film coating thickness could be adjusted downward slightly from 1.6 mils and not significantly impact the coating to metal performance while offering powder raw material savings during automatic spray. To accomplish the thickness reduction, the fluidizing air on each of the automatic spray guns was decreased from 14 psi to 13 psi. The atomizing air also had to be decreased, from 20 psi to 16 psi, to avoid blowing the powder back off the parts before curing. Similar considerations of gun settings would be required in the actual implementation of powder technology for the basement door parts.

A manual spray gun was configured to apply powder to the basement door parts just after automatic application to touchup any inadequately covered zones. These were primarily at bends in the metal or where handles, rods and latches had been welded to the main panels. To achieve proper manual delivery of the powder, the fluidizing air was set higher than for the automatic guns, to 24 psi, to ensure delivery of enough powder through a single gun, while the atomizing air was set lower than the automatic process, to 12 psi, to avoid blowing the powder back off of the parts.

Optimization Trial Laboratory Testing Results

Laboratory testing was performed on the powder coated and topcoated coupons to quantify the effects of process changes on coating performance. The results are summarized in Table 13. The most significant difference in the data from the feasibility trial was a decrease in the to failure in the salt spray test. The degree of rusting value fell from a rating of 8-9 to a rating of 6, with 10 being the highest quality. Most likely, the lower film thickness or perhaps slightly more porosity of the powder coating contributed to this change. This would still be significantly higher than the value of 1 for the degree of rusting for the flowcoat primer reported in the feasibility trial discussion. The degree of blistering remained constant from the feasibility to the optimization trial.

The only other notable exception in the data was an increase in the intercoat adhesion quality due to the application of a short forced cure bake cycle of the topcoat onto the primer. This raised the intercoat adhesion value from a 0 first week rating from the feasibility trial to a 3-4 initial rating.

However, forced curing in this manner would not be an option for field application of topcoats in most cases. Forced curing was performed just to determine the best intercoat adhesion possible with this powder primer/topcoat combination. (See Table 14).

Table 13. Optimization Testing Results for the Powder Primer and Primer / Topcoat Specimens

Test or Evaluation	Powder Coated Primer Coupon Test Data
Visual Appearance *	
Smoothness	smooth except in areas of substrate defects
Coverage	some orange peel effect complete coverage on coupons
Color	no significant numerical differences among specimens determined by spectrophotometer no noticeable differences to the naked eye
Coating Thickness	1.3 mils average
Gloss	32.5 at 60°
Corrosion Resistance *	
Salt Spray - 175 Hours	
ASTM D610 Rusting	6 (1.00% rusted area)
ASTM D714 Blistering	8 (< 0.10% affected area)
Physical Properties	
Pencil Hardness (Scratch Toughness)	4H
Pencil Hardness (Gouge Toughness)	> 8H
Direct Impact	passes 140 in/lbs
Reverse Impact	passes > 160 in/lbs
Conical Mandrel	pass 1/8" bend
Tape Adhesion (X-cut)	5 - no failure
Tape Adhesion (Cross-cut)	5 - no failure
	Powder Coat Primer with Alkyd Enamel Topcoat Coupon Data
Visual Appearance	smooth, even coverage uniform color and gloss
Intercoat Tape Adhesion (X-cut scribe)	3-4 - trace loss of coating 1/16" or less from scribe after forced curing

* Denotes specific Bilco Performance Requirement.

Supplemental Powder Coat/Topcoat Compatibility Trial

Several additional primer/topcoat compatibility trials were performed using commercially available materials to gather intercoat adhesion data. This data is intended to supplement the experimental data from initial topcoat compatibility testing and provide data using other powder coatings. Primer/topcoat compatibility was determined through the intercoat adhesion test described earlier and by visual appearance. The topcoat materials used and the powder coatings with the compatibility data obtained are summarized in Table 14.

The data shows that the Hi-Solids Polyurethane topcoat performed best with all three powder materials in terms of intercoat adhesion and appearance. The only other coating that had acceptable intercoat adhesion was the DTM Acrylic topcoat with the O'Brien powder coat.

A positive result is the finding of at least one topcoat that is compatible with powder primers and has good appearance. The data, at a minimum, shows the potential to find other topcoat / powder coat combinations that would work together successfully.

Optimization Demonstration Major Results

The optimization trial provided the opportunity to achieve enhanced parts cleaning and racking, and a demonstration that manual touchup would cover bare or thin areas after automatic spray application. Furthermore, these changes resulted in little effect, other than salt spray results, to the final product quality test data.

Validation Trials

A technology validation trial was conducted to simulate a production environment for powder coating the Bilco basement door parts. The trial focused on proving out the system settings and lessons learned from the previous trials, and to allow the collection of "live" material and utility data for operation cost estimation purposes.

Parts Processing

One "production" day was simulated consisting of a morning (AM) and afternoon (PM) powder coating shift. During each shift the line was loaded to capacity, consisting of 18 parts carriers. Either one large part, such as a rectangular door panel or triangular side panel, or two smaller parts were loaded per carrier.

Table 16 is an inventory of the parts and square footage processed during the "AM" and "PM" shifts. Bilco manufactures four standard sizes of basement doors which are given the designations O, B, C and S/L. Just under a total of six complete basement door systems were powder coated during the simulated production day.

Process Operating Conditions

The complete process cycle consisted of a part passing through the iron phosphate washer system, the dry off oven, the powder coating booth and the powder curing oven. Table 17 summarizes the critical iron phosphate and powder coating process parameters for the "AM" and "PM" shifts. All pretreatment system values were within the target ranges.

Table 14. Supplemental Intercoat Adhesion Data for Topcoats and Powder Coats

	Topcoat		Topcoat		Topcoat	
Major Liquid Components	Sherwin-Williams Direct to Metal (DTM) Semi-Gloss Acrylic • Water • Ethylene Glycol • 2-(2-Methoxyethoxy)-Ethanol • 2-(2-Butoxyethoxy)-Ethanol		Sherwin-Williams Hi-Solids Polyurethane (2 component) Base Paint • Mineral Spirits • Xylenes • Trimethylbenzenes • Methyl Isobutyl Ketone • Methyl n-Amyl Ketone Part 2 • n-Butyl Acetate • Hexamethylene Diisocyanate Polymer • Hexamethylene Diisocyanate		Sherwin-Williams Metalatex Semi-Gloss • Water • 2-(2-Butoxyethoxy)-Ethanol • Ethylene Glycol	
VOC Content (lbs/gallon)	1.5-1.9		2.3-2.5 Base 2.7 Part 2		1.1-1.8	
Powder Coating	**Visual Appearance**	**Intercoat Adhesion**	**Visual Appearance**	**Intercoat Adhesion**	**Visual Appearance**	**Intercoat Adhesion**
O'Brien Red Oxide	Poor, Runs, Sags	5	Good	5	Fair	0
Zinc-Rich Gray	Poor, Runs, Sags	0	Good	5	Fair	0
PPG Black	Poor, Runs, Sags	0	Good	3	Fair	0

established from the feasibility and optimization trials. The amount of iron phosphate coating weight, which indicates the buildup of phosphate film on the steel surface was fairly consistent with the results from previous trials.

Material, Utility and Labor Usage

Actual material and utility usage information was collected for the validation trial. The material data consisted of monitoring pretreatment chemical and raw powder coating usage. Water is also used in the pretreatment process, however, actual usage data for the day of the trial was not available. The utility data which was tracked consisted of the natural gas and electricity consumption. Table 15 summarizes the material and utility data for the production trial. The data for utilities and powder coating are reported for the whole day, and are not broken down by shift.

Labor was required to activate and program the complete coating system process through the electronic user interface, to supervise the coating operations, to load parts onto the conveyor, to prepare and titrate the pretreatment washer system phosphating stage, to apply powder coating using manual touchup, and to unload the finished parts. For this work a process engineer, a pretreatment system operator, a painting technician and a material handler were required for a total of four personnel.

Laboratory Results

Powder Coat Primer to Metal Performance Data

Coupon specimens and basement door parts from the "AM" and "PM" shifts were analyzed for powder coating to metal performance. The same tests as for the feasibility and optimization trials were performed to ensure consistency with the previous trials and to determine process quality consistency during production conditions. No additional topcoating was performed for the validation trial as the feasibility and optimization trials generated the required topcoat to powder primer testing data. Table 18 summarizes the results of this testing. The data reported is taken from the analysis of the actual powder coated basement door parts unless otherwise noted as being from coupon specimens. Each door part was also tested for coating thickness in multiple locations and for visual appearance. The thickness data is treated in a separate discussion.

The lab testing in general shows good agreement with previous trials and good shift to shift repeatability. One difference from the feasibility and optimization trials is that the coupon coating thickness is slightly higher. The visual inspections of the actual basement door parts also showed that some of the edges and subassemblies such as hooks and handles appeared to have a thinner layer of coating. The corrosion resistance, however, is equal to or better than all previous trials. (See Table 18)

Table 15. Validation Trial Material and Utility Usage Summary

Material	AM Shift	PM Shift
Prep-n-Coat 700 Phosphating Recharge	9 gallons	13 gallons
Sodium Hydroxide Neutralizer	1/8 gallon	1/16 gallon
	Total Day's Usage	
Powder Coating	55 pounds	
Utilities		
Electricity (kW-hrs)		
Washer & Dry Off Oven	375	
Conveyor	11	
Powder Booth	169	
Powder Cure Oven	79	
Natural Gas (SCF)	9,523	
Water	not monitored	

Basement Door Parts Thickness Profile Data

Each of the 20 AM shift and 14 PM shift basement door parts powder coated during the validation trial was checked for coating thickness at several points per part to determine the thickness profile and the degree of consistency for all the parts processed. Figures 5 and 6 show the average front side and back side thickness values directly on drawings of the various part types at the locations evaluated. The thickness values shown are averages for that particular location point from all of the parts of the same type (shape) processed during the validation trial.

A majority of the data points fall in the 1.1 mil to 2.9 mil thickness range. This includes 24 of the 25 front surface locations and 21 of the 28 back, or underside surface locations. The highest degree of consistency is found on the larger continuous surface areas. Several locations on the parts have an average thickness of over 3.0 mils. Higher coating buildup is observed on one backside edge of the header (3.4 to 6.5 mils), one backside edge of the door panel (4.3 to 5.1 mils), and at the front and back side middle data point on the footer. These regions were consistently higher for these locations on all parts processed.

Several powder coating application factors, which may explain the spread in the thickness profile data, include:

- surface temperature differences
- differences in electrostatic effects on and around the parts
- differences which occur during manual touchup.

Locations which cool more slowly than other points on the part after exiting the 275°F pretreatment dry off oven step will be hotter and thus may attract a greater film build. Differences in electrostatic potential at various locations on the parts can cause uneven coating on the initial pass of powder and for the attraction of any overspray, particularly at the edges of parts. And finally, even the most carefully applied manual touchup will result in some thickness variability. Electrostatics and manual touchup are the primary factors contributing to the thickness variation. Since the hot rolled steel base metal for all the parts is the same thickness and composition, very little difference in cooling rates and surface temperature should exist.

Each of these factors potentially can be optimized to tighten the range of thickness for the parts, depending upon the degree of control required. The primary consideration would be to achieve a total thickness and profile uniformity which meet product quality and cost goals.

Major Results Summary From Validation Testing

The following major results occurred through validation testing:

- basement door parts were powder coated in a simulated production environment
- final process engineering improvements were successfully implemented
- collection of "real-time" material and utility usage and cost data collected
- consistent shift to shift product quality was demonstrated.

COST ANALYSIS

Through material and energy comparisons, powder coating offers a distinct advantage over liquid systems by the elimination or significant reduction of VOC emissions and hazardous wastes. The future operation of liquid finishing systems could be impacted by the potential increases in the costs associated with disposal of hazardous wastes and control of VOC and HAP emissions. Because of the difficulty in predicting these increases, economic evaluations were performed to estimate the feasibility of powder coating based on current costs and production rates.

The cost analysis was performed on the two primary alternatives identified by Bilco. These alternatives are:

- continuing with the current flow coating system with the addition of a new VOC control system, and
- powder coating.

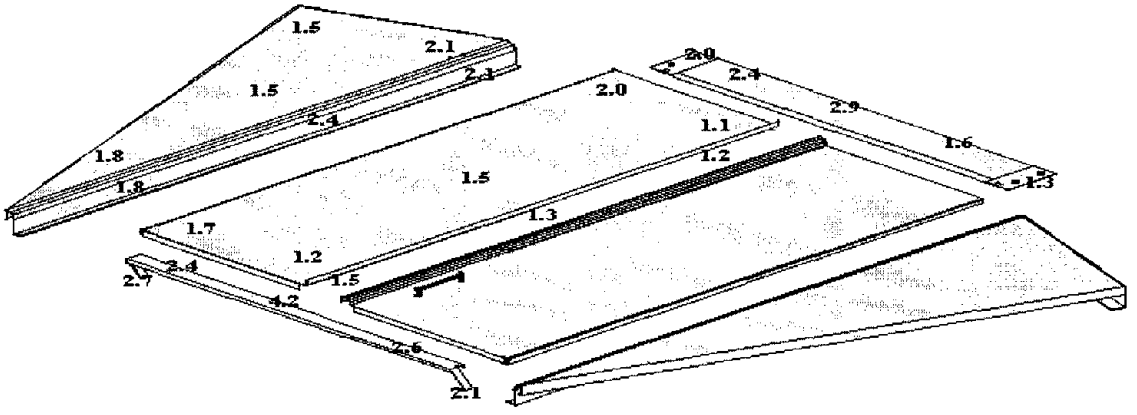


Figure 5. Average Thickness (Mils) Profile on Front Surface

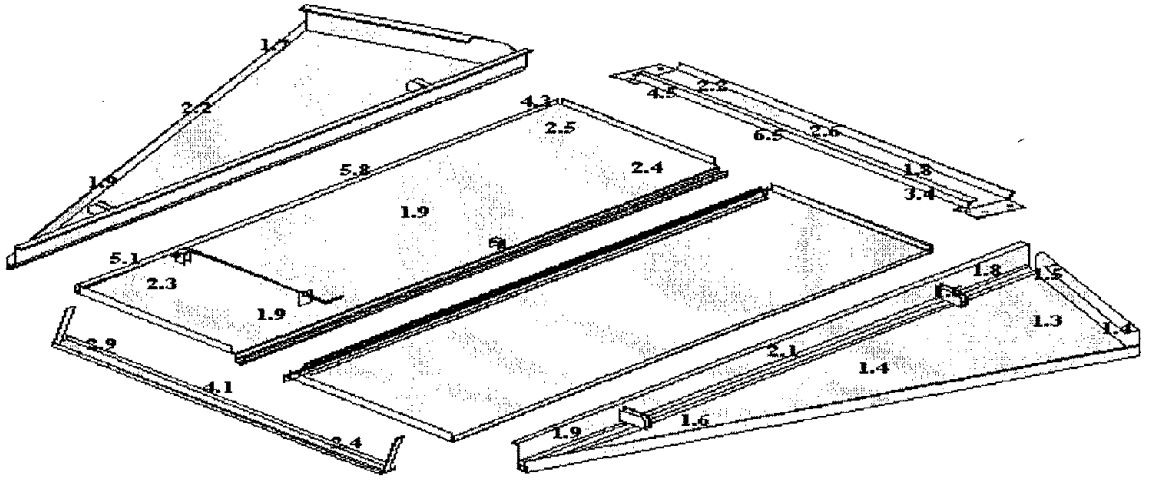


Figure 6. Average Thickness (Mils) Profile on Back Side Surfaces

Table 16. Validation Trial Inventory of Parts for AM and PM Shifts

AM SHIFT			PM SHIFT		
Part No.	Part Description	Square Footage	Part No.	Part Description	Square Footage
1	O Door Panel	20.9	1	B Door Panel	21.6
2	O Header	4.6	2	C Footer	2.0
3	O Door Panel	18.9	3	B Door Panel	22.6
4	B Footer	1.9	4	C Header	5.5
5	C Footer	2.0	5	C Door Panel	27.3
6	O Side Panel	19.5	6	C Footer	2.0
7	S/L Footer	1.9	7	C Door Panel	25.8
8	O Footer	1.7	8	C Header	5.5
9	B Door Panel	22.6	9	C Door Panel	27.3
10	C Header	5.5	10	C Door Panel	25.8
11	B Door Panel	21.6	11	C Side Panel	17.2
12	S/L Side Panel	23.6	12	C Side Panel	17.2
13	B Side Panel	17.1	13	C Side Panel	17.2
14	B Side Panel	17.1	14	C Side Panel	17.2
15	B Header	5.1	15	16 QC Coupons	10.6
16	C Door Panel	27.3			
17	B Header	5.1			
18	S/L Footer	1.9			
19	C Door Panel	25.8			
20	S/L Side Panel	23.6			
21	16 QC Coupons	10.6			

Table 17. Validation Trial Process Operating Conditions Summary

Parameter	AM Shift	PM Shift
Total Processing Time (min)	108	113
Total ft^2 Processed	278.4	245.1
Iron Phosphate Pretreatment System		
Total Acid (ml points)	10.2	10.2
pH	4.62	4.63
Pressure (psi)	10	10
Temperature (°F)	146	145
Conveyor Speed (ft/min)	4	4
Phosphating Time (sec)	75	75
Coating Weight (mg/ft^2)	51	57
Dry Off Oven		
Time (min)	6	6
Temperature (°F)	275	275
Powder Coating Application System		
Conveyor Speed (ft/min)	12	12
No. Automatic Guns	8	8
Powder Electrostatics (kV)	100	100
Fluidizing Air (psi)	13	13
Atomizing Air (psi)	16	16
No. Manual Touchup Guns	1	1
Powder Electrostatics (kV)	80	80
Fluidizing Air (psi)	24	24
Atomizing Air (psi)	12	12

Table 18. Validation Testing Results for the Primer and Primer / Topcoat Specimens

Test or Evaluation	Powder Coated Primer Test Data AM Shift	Powder Coated Primer Test Data PM Shift
Visual Appearance *		
Smoothness	smooth except in areas of steel substrate defects	smooth except in areas of steel substrate defects
	no fisheyes, craters, inclusions or other powder related defects	no fisheyes, craters, inclusions or other powder related defects
	some orange peel effect	some orange peel effect
Coverage	complete powder coverage	complete powder coverage
	some occurrences of visually thinner areas on latch and hook subassemblies	some occurrences of visually thinner areas on latch and hook subassemblies
	some thinning on bottom edges	some thinning on bottom edges
Color	no significant numerical differences among specimens determined by spectrophotometer	no significant numerical differences among specimens determined by spectrophotometer
	no noticeable differences to the naked eye	no noticeable differences to the naked eye
Gloss (60°)	40.7	40.9
Coating Thickness[#] (coupon testing)	1.62 mils	1.84 mils
Corrosion Resistance *		
Salt Spray - 175 Hours		
ASTM D610 Rusting	10 (no rust)	9-10 (no rust to < 0.03% affected area)
ASTM D714 Blistering	10 (no blistering)	8 (few blisters, < 1/32" dia.)
Physical Properties		
Pencil Hardness (Scratch Toughness)	2H	2H
Pencil Hardness (Gouge Toughness)	8H	8H
Direct Impact	passes > 160 in/lbs	passes > 150 in/lbs
Reverse Impact	passes > 160 in/lbs	passes > 160 in/lbs
Conical Mandrel	pass 1/8" bend	pass 1/8" bend
Tape Adhesion (X-cut)	5 - no failure	5 - no failure
Tape Adhesion (Cross-cut)	5 - no failure	5 - no failure

(* denotes specific Bilco performance requirement)
(# thickness data for actual basement door specimens shown on Figures 5 and 6)

The alternatives were evaluated using the National Institute of Standards and Technology (NIST) "Building Life-Cycle Cost" (BLCC) Program. BLCC provides economic analysis of proposed capital investments that are expected to reduce long-term operating costs. While BLCC was designed for the evaluation of alternative buildings and building-related projects, BLCC can also be applied to almost any project investment which is primarily intended to reduce future operating-related costs. BLCC calculations comply with:

- The American Society for Testing and Materials (ASTM)
- Criteria outlined in the DOD memorandum of agreement "Criteria/Standards for Economic Analysis/Life-Cycle Costing for MILCON Design", March 18, 1991
- OMB Circular A-94 Revised, "Guidelines and Discount Rates for Cost Analysis of Federal Programs," October 19, 1992.

Life-Cycle Cost (LCC) analysis is used as a decision-making tool for choosing among alternatives, based on their long-term economic performance, rather than on their initial costs. LCC is a technique of economic evaluation which sums, over a given study period, the costs of initial investment and operating costs. In this case, a study period of 15 years was

used. The results from the BLCC program are presented in a comparison of current year costs of the alternatives.

The estimated total capital costs for the alternatives are based on the approximate purchased equipment costs and are summarized in Table 19. The equipment cost for the VOC control system was obtained from Bilco, and the powder costs were obtained from vendors.

Table 19. Total Capital Cost

Item	Spray System with VOC Control	Powder Coat System
Purchased Equipment	380,000	1,293,046
Installation & Start-Up	95,000	120,000
Total Capital Cost	475,000	1,413,046

Operating costs used in the LCC comparisons were limited to raw materials, waste management, and utilities. Powder costs were estimated using the Powder Coating Institute's Finisher's Handbook[5]. Powder material costs were estimated based on the current production rate and an estimated powder cost of $2.50/pound from the powder vendor. Powder coat and liquid usage was estimated by using a 1.0 mil film thickness, which is an industry standard for estimating material usage and coverage. Costs for VOC control were estimated using the EPA Handbook[6] for estimating supplementary fuel and electricity requirements. Annual operating costs are shown in Table 20.

Table 20. Operating Cost Summary

Process	Raw Materials $/year	Waste Management $/year	Utilities $/year	Total Operating Cost $/year
Current + VOC Control	89,911	2,750	218,500	311,161
Powder	132,500	500	35,895	168,895

The Life Cycle Cost for each alternative is shown in Table 21.

Table 21. Life Cycle Cost Comparison

Process	Initial Cost $	Life-Cycle Cost $
Current + VOC Control	475,000	3,138,377
Powder	1,413,046	2,854,420

Based on this analysis, simple payback occurs in year 7 after investment. This period is longer than that obtained when replacing a conventional liquid spray system with powder because of flowcoating's high transfer efficiency and resultant low cost per part. One of the main benefits of powder coating is that material can be recycled and reused, and this is already occurring with the flowcoating system.

As mentioned earlier, escalating costs for hazardous waste disposal must be taken into account when considering the current coating system. Since these costs are so difficult to predict, they were not included in the analysis, but should be considered when evaluating the alternatives.

In addition, no attempt was made to place a value on the increased part performance realized through the use of powder. Through a significant increase in hardness and corrosion resistance, Bilco could potentially offer an extended warrantee on its products. As a result, this creates the potential to increase product price.

At current manufacturing rates of over 50,000 doors per year, this could mean an increase in revenue from sales of over $50,000 for a $1 per door price increase. With a $2 per door price increase, leading to over $100,000 in additional revenue, Bilco could dramatically increase the rate of return on its initial powder coat equipment investment.

Environmental Analysis

Regulatory Comparisons

The powder coating process can offer several advantages over the traditional flow coating operation. Typically, the powder coat process eliminates or significantly reduces the VOC emissions and hazardous waste generated as a result of traditional painting methods. The VOC content of the powder used in the powder coat process is usually low. Typically, the powder paint is considered to be a non-hazardous waste, and waste generation can be reduced by recycling the powder.

Although there are several advantages to the powder coat process, the waste water from the pretreatment line of the powder coat operation may subject Bilco to applicable CWA requirements and to local control by the New Haven WPCA. Presumably, the powder coat operation would involve the discharge of pretreatment rinse waters to the New Haven WPCA. This practice would subject Bilco to the WPCA's limitations and to all applicable requirements of the New Haven Code, which may include prohibitions on certain discharges, pretreatment requirements, and requirements for a waste water discharge permit.

Air emissions requirements are getting more stringent, and while they may not significantly impact Bilco's current

operation, they may restrict Bilco's ability to increase production in the future if increased production would also result in an increase in air emissions. Although the switch to a powder coating line with a pretreatment process that generates waste water would subject Bilco to regulation under the CWA, the powder coat system nevertheless can offer several advantages in that it reduces or virtually eliminates the generation of VOCs and hazardous waste that would occur using traditional painting methods.

Quality Analysis Summary

The Bilco Company's basement door primer performance criteria, shown in Table 22, serves as the basis for determining the suitability of powders to replace liquid coatings. Bilco's requirements basically fall into primer to metal or primer to topcoat performance categories. Flowcoated and powder coated specimens were tested to determine adherence to both performance categories.

Table 22. Bilco Basement Door Primer Specifications

	Primer to Metal Requirements
Corrosion Resistance	175 hours ASTM B117 salt spray Resist rust to a rating of 10 according to ASTM D610 No blisters according to ASTM D714
Appearance and Thickness	Smooth finish when applied to hot rolled steel weldments Complete coverage, no bare spots, drips or sags Red oxide color preferable 0.7 to 1.1 mils thickness
	Primer to Topcoat Requirements
Topcoating	Compatible with a finish coat of alkyd enamel applied in the field after installation Alternative topcoats acceptable as long as these have equal field performance and customer appeal

Primer to Metal Performance Category

The primer to metal performance of powder coating technology was determined to be equivalent or superior to the liquid primer presently in use for most of the evaluations where direct comparison is logical. The baseline powder coating material demonstrated significantly better resistance to corrosion for degree of rusting and degree of blistering and better resistance to delamination upon direct and reverse impact. The baseline powder coating material was equivalent to the liquid primer for pencil hardness (gouge and scratch resistance), flexibility (mandrel bending), and tape adhesion.

The cured film thickness of the powder coating was higher than the flowcoated primer. However, due to the inherent differences in liquid and powder application technologies and among various coating products in general, the powder thickness' achieved in this project are not necessarily relevant or logical for direct comparison. Product performance, material usage, waste generation, total cost and coating system capabilities are the key factors for determining optimum film thickness. The powder coating thickness was demonstrated during the optimization trials to have the ability to be adjusted downward while maintaining suitable overall primer to metal performance.

The final set of evaluations in the primer to metal performance category involved appearance ratings. The baseline powder coating was red in color, as per Bilco's requirements, and was consistent from specimen to specimen qualitatively and quantitatively as were the flowcoated baseline specimens. All of the flowcoating and the powder coating specimens were smooth in appearance with the exception of some characteristic orange peel effect exhibited by the powder coating. The baseline powder material also had a much higher gloss, which may or may not be desired, but which can be changed with a suitable powder coating material change to a flatter finish. A change to a flat finish might also enhance the topcoat performance data, discussed below in the next section, since certain components which impart increased gloss may also inhibit the adhesion of certain topcoats.

Primer to Topcoat Performance

A topcoat material was found which would adhere to the baseline powder material with equivalent intercoat adhesion performance as for the flowcoated primer with the preferred alkyd enamel topcoat.

Additional Process Quality Considerations

The flowcoating process requires few quality checks other than visual appearance and cured film thickness checks. However, a switch to powder coating would introduce at least one other series of process quality checks. The iron phosphate pretreatment system, at a minimum, would require control of the phosphating chemical concentration via an acid-base titration, and possibly periodic gravimetric determinations of iron phosphate coating weight. Bilco also would have to work with their pretreatment chemical supplier to optimize the pretreatment process initially and to obtain periodic advice for maintaining peak.

CONCLUSIONS

New environmental regulations are placing more stringent restrictions on how manufacturers can coat parts. Powder coating is an environmental technology with the potential for reducing VOC emissions to zero. *CTC*, through the performance of the EPA Powder Coat Applications Task has demonstrated that powder coatings offer a viable solution to small business manufacturers for coating parts. First, powder coat materials have demonstrated the ability to meet and exceed current liquid coating performance.

Second, powder coatings offer small businesses a way to significantly reduce coating costs by reducing air exhaust and air make-up requirements, reducing wasted paint material through recycling, and avoiding costs such as the installation and maintenance of VOC destruction systems.

Finally, powder coatings offer small businesses a way to reduce VOC emissions. By virtually eliminating VOC emissions from the coating process, manufacturers may avoid the cost of installation and maintenance of VOC destruction systems.

REFERENCES

1. *Compilation of Air Pollutant Emission Factors,* 5th Edition, January 1995, U.S. EPA, Vol. 1. AP-42 (GPO-055-000-005-001).

2. *Annual Books of ASTM Standards,* Volume 6.01, Paint-Tests for Chemical, Physical, and Optical Properties Appearance. Copyright 1995 American Society for Testing and Materials, Philadelphia, PA. ASTM 1916 Race Street, Philadelphia, PA 19103-1187, U.S.A., Publication Code Number (PCN): 01-060195-14.

3. *Annual Books of ASTM Standards,* Volume 6.02, Paint - Products and Applications; Protective Coatings; Pipeline Coatings. Copyright 1995 American Society for Testing and Materials, Philadelphia, PA. ASTM 1916 Race Street, Philadelphia, PA 19103-1187, U.S.A., PCN: 01-060295-14.

4. *Annual Books of ASTM Standards,* Volume 2.05, Metallic and Inorganic Coatings, Metal Powders, Sintered P/M Structural Parts. Copyright 1993 American Society for Testing and Materials, Philadelphia, PA. ASTM 1916 Race Street, Philadelphia, PA 19103-1187, U.S.A. PCN: 01-020593-05.

5. *Powder Coating, The Complete Finisher's Handbook,* Alexandria, VA, Powder Coating Institute, First Edition, 1994; 351-360.

6. *EPA Handbook: Control Technologies for Hazardous Air Pollutants*, Chapter 4, Design & Cost of HAP Control Technologies, Section 4.2, Thermal Incineration, p. 4-1-4-10, U.S. EPA-625/6-86-014 (NTIS PB91-228809), 1986.

APPENDIX A

Facility Baseline Survey Questionnaire

OPERATING DATA

SITE: _____	**PROCESS:** _____
SITE POC AND PHONE NO.:	_____ (___) ___-____
ADDITIONAL POC(S) AND NO.(S):	_____ (___) ___-____
	_____ (___) ___-____

(Please attach additional information as required.)

PROCESS FLOW DIAGRAM:

- Label all process units
- Identify and label input and output streams (Note where outputs go)
- Identify direction of flow
- Note previous operations/processes (Where do parts come from?)
- Note subsequent operations/processes (Where do parts go?)

Explanatory Notes:

OPERATING DATA

PROCESS DESCRIPTION:

1. How long has current process operated? _____

2. What past process changes have been made to enhance pollution prevention efforts? (Equipment changes, material changes, operational changes, other.) _____

3. Assuming continued use for the existing process technology, what future pollution prevention upgrades would be required? (Equipment changes, material changes, operational changes, etc.) _____

4. Is the current process batch or continuous? _____

5. Estimate or provide actual data for identified representative ("typical") parts that are processed; Name(s) of Representative Parts, End Item (what do parts belong to), and Quantities processed:

PART NAME	END ITEM	ANNUAL QUANTITY	QUANTITY PER SHIFT or HOUR

6. Provide data to characterize the identified parts, as applicable:

PART NAME	TYPICAL SIZE(S), WEIGHT(S), SHAPE(S), SUBSTRATE(S)

OPERATING DATA

1. Please list any raw materials (substrates, pretreatment and coatings) inspections (visual, chemical, instrumental, destructive, nondestructive, other) performed or required and the quantitative or qualitative target results for these checks.

Raw Material	Check Performed	Quality/Quantity Range or Result

2. Please list the critical automated or manual process control checks (on materials an equipment) performed during a production run to control or monitor process conditions such as chemical analyses, equipment settings, etc.

In-Process Material/Equipment Check Performed	Quality/Quantity Target Control Result or Range

3. Please list any in-service or field quality or performance requirements for the finished product.

1.
2.
3.
4.

4. Please list any quality inspections performed on the manufactured parts and the target result or range for product quality.

Type of Quality Check on Products	Quality/Quantity Target Result or Range

OPERATING DATA

5. Please list typical number of parts re-worked or rejected during a production run and the attributable cause(s).

Type of Problem	Number Re-worked or Rejected	Attributable Cause(s)

6. Please list the total number of parts manufactured and the total number sampled for quality checks for a normal production run or period.

    1. Number of parts manufactured: _____

    2. Number of parts sampled for quality inspection: _____

7. Please list the quality checks, if any, performed by your material or equipment suppliers on a regular basis for your facility.

    1.
    2.
    3.
    4.

8. Please list any types of field or in-service problems with your product that have been encountered.

Parts Type	Nature of Problem

OPERATING DATA

PROCESS EQUIPMENT:

1. Identify overall process footprint. _____

_____

_____

2. Identify major process equipment size(s) and/or capacity(s) (tanks, booths, motors, blowers, etc.), as applicable.

ITEM	SIZE/CAPACITY

3. What are minimum and maximum part size envelopes?
   Minimum: _____

_____

_____

   Maximum: _____

_____

_____

4. Are there any maximum weight restrictions? If so, identify: _____

_____

_____

5. List all utilities used by the process: _____

_____

_____

6. List any additional utilities, available to the process: _____

_____

_____

7. List any recent or anticipated equipment modifications, and denote if they are being made to improve production, quality, pollution prevention, other: _____

_____

_____

OPERATING DATA

INPUT STREAMS:

List input streams from process flow diagram and Estimate quantities where possible: such as amount used/day, week, or year. Annual quantities are preferred. Please attach MSDS sheets for significant input materials.

Also, for annual quantities, provide the baseline year.

STREAM NAME	QUANTITY/UNITS

OUTPUT STREAMS:

List output streams from process flow diagram and Estimate quantities where possible: quantity discharged/day, week, year; quantity disposed/day, week, or year; etc. Annual quantities are preferred. Provide % compositions or waste profiles if known, as well as hazardous waste codes (D001, D003, etc.).

Also, for annual quantities, provide the baseline year.

STREAM NAME	QUANTITY/UNITS

OPERATING DATA

OPERATIONS:

For the entire production process, identify operating days, shifts, # of operators, etc.

ITEM	QUANTITY/UNITS
OPERATING DAYS	days/week days/year
# OF SHIFTS	shifts/day
OPERATING HOURS	hours/shift
OPERATORS	#/shift
OPERATOR HOURS	hours/shift
SUPERVISOR HOURS	hours/shift
SCHEDULED MAINTENANCE	days/year
MAINTENANCE HOURS	hours/week hours/year

REGULATORY COMPLIANCE:

1. Identify regulations that affect the process, if applicable: _____

_____

_____

2. Identify any permit(s) for the process, ifapplicable: _____

_____

_____

3. Identify the significant requirements of the permit(s), if applicable: _____

_____

_____

OPERATING DATA

4. Identify for each waste stream or for the entire process, as applicable, what if any of the following activities are performed, by whom (company personnel, outside contractor, etc.), how often (1/mo., 1/yr., etc.), and number of hours associated to each task.

Manifesting: _____

_____

_____

_____

Reporting: _____

_____

_____

_____

Monitoring: _____

_____

_____

_____

Testing:

_____

_____

_____

Labeling: _____

_____

_____

Permitting: _____

_____

_____

Training (facility wide related to this manufacturing process, also internal & external training):

_____

_____

_____

OPERATING DATA

WASTE MANAGEMENT:

1. For each waste stream, identify which of the following waste management categories apply, and whether or not they are performed on or off-site, as applicable:

Pre-Treatment: _____

_____

_____

_____

On-Site Storage: _____

_____

_____

_____

Treatment: _____

_____

_____

_____

Hauling: _____

_____

_____

_____

Insurance: _____

_____

_____

_____

Disposal: _____

_____

_____

_____

Recycling: _____

_____

_____

OPERATING DATA

HEALTH AND SAFETY:

1. Identify any physical hazards associated with the current process:

_____

_____

_____

2. Identify any chemical hazards associated with the current process:

_____

_____

_____

3. List any personal protection equipment necessary to operate the process:

_____

_____

_____

4. List any safety training that is required for the operator(s) and frequency:

_____

_____

_____

COST DATA

MATERIAL & MAINTENANCE COSTS:

Identify costs for all materials identified as Input Streams on the process flow diagram, for all recycled materials, and for all significant maintenance items.

ITEM	COST/UNIT

LABOR COSTS:

Identify cost of all manufacturing process direct labor.

ITEM	COST/UNIT
OPERATOR(S)	
SUPERVISION	
MAINTENANCE	

UTILITIES:

Identify cost of utilities used by the process, such as gas, electricity and water, and any additional utilities that are available to the process.

ITEM	COST/UNIT

COST DATA

REGULATORY COMPLIANCE:

Quantify regulatory compliance costs for waste stream(s) or for the entire process, where possible, for activities identified previously.

ITEM	WASTE STREAM/ PROCESS	COST/UNIT
MANIFESTING		
REPORTING		
MONITORING		
TESTING		
LABELING		
PERMITTING		
TRAINING		

COST DATA

WASTE MANAGEMENT:

Quantify waste management costs, where possible and applicable, for identified waste streams.

ITEM	WASTE STREAM	COST/UNIT
PRE-TREATMENT		
ON-SITE HANDLING		
STORAGE		
TREATMENT		
HAULING		
INSURANCE (include all process related insurance costs)		
DISPOSAL		
RECYCLING		

COST DATA

HEALTH AND SAFETY:

Identify costs associated to personal protection equipment, safety monitoring, and safety training for the process.

ITEM	COST/UNIT

Explanatory Notes: _____

_____

_____

_____

FUTURE LIABILITY:

For the following items, identify any recent/known fines, penalties, injury, or damage associated to the process. Identify any potential costs in the future, where possible. What risks/ramifications are associated the operation of the process while in and/or out of compliance?

ITEM	COST/UNIT
FINES/PENALTIES	
PERSONAL INJURY	
PROPERTY DAMAGE	
ENVIRONMENTAL DAMAGE	

Explanatory Notes: _____

_____

_____

_____

COST DATA

CAPITAL COSTS:

Quantify any of the previously identified capital equipment expenditures.

ITEM	COST

REVENUES and FINAL COSTS

Revenues: Total Sales of Product: _____

Revenues: Revenues per Unit _____

Revenues: Marketable By-Products _____

Your Calculated Cost To Coat Per Unit _____

and to Coat Per Square Foot _____

Any Other Cost/Revenue Figures Used _____

_____

APPENDIX B

Material Safety Data Sheets for Bilco Primer and Solvent Thinner

MATERIAL SAFETY DATA SHEET

EXXON CHEMICAL AMERICAS, P.O. BOX 3378, HOUSTON, TEXAS 77081
A Division of EXXON CHEMICAL COMPANY, A Division of EXXON CORPORATION

AROMATIC 100 SOLVENT	PAGE:	1
	DATE PREPARED:	JUNE 3, 1992
	NO:	92940652

SECTION 1: PRODUCT IDENTIFICATION & EMERGENCY INFORMATION

PRODUCT NAME: AROMATIC 100 Solvent
CHEMICAL NAME: Aromatic Hydrocarbon CAS 64742-95-6
CHEMICAL FAMILY: Petroleum Hydrocarbon
PRODUCT DESCRIPTION: Clear colorless liquid.

EMERGENCY TELEPHONE NUMBERS:

EXXON CHEMICAL AMERICAS: 713-870-6000
CHEMTREC: 800-424-9300

SECTION 2: HAZARDOUS INGREDIENT INFORMATION

The composition of this mixture may be proprietary information. In the event of a medical emergency, compositional information will be provided to a physician or nurse. This product is hazardous as defined in 29 CFR1918.1200, based on the following compositional information:

COMPONENT	OSHA HAZARD
Petroleum Hydrocarbons	Combustible
Trimethylbenzene	OSHA PEL; ACGIN TLV
Zylene	OSHA PEL; ACGIN TLV
Cumene	OSHA PEL; ACGIN TLV
Ethylbenzene	OSHA PEL; ACGIN TLV

For additional information see Section 3.

SECTION 3: HEALTH INFORMATION & PROTECTION

NATURE OF HAZARD

EYE CONTACT:

Slightly irritating but does not injure eye tissue.

SKIN CONTACT:

Frequent or prolonged contact may irritate and cause dermatitis.
Low order of toxicity.
Skin contact may aggravate an existing dermatitis condition.

INHALATION:

High vapor/aerosol concentration (greater than approximately 1000 ppm) are irritating to the eyes and the respiratory tract, may cause headaches, dizziness, anesthesia, drowsiness, unconsciousness, and other central nervous system afftects, including death.

INGESTION:

Small amounts of this product aspirated into the respiratory system during ingestion or vomiting may cause mild to severy pulmonary injury, possibly progressing to death. Minimal toxicity.

FIRST AID

EYE CONTACT:

Flush eyes with large amounts of water until irritation subsides. If irritation persists, get medical attention.

SKIN CONTACT:

Flush with large amounts of water; use soap if available.

Remove grossly contaminated clothing, including shoes, and launder before reuse.

INHALATION:

Using proper respiratory protection, immediately remove the affected victim from exposure. Administer artificial respiration if breathing is stopped. Keep at rest. Call for prompt medical attention.

INGESTION:

If swallowed, DO NOT induce vomiting. Keep at rest. Get prompt medical attention.

ACUTE TOXICITY DATA IS AVAILABLE UPON REQUEST.

WORKPLACE EXPOSURE LIMITS

OSHA REGULATION 29CFR1910.1000 REQUIRES THE FOLLOWING PERMISSIBLE EXPOSURE LIMITS:

A TWA of 25 ppm (125 mg/m^3) for Trimethyl Benzene.

A TWA of 100 ppm (435 mg/m^3) and a STEL of 150 ppm (655 mg/m^3) for Xylene.

A TWA of 50 ppm (246 mg/m^3) for Cumene (skin).

A TWA of 100 ppm (435 mg/m^3), and a STEL of 125 ppm (545 mg/m^3) for Ethyl Benzene.

THE ACGIH RECOMMENDS THE FOLLOWING THRESHOLD LIMIT VALUES:

A TWA of 25 ppm (123 mg/m^3) for Trimethyl Benzene.

A TWA of 100 ppm (434 mg/m^3), and a STEL of 150 ppm (651 mg/m^3) for Xylene.

A TWA of 50 ppm (246 mg/m^3) for Cumene (skin).

A TWA of 100ppm (434 mg/m^3) and a STEL of 125ppm (543 mg/m^3) for Ethyl Benz.

EXXON RECOMMENDS THE FOLLOWING OCCUPATIONAL EXPOSURE LIMITS:
50 ppm total hydrocarbon based on composition.

PRECAUTIONS

SPECIAL PRECAUTION:

Health studies have shown that many petroleum hydrocarbons pose potential human health risks which may vary from person to person. As a precaution, exposure to liquids, vapors, mists or fumes should be minimized.

PERSONAL PROTECTION:

For open systems where contact is likely, wear safety glasses with side shields, long sleeves, and chemical resistant gloves.

Where contact may occur, wear safety glasses with side shields.

Where concentrations in air may exceed the limits given in this section and engineering, work practice or other means of exposure reduction are not adequate, NIOSH/NSMA approved respirators may be necessary to prevent overexposure by inhalation.

VENTILATION:

The use of local exhaust ventilation is recommended to control process emissions near the source. Laboratory samples should be stored and handled in a lab hood. Provide mechanical ventilation of confined spaces.

See respiratory protection recommendations.

SECTION 4: FIRE & EXPLOSION HAZARD

FLASHPOINT: 106 Deg. F, METHOD: TCC NOTE: Minimum
FLAMMABLE LIMITS: LEL: 1.9 WEL: 12.6 77 °F. Note: Approximate
AUTOIGNITION TEMPERATURE: 880 °F. Note: Approximate

GENERAL HAZARD:

Combustible Liquid, can form combustible mixtures at temperatures at or above the flashpoint.

Static Discharge, material can accumulate static charges which can cause an incendiary electrical discharge.

"Empty" containers retain product residue (liquid and/or vapor) and can be dangerous, DO NOT PRESSURIZE, CUT, WELD, BRAZE, SOLDER, DRILL, GRIND, OR EXPOSE SUCH CONTAINERS TO HEAT, FLAME, SPARKS, STATIC ELECTRICITY, OR OTHER SOURCES OF IGNITION; THEY MAY EXPLODE AND CAUSE INJURY OR DEATH.

Empty drums should be completely drained, properly bunged and promptly returned to a drum reconditioner, or properly disposed of.

FIRE FIGHTING:

Use water spray to cool fire exposed surfaces and to protect personnel.
Isolate "fuel" supply from fire.
Use foam, dry chemical, or water spray to extinguish fire.
Avoid spraying water directly into storage containers due to danger of boilover.
This liquid is volatile and gives off invisible vapors. Either the liquid or vapor may settle in low areas or travel some distance along the ground or surface to ignition sources where they may ignite or explode.

HAZARDOUS COMBUSTION PRODUCTS: No Unusual

SECTION 5: SPILL CONTROL PROCEDURE

LAND SPILL:

Eliminate sources of ignition. Prevent additional discharge of material, if possible to do so without hazard. For small spills implement cleanup procedures: for large spills implement cleanup procedures and, if in public area, keep public away and advise authorities. Also, if this product is subject to CERCLA reporting (see Section 7) notify the National Response Center.
Prevent liquid from entering sewers, watercourses, or low areas. Contain spilled liquid with sand or earth. Do not use combustible materials such as sawdust.
Recover by pumping (use an explosion proof or hand pump) or with a suitable absorbent.
Consult an expert on disposal of recovered material and ensure conformity to local disposal regulations.

WATER SPILL:

Remove from surface by skimming or with suitable adsorbents. If allowed by local authorities and environmental agencies, sinking and/or suitable dispersants may be used in non-confined waters. Consult an expert on disposal of recovered material and ensure conformity to local disposal regulations.

SECTION 6: NOTES

HAZARD RATING SYSTEMS:

This information is for people trained in: National Paint & Coatings Association's (NPCA) Hazardous Materials Identification System (NMIS)
National Fire Protection Association (NFPA 704)
Identification of the Fire Hazards of Materials

	NPCA-NMIS	NFPA 704	KEY
HEALTH	1	1	4 = Severe
FLAMMABILITY	2	2	3 = Serious
REACTIVITY	0	0	2 = Moderate
			1 = Slight; 0 = Min.

AROMATIC 100 SOLVENT	PAGE:	5
	DATE PREPARED:	JUNE 3, 1992
	NO:	92940652

SECTION 7: REGULATORY INFORMATION

DEPARTMENT OF TRANSPORTATION (DOT):

DOT PROPER SHIPPING NAME:

Petroleum Kaphtha, Combustible Liquid Uk 1255

DOT HAZARD CLASS: Combustible Liquid

DOT IDENTIFICATION NUMBER: UK 1255 NAME: Kaphtha, petroleum

FLASHPOINT: 106 °F, METHOD: TCC, NOTE: Minimum

TSCA:

This product is listed on the TSCA Inventory as a UVCS (Unknown, Variable Composition or Biological) Chemical at CAS Registry Number 64742-95-6

CERCLA:

This product, as sold, is derived from a fraction of crude oil and is excluded from the spill reporting requirements by CERCLA Section 101(14)(F). When this product is used in a mixture or as an ingredient in another product or in a manufacturing operation, the petroleum exclusion may terminate and an accidental spill may require reporting to the National Response Center at 556-424-3302.

This product contains approximately 3% of Xylene.

The reportable quantity of Zylene is 1,000 pounds.

This product contains approximately 2% of Cumene.

The reportable quantity of Cumene is 5,000 pounds.

This product contains approximately 1% of Ethylbenzene.

The reportable quantity of Ethylbenzene is 1,000 pounds.

SARA TITLE III:

Under the provisions of Title III, Sections 311/312 of the Superfund Amendments and Reauthorization Act, this product is classified into the following hazard categories: Delayed Health, Fire.

This product contains the following Section 313 Reportable ingredients:

COMPONENT	CAS NO.	MAXIMUM %
1,2,4-Trimethylbenzene	95-63-6	32.0
Zylene	1330-20-7	3.0
Cumene	98-82-8	1.5
Ethylbenzene	100-41-4	0.5

SECTION 8: TYPICAL PHYSICAL & CHEMICAL PROPERTIES

SPECIFIC GRAVITY: 0.87 AT 50 Density: 7.3 lbs/gal at 59	**VAPOR PRESSURE**, mmHg at °F: 11 @ 100 Approx.; 4 @ 68 Approx.

AROMATIC 100 SOLVENT	PAGE:	6
	DATE PREPARED:	JUNE 3, 1992
	NO:	92940652

SOLUBILITY IN WATER, Wt.%, °F: 0.02 at 77 Calculated.	**VISCOSITY OF LIQUID**, CST AT °F: 1 at 77 Approximate
SP. GRAV. OF VAPOR, at 1 atm (Air=1) 20	**FREEZING/MELTING POINT**, °F: -76
EVAPORATION RATE, (n-Bu Acetate =1) 0.3 Approximate	**BOILING POINT**, °F: 318 TO 338

SECTION 9: REACTIVITY DATA

STABILITY: Stable	**HAZARDOUS POLYMERIZATION:** Will not occur

CONDITIONS TO AVOID INSTABILITY:
Not applicable

MATERIALS AND CONDITIONS TO AVOID INCOMPATIBILITY:
Nitric acid, sulfuric acid, strong oxidizing agents.

HAZARDOUS DECOMPOSITION PRODUCTS:
None

SECTION 10: STORAGE AND HANDLING

ELECTROSTATIC ACCUMULATION HAZARD:
Yes, use proper grounding procedure.

STORAGE TEMPERATURE, °F: Ambient	**LOADING/UNLOADING TEMP.**, °F: Ambient
STORAGE/TRANSPORT PRESSURE: Atmospheric	**VISC. AT LOADING/UNLOADING TEMP.**, cST: 1

REVISION SUMMARY:
Since May 8, 1992 this MSDS has been revised in Section 7

REFERENCE NUMBER:	DATE PREPARED:	SUPERSEDES ISSUE DATE:
WDMA-C-25028	June 3, 1992	May 8, 1992

FOR ADDITIONAL PRODUCT INFORMATION, CONTACT YOUR TECHNICAL SALES REPRESENTATIVE
FOR ADDITIONAL HEALTH/SAFETY INFORMATION, CALL 713-670-6884

MATERIAL SAFETY DATA SHEET

For Chemicals, Coatings, and Related Materials
In Compliance with OSHA 29 CFR 1910.1200

RED OXIDE BAKE PRIMER	PAGE:	1
	DATE PREPARED:	FEB. 16, 1995
	NO:	41U-318

SECTION 1: PRODUCT

PRODUCT NAME: RED OXIDE BAKE PRIMER
CLASS: MODIFIED ALKYD BAKE ENAMEL
NUMBER: 41U-318

HMIS HAZARD CODES
Health: 2 MODERATE
Flammability: 2 MODERATE
Reactivity: 0 MINIMAL
Personal Protective Equipment: G

SECTION 2: HAZARDOUS INGREDIENTS

Ingredient Mat'l. Description	% By Weight	C.A.S. Registry No.	PEL OSHA	TLV ACGIH	UNIT
Ethylamine	0.09	121-44-8	15.0	10.0	PPM
Alkylolammonium Salt Sol'n.	0.99	MIXTURE	50.0	50.0	PPM
Petroleum Hydrocarbon	6.32	64742-95-6		50.0	PPM
1,2,4-Trimethyl-benzene	0.99	95-63-6	25.0	25.0	PPM
Medium Aliphatic Petroleum Sol'n.	28.98	64742-88-7	100.0	100.0	PPM
Naphthalene	0.14	91-20-3	10.0	10.0	PPM
Cobalt	0.03	7440-48-4		0.1	MG/M^3
Manganese Compound	0.04	7439-96-5	5.0	1.0	MG/M^3

SECTION 3: PHYSICAL DATA

Boiling range: 193.1 - 413.0 °F	**Freezing Range:** -174.50 °F
Vapor Pressure: 0.0 mm @ 20 °C	**Vapor Density:** LIGHTER
Specific Gravity: 1.29	**H_2O Soluble:** Negligible <0.1%

Evaporation Rate: SLOWER (relative to n-butyl acetate)

% Volatile by Volume:	Density:	VOC:
60.45	10.773 lbs/ gal	3.99

APPEARANCE AND ODOR: RED LIQUID, SOLVENT ODOR

RED OXIDE BAKE PRIMER	PAGE:	2
	DATE PREPARED:	FEB. 16, 1995
	NO:	41U-318

SECTION 4: FIRE AND EXPLOSION HAZARD DATA

Flash Point: 110.0 °F (Method Used) SETAFLASH	Explosive Limits: LEL UEL (% in air) 1.0 12.6

FLAMMABILITY CLASSIFICATION:

OSHA: COMBUSTIBLE LIQUID - CLASS II
DOT: COMBUSTIBLE LIQUID

EXTINGUISHING MEDIA:

Use water fog, foam, dry chemical, or carbon dioxide.

SPECIAL FIRE FIGHTING PROCEDURES:

WARNING...FLAMMABLE
Do not enter fire space without full bunker gear.
Cool fire exposed containers with water.

UNUSUAL FIRE AND EXPLOSION HAZARDS:

Vapors may travel considerable distances by air and become ignited by ignition sources.
Material creates a special hazard because it floats on water.
Dangerous when exposed to heat, sparks, flame or oxidants.
Handle in properly bonded and grounded equipment.
Vapors may form explosive mixtures in the air.

SECTION 5: HEALTH HAZARD DATA

Ingredient Material Description	Carcinogenicity Listing			LD50 (mg/kg) (rat) : (rbt) ORAL : DERMAL
	OSHA	NTP	IARC	
Triethylamine	N/A	N/A	N/A	
Alkylolammonium Salt Solution	N/A	N/A	N/A	250.00
Petroleum Hydrocarbon	NO	NO	NO	
1,2,4-Trimethylbenzene	NO	NO	NO	
Medium Aliphatic Petroleum Solvent	N/A	N/A	N/A	
Naphthalene	NO	NO	NO	
Manganese Compound	N/A	N/A	N/A	

RED OXIDE BAKE PRIMER	PAGE:	3
	DATE PREPARED:	FEB. 16, 1995
	NO:	41U-318

SECTION 6: HEALTH HAZARD INFORMATION

EFFECTS OF OVEREXPOSURE

INHALATION:

Chronic exposure may cause liver and kidney damage.
May cause dizziness, anesthesia, drowsiness or unconsciousness.
Vapors may irritate nose, throat, and respiratory tract.
Pre-existing respiratory disorders may be aggravated.
Excessive inhalation causes headache, dizziness, & nausea.
Aspiration may cause pulmonary edema & chemical Pneumoniti.
May cause injury to bone marrow, blood cells, kidney & liver.
May produce central nervous system depression.
Aspiration into lungs may occur during vomiting which may result in lung injury.
Vapor may cause Trachaitis, Bronchitis, & Pulmonary edema.
Results have associated repeated, intentional exposure with permanent brain and nervous system damage.
Vapors may be harmful or fatal.

INGESTION:

Chronic exposure may cause liver and kidney damage.
May cause headaches, dizziness, anesthesia, and drowsiness.
Fatigue.
Vomiting.
May cause irritation to the gastrointestinal tract.
Aspiration may cause pulmonary edema and chemical pneumoniti.
Moderately irritating.
May produce central nervous system depression.
Moderately toxic and may be harmful if swallowed.
Burns to mouth, throat, and stomach.
Possible liver and kidney damage.

EYES:

Pre-existing eye disorders may be aggravated.
Moderately irritating.
Corneal injury may be severe.
Unpleasant deposits in eyes.

SKIN:

Repeated contact may cause skin irritation and dermatitus.
Pre-existing skin disorders may be aggravated.

RED OXIDE BAKE PRIMER	PAGE:	4
	DATE PREPARED:	FEB. 16, 1995
	NO:	41U-318

SKIN: (con't.)

Prolonged skin contact may result in the absorption of harmful amounts of material.

EMERGENCY AND FIRST AID PROCEDURES

EYES:

Flush eyes with large amounts of water for 15 minutes.
See a physician.
Seek medical attention immediately.

SKIN:

Wash exposed skin with soap and water.
See a physician.

INHALATION:

Remove to fresh air.
Preform artificial respiration if breathing has stopped.
See a physician.
Seek medical attention immediately.

INGESTION:

Do not induce vomiting.
Have conscious patient drink several glasses of water.
Seek medical attention immediately.
See a physician.

SECTION 7: REACTIVITY DATA

STABILITY:	**POLYMERIZATION:**
Yes	No
STABILITY CONDITIONS TO AVOID:	**POLYMERIZATION CONDITIONS TO AVOID:**
Avoid heat, flame, fire, and sparks. Under normal conditions, this material is stable.	Hazardous Polymerization will not occur.
INCOMPATIBILITY:	**HAZARDOUS DECOMPOSITION PRODUCTS:**
Strong Oxidixing Agents	Oxides of Carbon and Nitrogen
Heat or Flame — Permanganates	Carbon Monoxide
Nitric Acid — Sulfuric Acid	Toxic Vapors
Alkali Metals — Sodium Hydroxide	Phosphoric Oxide
Aldehydes — Mineral Acids	

RED OXIDE BAKE PRIMER	PAGE:	5
	DATE PREPARED:	FEB. 16, 1995
	NO:	41U-318

SECTION 8: SPILL OR LEAK PROCEDURES

STEPS FOR MATERIAL SPILLAGE:

Remove all ignition sources.
Ventilate the area.
Wear appropriate respirator and other protective clothing.
Contain large spills with dikes.
Pump to storage tanks if possible.
Absorb with an inert material.
Place in non-leaking container for disposal.
Flush area with water to remove trace residue.
Keep product out of sewers and watercourses.
Do not use Combustible Materials such as Sawdust.
Use foam to control vapors.
Toxic to fish.
Handling equipment must be grounded to prevent sparking.

WASTE DISPOSAL METHODS:

Landfill in accordance with Local, State, & Federal regulations.
Must be treated as a hazardous ignitable waste.

SECTION 9: SPECIAL PROTECTION INFORMATION:

RESPIRATORY PROTECTION: Self contained breathing apparatus	**VENTILATION:** Exhaust at point of use Explosion proof ventilation
PROTECTIVE GLOVES: Gloves impervious to solvents	**EYE PROTECTION:** Splashproof safety goggles

OTHER PROTECTIVE EQUIPMENT:

Eyewash station
Emergency shower
Use chemical resistant apron
Wear impervious clothing & boots for prolonged exposure

SECTION 10: SPECIAL PRECAUTIONS

REGULATORY DATA: UN/NA Number: UN 1263

Hazard Class: COMBUSTIBLE LIQUID	**Shipping Name:** PAINT

CERCLA Reportable Quantity: See Section 11

HANDLING AND STORAGE PRECAUTIONS:

Overheating may cause container to rupture.
Use explosion-proof equipment.
Keep containers closed when not in use.
Do not store near high heat or ignition.
Wash thoroughly after handling.

OTHER PRECAUTIONS:

Avoid prolonged breathing or contact with skin or eyes.
Do not cut, puncture, or weld near container.
Should be grounded or bonded to reduce static electricity.
Sudden release of hot organic chemical vapors or mists from process equipment operating at elevated temperatures or pressure or sudden ingress of air into vacuum equipment may result in ignition without the presence of obvious ignition sources.
Empty drums retain hazardous product residue.
Use non-sparking tools.

SECTION 11: SARA SECTION 313 TOXIC CHEMICALS

Chemical	CAS Number	Weight %	Rep. Qty.	Hazard	
				Acute	Chron.
Alkylolammonium Salt Sol'n.	MIXTURE	0.99	X	X	X
1,2,4-Trimethyl-benzene	95-63-6	0.99	X		X
Naphthalene	91-20-3	0.14	X		X
Cobalt	7440-48-4	0.03	X		X

SARA TITLE III COMPLIANCE:

This product contains the above toxic chemicals subject to the reporting requirements of SARA TITLE III EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW act of 1986 and 40 CFR 372.

DISCLAIMER

Every effort has been made to ensure that the safety information on this sheet is accurate, but because CHEMCOAT, INC. has no control over the condition under which the product will be used, liability is limited exclusively to replacement or refundof the purchased price of this product. Except as stated herein, there are no EXPRESSOR IMPLIED WARRANTIES INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY OR FINESS FOR A PARTICULAR PURPOSE. CHEMCOAT, INC. assumes no liability for injury or incidental or consequential damages arising out of the storage and handling or use of this product.