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September 2006

Environmental Technology Verification Report

EXEL Industrial, Inc.
Kremlin Airmix® Spray Gun

Prepared by

National Defense Center for Environmental Excellence

Operated by

Concurrent Technologies Corporation

for the

U.S. Environmental Protection Agency

Under Contract No. W74V8H-04-D-0005

with the U.S. Army Contracting Center of Excellence
via EPA Interagency Agreement No. DW2192190801

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The Environmental Technology Verification (ETV) Program has been established by the U.S. Environmental Protection Agency (EPA) to verify the performance characteristics of innovative environmental technologies across all media and report this objective information to the states, buyers, and users of environmental technology; thus, accelerating the entrance of these new technologies into the marketplace. Verification organizations oversee and report verification activities based on testing and quality assurance protocols developed with input from major stakeholders and customer groups associated with the technology area. ETV consists of six technology centers. Information about each of these centers can be found on the Internet at http://www.epa.gov/etv/.

EPA's ETV Program, through the National Risk Management Research Laboratory (NRMRL), Air Pollution Prevention and Control Division (APPCD) has partnered with Concurrent Technologies Corporation (CTC), through the National Defense Center for Environmental Excellence (NDCEE), to verify innovative coatings and coating equipment technologies for reducing air emissions from coating operations. Pollutant releases to other media are considered in less detail.

The following report describes the verification of the performance of EXEL Industrial, Inc.'s Kremlin Aimix® high transfer efficiency (TE) spray gun for wood finishing applications.

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Environmental Technology Verification Report

EXEL Industrial, Inc.
Kremlin Airmix® Spray Gun

Prepared by

Robert Fisher
Lynn Summerson

Of the
National Defense Center for Environmental Excellence

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Johnstown, PA 15904

Under Contract No. W74V8H-04-D-0005 (Task No. 0428, Subtask 3)
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EPA Project Officer:
Michael Kosusko
Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
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Foreword

The Environmental Technology Verification (ETV) Program has been established by the U.S. Environmental Protection Agency (EPA) to verify the performance characteristics of innovative environmental technologies across all media and report this objective information to the states, buyers, and users of environmental technology; thus, accelerating the entrance of these new technologies into the marketplace. Verification organizations oversee and report verification activities based on testing and quality assurance protocols developed with input from major stakeholders and customer groups associated with the technology area. ETV consists of six technology centers. Information about each of these centers can be found on the Internet at http://www.epa.gov/etv/.

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The following report describes the verification of the performance of EXEL Industrial, Inc.'s Kremlin Airmix® high transfer efficiency (TE) spray gun for wood finishing applications.

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Kremlin Airmix® Data Notebook (Available from *CTC* upon request)

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ETV JOINT VERIFICATION STATEMENT

TECHNOLOGY TYPE:	**HIGH TRANSFER EFFICIENCY (TE) LIQUID COATING SPRAY APPLICATION EQUIPMENT**
APPLICATION:	**LIQUID ORGANIC COATINGS APPLICATION IN WOOD FINISHING**
TECHNOLOGY NAME:	**Kremlin Airmix®**

COMPANY: **EXEL Industrial, Inc.**
POC: **Mr. John Patry – President**
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West Chicago, Il 60185
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The United States Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by substantially accelerating the acceptance and use of improved, cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations, stakeholder groups consisting of buyers, vendor organizations, and states, and with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The ETV Coatings and Coating Equipment Program (CCEP), one of six verification centers under the ETV Program, is operated by Concurrent Technologies Corporation (*CTC*) under the National Defense Center for Environmental Excellence (NDCEE), in cooperation with EPA's National Risk Management Research Laboratory. The ETV CCEP has recently evaluated the performance of innovative liquid coating spray application equipment intended for wood finishing applications. This verification statement provides a summary of the test results for the Kremlin Airmix® high transfer efficiency (TE) spray gun, manufactured by EXEL Industrial, Inc.

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VERIFICATION TEST DESCRIPTION

The ETV CCEP evaluated the pollution prevention capabilities of high TE liquid spray equipment. The test was conducted under representative factory conditions at *CTC*. It was designed to verify the environmental benefit of the high-TE spray gun with specific quality requirements for the resulting finish. The finish quality applied by the Airmix® was verified to be comparable to the finish quality obtained by three baseline high-volume, low-pressure (HVLP) spray guns. The environmental benefit of HVLP spray guns compared to conventional air spray equipment has previously been verified und the ETV Program. The results of the HVLP verification tests can be found on the EPA's ETV website (www.epa.gov/etv). If a high-TE spray gun cannot provide an acceptable finish while operating at efficiencies representative of HVLP spray guns, the end users may have a tendency to raise the input air pressure to meet their finishing requirements. However, these adjustments may reduce the environmental benefits of the high-TE spray gun. In earlier verification tests, HVLP guns were shown to improve TE by 18.9% to 63.9% when compared to conventional paint spray guns, depending on the coating sprayed. This improved TE resulted in a reduction of 16% to 40% of coating material use, emissions of volatile organic compounds (VOC) and hazardous air pollutants (HAP), and of solid waste generated. This verification test compared the TE of a high TE liquid spray gun against a baseline of HVLP guns, which could be subsequently used to qualify the environmental benefits provided by the Airmix® when compared to conventional air spray equipment.

In this test, the Airmix® high-TE spray gun was tested under conditions recommended by EXEL Industrial, Inc., the gun's manufacturer. Two targets were used. The first target consisted of 24 in. x 24 in. wood panel backboards that were covered with heavy duty aluminum foil and suspended in the spray booth by hooks. The second target consisted of 12 in. x 24 in. wood panels that were sealed and sanded and suspended in the spray booth by hooks. Three foil-covered backboards were coated in each of five runs for each gun to be used for TE analysis. One wood panel was coated in each of five runs for each gun to be used for finish quality analysis. The application pattern was consistent among each target type. The spray guns were triggered so that 6 in. (3 in. lead and 3 in. lag) of overspray were obtained for each pass. The application pattern for all guns also allowed 50% of the first and last pass to be either above or below the panel, respectively. The spray guns were mounted on a robotic translator to increase accuracy and repeatability of the test. The translator moved the spray gun horizontally and/or vertically. The TE improvement of the Airmix® spray gun over a HVLP gun baseline was verified using American Society for Testing and Materials (ASTM) method D 5286. The Airmix® and HVLP baseline guns were all pressure-feed guns. The finish quality of the Airmix® was determined to be comparable to the finish quality of the HVLP baseline and was able to meet the finish quality requirements of the test coating; thus, the TE values obtained for the Airmix® test are representative of the actual operation of the equipment and the TE comparison was deemed to be valid.

The details of the test, including a summary of the data and a discussion of results, may be found in Chapters 4 and 5 of "Environmental Technology Verification Report – EXEL Industrial, Inc. Kremlin Airmix® Spray Gun," which was published by *CTC*. Copies of this Verification Statement and the associated Verification Report are available at http://www.epa.gov/etv/verifications/vcenter6-16.html. Contact Robert J. Fisher of *CTC* at (814) 269-2702 to obtain copies of the Data Notebook

TECHNOLOGY DESCRIPTION

The Airmix® spray gun was tested as received from EXEL Industrial, Inc. The gun was equipped with a VX14 air cap and a 14-174+ fluid tip. The Airmix® is an improved version of an air assisted-airless spray gun design. The paint is delivered to the gun under moderate pressure, a specially designed fluid tip atomizes the pressurized paint, and a small amount of compressed air is used to shape the fan pattern. The vendor claims that the fan pattern achieved by this design exhibits a uniform density along the long axis of the pattern, allowing for a more consistent and controllable film build. Because the Airmix® spray gun is marketed to wood finishing applications, EXEL Industrial, Inc. selected a wood furniture finishing clear topcoat manufactured by Valspar called 35 Sheen Ecoplast E1.

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More information on the spray gun, including recommended air caps and fluid tips for various paint formulations, is available from EXEL Industrial, Inc. At the time of this verification test, the list price of the Airmix® spray gun and pressure pump was approximately $2,000.

VERIFICATION OF PERFORMANCE

The performance characteristics of the Airmix® spray gun include the following:

Environmental Factors

- Transfer Efficiency (TE): The TE was determined per ASTM D 5286. The following TEs and associated standard deviations were obtained for the conditions tested:

Spray Gun	Airmix®	HVLP #1	HVLP #2	HVLP #3
Average TE (%)	54.4	51.6	53.1	52.2
Std. Dev.	0.5	0.6	0.3	0.5

The Airmix® provided a higher TE than the three HVLP guns for all comparisons at 95% confidence interval.

Marketability Factors

- Air Flow: The air consumption data was obtained using a calibrated air flow meter. The following air flows and associated standard deviations were obtained during this test:

Spray Gun	Airmix®	HVLP #1	HVLP #2	HVLP #3
Average Air Flow (SCFM)	Gun - 3 Pump - 2	14[a]	9[a]	12[a]
Std. Dev.	0.0	0.0	0.0	0.0

[a] The air consumption of the pressure pump used for the three HVLP spray guns was not significant compared to the air consumption of the guns themselves.

- Dry Film Thickness (DFT): The DFT data was obtained per ASTM D 6132. Based on recommendations in Valspar's product data sheets for the 35 Sheen Ecoplast E1 topcoat, the target DFT was established at approximately 1.0 mil in one coat. DFTs for all tests were determined from multiple points measured on each finish quality panel. The following DFTs and associated standard deviations were obtained during this test:

Spray Gun	Airmix®	HVLP #1	HVLP #2	HVLP #3
Average DFT	1.1	1.2	1.2	1.2
Std. Dev.	0.1	0.1	0.1	0.1

- Gloss: The gloss was measured per ASTM D 523 at multiple points on each finish quality panel. The test method has a range of 0–100 gloss units. Since each coating has its own gloss target, it is important to achieve similar gloss measurements using each piece of application equipment. The following gloss measurements and associated standard deviations were obtained during this test:

Spray Gun	Airmix®	HVLP #1	HVLP #2	HVLP #3
Average Gloss	30	34	32	33
Std. Dev.	2	3	2	2

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- Visual Appearance: *CTC* personnel assessed the visual appearance of all finish quality panels. The intent of this analysis was to identify any obvious coating abnormalities that could be attributed to the application equipment. The visual appearance of the coating was found to be acceptable with no obvious visual abnormalities that would render the coating unacceptable for its intended application.

SUMMARY

The test results show that the Airmix® spray gun provides paint transfer efficiency higher than that of HVLP spray equipment while maintaining comparable finish quality. HVLP spray equipment has been shown during earlier verification testing to have significantly higher transfer efficiency than conventional paint spray guns, thereby reducing VOC/HAP emissions, paint usage rates, and solid waste generation. Hence, the Airmix® spray gun provides a significant environmental benefit when compared to conventional spray guns. As with any technology selection, the end user must select appropriate paint spray equipment for a process that can meet the associated environmental restrictions, productivity, and coating quality requirements.

Original signed on
9/26/06

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Sally Gutierrez
Director
National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency

Original signed on
10/2/06

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Robert J. Fisher
Manager
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Concurrent Technologies Corporation

NOTICE: EPA verifications are based on evaluations of technology performance under specific, predetermined criteria and appropriate quality assurance procedures. EPA and *CTC* make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end user is solely responsible for complying with any and all applicable federal, state, and local requirements. Mention of commercial product names does not imply endorsement.

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Acknowledgments

CTC acknowledges the support of all those who helped plan and implement the verification activities and prepare this report. In particular, a special thanks to Michael Kosusko, EPA ETV CCEP Project Manager, and Shirley Wasson, EPA ETV CCEP Quality Assurance Manager, both of EPA's National Risk Management Research Laboratory in Research Triangle Park, North Carolina.

CTC also expresses sincere gratitude to EXEL Industrial, Inc., the manufacturer of the Kremlin Airmix® spray gun, for their participation in, and support of this program and their ongoing commitment to improve organic finishing operations. In particular, *CTC* would like to thank Mr. John Patry, President of EXEL Industrial, Inc. and Mr. Michael Michalski, Regional Sales Manager with EXEL Industrial, Inc. EXEL Industrial, Inc.'s U.S. office is based in West Chicago, Illinois.

SI to English Conversions

SI Unit	English Unit	Multiply SI by factor to obtain English
°C	°F	1.80, then add 32
L	gal. (U.S.)	0.2642
m	ft	3.281
kg	lbm	2.205
kPa	psi	0.14504
cm	in.	0.3937
mm	mil (1 mil = 1/1000 in.)	39.37
m/s	ft/min	196.9
kg/L	lbm/gal. (U.S.)	8.345

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List of Abbreviations and Acronyms

ASTM	American Society for Testing and Materials
CCEP	Coatings and Coating Equipment Program
CTC	Concurrent Technologies Corporation
DEP	Department of Environmental Protection
DFT	dry film thickness
EPA	U.S. Environmental Protection Agency
ETV	Environmental Technology Verification
HAP	hazardous air pollutant
HVLP	high-volume, low-pressure
ID	identification
NDCEE	National Defense Center for Environmental Excellence
NIST	National Institute for Standards and Technology
P2	pollution prevention
PEA	performance evaluation audit
QA/QC	quality assurance/quality control
SCAQMD	South Coast Air Quality Management District
SCFM	standard cubic feet per minute
TCEQ	Texas Commission on Environmental Quality
TE	transfer efficiency
TNRCC	Texas Natural Resources Conservation Commission
TQAPP	Testing and Quality Assurance Project Plan
TSA	technical system audit
VOC	volatile organic compound

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Section 1
Introduction

1.1 ETV Overview

Through the Environmental Technology Verification (ETV) Pollution Prevention (P2) Innovative Coatings & Coating Equipment Program (CCEP) pilot, the United States Environmental Protection Agency (EPA) is assisting manufacturers in selecting more environmentally acceptable coatings and equipment to apply coating materials. The ETV program, established by the EPA as a result of the President's environmental technology strategy, *Bridge to a Sustainable Future*, was developed to accelerate environmental technology development and commercialization through third-party verification and reporting of performance. Specifically, this pilot targets coating technologies that are capable of improving organic finishing operations, while reducing the quantity of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) generated by coating applications. The overall objective of the ETV CCEP is to verify pollution prevention and performance characteristics of coatings and coating equipment technologies and to make the results of the verification tests available to prospective technology end users. The ETV CCEP is managed by Concurrent Technologies Corporation (*CTC*), located in Johnstown, Pennsylvania. *CTC*, under the National Defense Center for Environmental Excellence (NDCEE) program, was directed to establish a demonstration factory with prototype manufacturing processes that are capable of reducing or eliminating materials that are harmful to the environment. The demonstration factory finishing equipment was made available for this project.

The ETV CCEP is a program of partnerships among the EPA, *CTC*, the vendors of the technologies being verified, and a stakeholders group. The stakeholders group comprises representatives of end users, vendors, industry associations, consultants, and regulatory permitters.

The purpose of this report is to present the results of verification testing of the EXEL Industrial, Inc. Kremlin Airmix® pressure-feed spray gun, hereafter referred to as Airmix®, which is designed for use in wood finishing. This test compared the Airmix® against three high-volume, low-pressure (HVLP) spray guns using a clear topcoat from Valspar intended for wood furniture finishing applications. Analyses performed during these tests followed American Society for Testing and Materials (ASTM) methods or other standard test methods.

1.2 Potential Environmental Impacts

VOCs are emitted to the atmosphere from many industrial processes as well as through natural biological reactions. VOCs are mobile in the vapor phase, enabling them to travel rapidly to the troposphere where they combine with nitrogen oxides in the presence of sunlight to form photochemical oxidants. These photochemical oxidants are precursors to ground-level ozone or photochemical smog.[1] Many VOCs, HAPs, or the subsequent reaction products are mutagenic, carcinogenic, or teratogenic, (i.e., cause gene mutation, cancer, or abnormal fetal development).[2] Because of these detrimental effects, Titles I and III of the Clean Air Act Amendments of 1990 were established to control ozone precursors and HAP emissions.[2,3]

Painting operations contribute approximately 20% of stationary source VOC emissions. These operations also contribute to HAP emissions, liquid wastes, and solid wastes. End users and permitters often overlook these multimedia environmental effects of coating operations. New technologies are needed and are being developed to reduce the total generation of pollutants from coating operations. However, the emerging technologies must not compromise coating performance and finish quality.

*CT*C's testing equipment is located in a demonstration factory that was established under the NDCEE program. This equipment includes full-scale, state-of-the-art organic finishing equipment, as well as the laboratory equipment required to test and evaluate organic coatings. The equipment and facilities have been made available for this program for the purpose of testing and verifying the abilities of finishing technologies.

1.3 Technology Description

The Airmix® was developed to reduce air pollution that typically results from organic finishing operations by improving paint transfer efficiency (TE). Many current regulations require the use of HVLP spray guns or spray equipment that is at least as efficient as HVLP

EXEL Industrial, Inc. proposes that the Airmix® can provide a high TE, comparable to HVLP spray guns. That high TE leads to a reduction in paint usage, VOC and HAP emissions, solid waste disposal, and spray booth maintenance costs. Reduced overspray and bounce-back provide a cleaner work environment with improved operator visibility.

1.4 Technology Testing Process

Technology focus areas were selected based on input from the ETV CCEP stakeholders group and market research. Upon initiating agreements with interested vendors, a draft Generic Verification Protocol for high TE spray equipment was developed by *CTC*. *CTC*, with significant input from the vendors, then developed a technology-specific Testing and Quality Assurance Project Plan (TQAPP) for each piece of equipment being verified. After the vendor concurred with, and the EPA and *CTC* approved, the TQAPP, *CTC* personnel performed the verification test. The Verification Statement that is produced as a result of this test may be used by the technology vendor for marketing purposes, or by end users selecting high TE spray equipment. The Verification Statement for this product is included on pages v–viii of this report.

Organic finishing technologies that demonstrated the ability to provide environmental advantages were reviewed and prioritized by the ETV CCEP stakeholders group. The stakeholders group is composed of coating industry end user and vendor association representatives, end users, vendors, industry consultants, and state and regional technical representatives. The stakeholders group reviewed the pollution prevention potential of each candidate technology and considered the interests of industry. High TE spray equipment was found to have a large pollution prevention potential, could be widely used by industry in organic finishing activities, and could potentially satisfy the HVLP equivalent alternatives allowance provided by many regulating agencies and government specifications. As a result, High TE spray equipment received a high ranking by the Stakeholders.

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1.5 Test Objectives and Approach

The testing was performed according to the EXEL Industrial Kremlin Airmix® TQAPP. This project was designed to verify that the Airmix® is capable of providing the end user with a pollution prevention benefit and an acceptable quality finish that is comparable or better than HVLP spray equipment. This project supplies the end users with the best available, unbiased technical data to assist them in determining whether the Airmix® meets their needs. The quantitative pollution prevention benefit, in terms of improved TE, depends on innumerable factors that are often unique to each coating production line. Attempting to verify every possible combination of these factors is unrealistic. For this verification test, a specific combination of these factors was selected by *CTC*, EPA, EXEL Industrial, Inc., and the ETV CCEP stakeholders. The data presented in this report are representative only of the specific conditions tested; however, the test design represents an independent, repeatable evaluation of the pollution prevention benefits and performance of the technology. To determine the environmental benefit, the Airmix®'s TE is quantitatively and qualitatively compared to a three-gun, HVLP baseline (see Section 4). The HVLP guns used for this verification test were also pressure-feed.

All processing and laboratory analyses were performed at *CTC* facilities. TE was calculated to determine the relative pollution prevention benefit of the technology. Dry film thickness (DFT), gloss, and visual appearance were evaluated to verify finish quality. The finish quality of the HVLP baseline panels was also evaluated to validate the comparability of the TE data.

1.6 Performance and Cost Summary

This verification has quantitatively shown that the Airmix® is capable of providing an environmental benefit equivalent or better than HVLP guns (see Table 1). This environmental benefit was quantified through the ability of the Airmix® to apply a coating at the same or higher TE. This verification test has also shown that the Airmix® is capable of providing the end user with an acceptable quality finish. The increased TE reduces paint usage and solid waste generation. The reduction in paint usage translates into a reduction in VOC and HAP emissions. The extent that emissions and wastes are reduced depends on each individual application, which must be determined on a case-by-case basis.

TE is defined as the percentage of the paint solids sprayed that actually adhere to the substrate. This test was designed to determine whether the Airmix® was capable of meeting or exceeding the efficiency of three HVLP spray guns. The test utilized wood panels for finishing quality and wood panels wrapped with aluminum foil for TE measurement. A wood furniture clear topcoat was used for both the Airmix® and HVLP baseline tests. Each spray gun completed five runs, with each run consisting of three TE foils and one wood panel. Table 1 summarizes the results for TE, air flow, DFT, gloss, and visual appearance.

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Table 1. Verification Results for the Airmix® and HVLP Baseline

Factor	Target	Results	
		Airmix®	HVLP (ave. of 3 guns)
Transfer Efficiency[a] (%)	Equivalent or better than the HVLP baseline	54.4	52.3
Air Flow (SCFM)	Minimal	3 – 5	12
Dry Film Thickness (mil)	Approximately 1 mil	1.1	1.2
Gloss, gloss units	Comparable to the HVLP baseline	30	33
Visual Appearance	No significant defects	No defects	No defects

[a] Note that the TE for the Airmix® is better than the average and all individual HVLP data. In addition, the DFT and gloss are comparable.

The capital costs of high TE spray guns are typically lower than HVLP spray guns. At the time of this verification test, the list price of the Airmix® system (i.e., spray gun and high-pressure fluid pump) was approximately $2,000, and the HVLP guns used for the baseline testing ranged in list price from $450 - $550 (gun only). Pressure-feed spray guns can be used with multiple fluid delivery systems (e.g., pressurized paint pots, low-pressure fluid pumps, etc.), which increases the cost of an HVLP system by another $500 - $2,000. The operating costs of the Airmix® and HVLP guns are similar, except that the Airmix® consumes less compressed air at lower pressures than the HVLP guns.

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Section 2
Description of the Technology

2.1 Technology Performance, Evaluation, and Verification

The overall objectives of this verification study are to verify pollution prevention characteristics and performance of coating equipment technologies and to make the results of the verification tests available to the technology vendor for marketing to prospective technology end users. The Airmix® is designed for use in wood finishing applications. The combination of the fluid tip and air cap determines the quality of the finish and the productivity potential. For this verification study, the Airmix® used a pressure-feed system, which utilized a fluid pump to deliver the coating to the gun at 380 psig. The HVLP spray guns used a similar pressure-feed system, but the coating was delivered to the spray guns at between 30-40 psig. A wood furniture finishing clear topcoat, 35 Sheen Ecoplast E1 manufactured by Valspar, was used for both the Airmix® and HVLP baseline tests.

CTC, the independent, third-party evaluator, worked with the vendor of the technology and the EPA throughout verification testing. *CTC* prepared this verification report and was responsible for performing the testing associated with this verification.

2.2 The Airmix® Test

This verification test is based on the ETV CCEP EXEL Industrial Kremlin Airmix® and the Valspar 35 Sheen Ecoplast E1 HVLP Baseline TQAPPs, which were reviewed by the EPA and the vendor. EXEL Industrial, Inc., the manufacturer of the Airmix®, worked with *CTC* to identify the optimum performance settings for the gun. EXEL Industrial, Inc. had determined the parameters through tests that their personnel conducted at their facility and at *CTC*'s facility in Johnstown, Pennsylvania. *CTC* personnel used this data to optimize the setup of the Airmix® prior to the actual verification test. Certain parameters used in the setup of the Airmix® spray gun were utilized to establish a basis for optimization f or the HVLP spray guns. *CTC* personnel used these parameters and the manufacturers' documentation to optimize the setup of the HVLP spray guns. Preliminary TQAPPs were generated using the vendor supplied information and were submitted to EPA for review of content. Following review by EPA and incorporation of their comments, the vendor was given the opportunity to comment on the specifics of the TQAPPs. Any information pertinent to maintaining the quality of the study was incorporated into the TQAPPs. A final draft of the TQAPPs were reviewed by the vendor and technical peer reviewers then approved by the EPA and *CTC* prior to testing.

Testing was conducted under the direction of *CTC* personnel, with a representative from EXEL Industrial, Inc. present during a portion of the testing. The EXEL Industrial, Inc. representative aided *CTC* in the initial Airmix spray gun setup, including making suggestions as to which fluid tip, air and fluid pressures to use. However, during the actual verification test, the EXEL Industrial, Inc. representative served only as an observer.

All information gathered during verification testing was analyzed, reduced, and documented in this report. TE and finish quality measurements of the Airmix® and the relative TE comparison to an HVLP baseline were the primary objectives of this report. The data comparison highlights the pollution prevention benefit of the Airmix® spray gun, as well as its ability to provide the required finish quality. A portion of the test data has been quality audited by EPA and the *CTC* Quality Assurance Officer to ensure the validity of the data.

2.3 Airmix® Spray Application Equipment

Pressure-feed systems consist of a fluid pump and a fluid hose capable of handling the required pressures. The fluid pumps are designed to maintain a relatively constant paint flow rate to the spray guns during operation. The Airmix®, a modified air-assisted airless spray gun, operates at fluid pressures somewhat higher than typical HVLP spray guns. However, the fluid pressure is significantly less than a typical airless spray gun.

2.3.1 Applications of the Technology

The Airmix® is relatively universal in its applications, with some applications obtaining better results. The Airmix® can be used for many applications; however, a wood finishing application was the subject of this verification test. Wood finishing operations use the Airmix® because it is a nearly a drop-in substitute for conventional and HVLP spray guns, requires less air flow, is capable of high production rates, and has comparable maintainability and is interchangeable with other spray guns.

2.3.2 Advantages of the Technology

The Airmix® is designed to reduce VOC emissions that typically result from spray painting operations by increasing paint TE. HVLP equipment use has been legislated as a requirement in many states, such as, California South Coast Air Quality Management District's (SCAQMD) Rules 1151 and 1145, the Texas Commission on Environmental Quality (TCEQ), Texas Administrative Code 30 TAC 115.422, and the Pennsylvania Department of Environmental Protection's (DEP) Title 25, Section 129.52. Similar requirements have been adopted in legislation throughout the United States. High efficiency spray guns, like the Airmix®, have the potential for being recognized as equivalent to HVLP for regulatory purposes and, therefore, eligible for use in traditionally HVLP-only areas.

2.3.3 Limitations of the Technology

If the Airmix® is accepted by the appropriate local regulatory agencies as compliant with the applicable regulatory requirements, there are no apparent limitations on the Airmix® for wood finishing or any other organic finishing operations. However, some agencies may require approval prior to using the Airmix® in their jurisdiction. The use of the Airmix® may be limited in areas were approval is not granted.

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2.3.4 Technology Deployment and Costs

The Airmix® has many potential applications, with few limitations on its distribution throughout the various finishing industries. The use of a portable fluid pump and reduced air consumption enhances its usability. The Airmix® is cost effective because it is similar in capital and operating costs to HVLP; however, economic benefits are realized through reduced paint usage as a result of improved TE and finish quality.

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Section 3
Description and Rationale for the Test Design

3.1 Description of Test Site

The testing of the Airmix® was conducted at the Organic Finishing Line, in *CTC*'s Environmental Technology Facility Demonstration Factory. The layout of the Organic Finishing Line is shown in Figure 1.

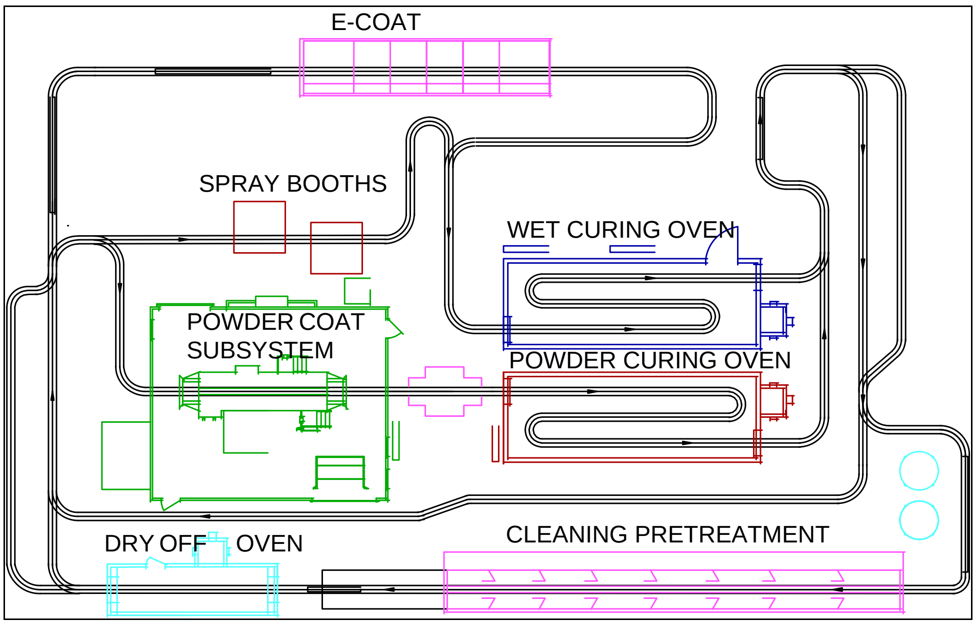

Figure 1. Organic Finishing Line at *CTC*

The finishing quality test panels were provided to *CTC* by EXEL Industrial, Inc. The panels were sealed and mechanically sanded prior to shipment to *CTC*. The TE foils were wrapped on wood panels similar in shape and size to the finish quality panels. The aluminum foil sheets were cut, weighed and stored until needed for testing.

The spray booths are capable of producing air velocities of over 0.6 m/s (120 ft/min). The three stages of dry filters are equipped with a gauge that monitors the pressure drop across the filter bank. Air supply lines for operating the guns and gauge readouts are located at the spray booths and were used for this test. A linear robotic translator was used to move the spray guns vertically and horizontally when applying the coatings. The computer-controlled translator system was used to remove any operator bias.

CTC's Environmental Laboratory maintains extensive state-of-the-art facilities that are dedicated to coating technology evaluations and can also measure and characterize products, processes, and waste specimens resulting from factory activities.

3.2 Evaluation of Airmix® Performance

The overall objectives of the verification study were to establish the pollution prevention benefit of the Airmix®, relative to the TE of HVLP spray guns, and to determine the effectiveness of the Airmix® in providing an acceptable coating finish. Section 4 discusses the details of the HVLP baseline. Finish quality cannot be compromised in most applications, despite the environmental benefit that may be achieved; therefore, this study has evaluated both of these crucial factors. Results from the Airmix® verification testing will benefit prospective end users by enabling them to better determine whether the Airmix® will provide a pollution prevention benefit while meeting the finish quality requirements for their application.

3.2.1 Test Operations at CTC

The TQAPPs for the Airmix® and HVLP baseline identified that testing would consist of foils used for TE and wood panels used for finish quality. The statistical analyses for all response factors were performed using a Microsoft Excel spreadsheet. The spreadsheet was programmed to calculate values like standard deviation, confidence interval, and relative percent difference.

The TE foils measured approximately 91.4 cm by 91.4 cm (36 in. x 36 in.). All foils were wrapped onto wood panels measuring 61.0 cm by 61.0 cm (24 in. x 24 in.), which were suspended in the spray booth using two hooks. The foil covered panels were carried by hand to and from the booth. Once coated, the foils were carefully moved to a location outside the spray booth and allowed to air dry for at least four days.

The finish quality panels used for verification testing were flat, wood panels, sealed and sanded. The wood panel dimensions were 30.5 cm by 61.0 cm (12 in. x 24 in.). The wood panels were also suspended in the spray booth using two hooks. Once the panels were coated, they were moved to a location outside the spray booth by hand and allowed to air dry for at least four days. Figure 2 illustrates the application pattern used both the TE foils and the finish quality wood panels.

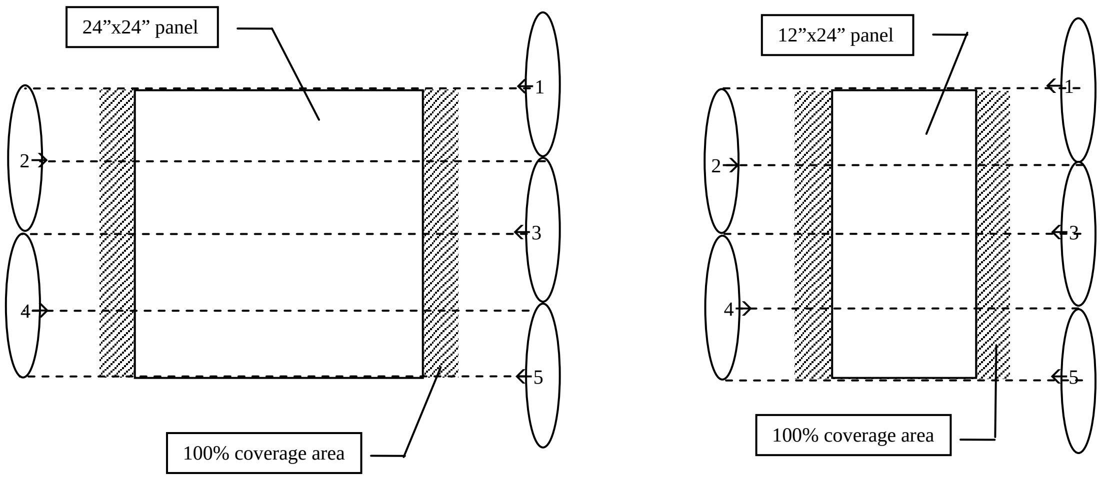

Figure 2. Application Pattern Diagrams

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The Valspar clear topcoat used for this test was mixed 10:1 with the Valspar reducer. The mixed clear topcoat had an estimated pot life of 4 hours. A single batch of coating was mixed for each gun. Samples were taken just prior to each of the five runs to measure the temperature, viscosity, percent solids, and density.

The Airmix® and HVLP spray guns were mounted on a nylon arm extending from the carrier plate of the robotic translator, which was computer-controlled. The computer also controlled the pneumatic cylinder that triggered the gun. The product data sheets for the Airmix® and baseline HVLP spray guns can be found in Appendix A of the Kremlin Airmix® Data Notebook. The air traveled from a quick disconnect at the shop line to the air inlet to the spray gun using 9.5-mm (3/8-in.) inside diameter air hose. The operating parameters for the spray guns were based on manufacturer's recommendations (see Sections 4 and 5).

The booth air velocity was measured in close proximity to the panels. The air velocity through the booth was measured between 0.6 and 0.7 m/s (~120 and 140 ft/min). The velocity measured near the panels may vary greatly because of the disruption of the air currents by the rack and panels. The pressure drop across the filters was also checked prior to each run and at the end of the test. To ensure that the filter bank system was functioning properly, a pressure drop across the filter bank greater than 1.0 cm of water indicated that the system required service.

Once the foils/panels were in position, all pertinent measurements taken, and equipment adjustments made, the computer system was used to activate the motors that drove the linear motion translators and the pneumatic cylinder that triggered the gun. The panels were automatically sprayed using vertical overlap of the fan pattern. The foils and panels were air dried in the factory for at least four days prior to being transferred to the laboratory for analysis.

Fifteen foils and five wood panels were coated by each of the four spray guns. TE was determined using the average weight gain of the foils, per the ASTM standard. Coated wood panels were analyzed for DFT, gloss, and visual appearance.

3.2.2 Test Sampling Operations at *CTC*'s ETF facility

Foils and panels were used in this project. The foils were marked with a permanent marker prior to checking their initial weight. Wood panels were also marked with a unique alphanumeric identifier. The experimental design used 3 foils and 1 wood panel in each of five runs per gun.

The laboratory analyst recorded the date and time of each run and the time at which each measurement was taken. After curing, the foils and panels were transferred to the laboratory for analysis.

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3.2.3 Sample Handling and Quality Assurance/Quality Control Procedures

Each batch of test coating was mixed in the laboratory by a laboratory analyst. The components were all taken from the same production batches. All coating batches were mixed to the same ratio recommended by the coating manufacturer. The temperature, viscosity, density, VOC content, and percent solids analyses were performed. Data were logged on bench data sheets, precision and accuracy data were evaluated, and results were recorded on the ETV CCEP Quality Assurance/Quality Control (QA/QC) Data forms. Another laboratory staff member reviewed the data sheets for QA.

After curing, the laboratory analyst logged the coated samples panels into the laboratory system, giving each a unique laboratory identification (ID) number. The analyst who delivered the test panels to the laboratory completed a custody log that indicated the sampling point IDs, sample material IDs, quantity of samples, time and date of testing, and the analyst's initials. The product evaluation tests were also noted on the custody log, and the laboratory's sample custodian verified this information. The analyst and the sample custodian both signed the custody log, indicating the transfer of the samples from the processing area to the laboratory analysis area. The laboratory sample custodian logged the test panels into a bound record book, stored the test panels under the appropriate conditions, and created a work order to initiate testing.

Each apparatus used to assess the quality of a coating on a test panel is set up and maintained according to the manufacturer's instructions and/or the appropriate reference methods. Actual sample analysis was performed only after setup was verified per the appropriate instructions. As available, samples of known materials, with established product quality, were used to verify that a system was working properly.

3.3 Data Reporting, Reduction, and Verification Steps

3.3.1 Data Reporting

Raw data were generated and collected manually and electronically by the analysts at the bench and/or process level. Process data were recorded on process log sheets during factory operations. The recorded data included original observations, printouts, and readouts from equipment for sample, standard, and reference QC analyses. Data was checked twice by the analyst or operator before being recorded. The analyst processed raw data and was responsible for reviewing the data according to specified precision, accuracy, and completeness policies. Raw data bench sheets, calculations, and data summary sheets for each sample batch were kept together. The data transcribed into electronic format was reviewed by a second staff member.

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3.3.2 Data Reduction and Verification

A preliminary data package was assembled by the primary analyst(s). The data package was reviewed by a different analyst to ensure that tracking, sample treatment, and calculations were correct. A preliminary data report was prepared and submitted to the Laboratory Manager, who then reviewed all final results for adequacy to project QA objectives. After the EPA reviewed the results and conclusions from the Technical Project Manager, the Verification Statement/Verification Report was written, sent to the vendor for comment, passed through technical peer review, and submitted to EPA for approval. The Verification Statement was disseminated by permission of the vendor.

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Section 4
Reference Data

4.1 HVLP Parameter Development

Each of the HVLP guns was set up in the same apparatus as the Airmix®. The HVLP guns were set at 17.8 cm (7 in.) from the surface of the targets, and their air adjustments were set to achieve a 30.5 cm (12 in.) fan pattern at the target. The Airmix® was set at 20.3 cm (8 in.) from the targets with its air adjustment wide open in order to maintain the same 30.5 cm (12 in.) fan pattern as the HVLP spray gun. The HVLP spray gun parameters were optimized by *CTC* personnel according to the manufacturers' documented procedures.

The fan pattern, application pattern, and horizontal gun speed were fixed to establish the basis for comparison. Using information from the gun manufacturers' product data sheets, a trial-and-error method was used to obtain a wet film thickness of approximately 3 mils, which corresponds to a dry film thickness of 1.0 mil. A wet film thickness gauge was used during this process. The fluid pressure delivered to the guns was the primary method of adjustment. If the wet thickness obtained on a practice specimen was less than 3 mils, then the fluid pressure was increased, and vice-versa. Table 2 lists the configuration and setup conditions the three HVLP guns.

Table 2. HVLP Baseline Guns Configuration and Setup

HVLP Gun	**#1**	**#2**	**#2**
Air Cap	192-321	VLP5	95AP
Fluid Tip (mm)	1.4 mm	1.4 mm	1.4 mm
Fluid Pressure (psig)	40	30	32
Fluid Flow Rate (g/min)	658	567	601
Fluid Adjustment	Wide Open	Wide Open	Wide Open
Fan Adjustment	1 full turn in	½ turn in	1 ¼ turn in
Fan Pattern (cm)	30.5	30.5	30.5
Number Passes	5	5	5
Number Coats	1	1	1
Distance to Target (cm)	17.8	17.8	17.8
Horizontal Travel Distance per Pass (cm) [Foil / Wood Panels]	106.7 / 76.2	106.7 / 76.2	106.7 / 76.2
Spray Distance per Pass (cm) [Foil / Wood Panels]	76.2 / 45.7	76.2 / 45.7	76.2 / 45.7
Vertical Drop Between Passes (cm)	15.2	15.2	15.2
Horizontal Gun Speed (cm/s)	61.0	61.0	61.0
Paint Temperature (°C)	21.0	21.5	20.6
Viscosity (s)	29.4	29.7	29.3
Density (g/L)	961	958	960
Weight % solids (%)	33.9	34.1	34.0

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4.2 HVLP Results

The data in Table 3 shows the operational characteristics obtained for each of the three HVLP guns. The data indicate that finish quality was not sacrificed to maximize TE. Therefore, the comparison of the TE data from the HVLP baseline and the Airmix® is valid.

Table 3. HVLP Baseline Guns Response Factor Results

HVLP Gun	#1	#2	#3
Dynamic Input Air Pressure (psig)	40	40	50
Dynamic Output Air Pressure (psig)	Horn – 5 Center – 10	Horn – 7 Center – 10	Horn – 8 Center – 10
Air Flow (scfm)	14	9	12
Average DFT (mils)	1.2	1.2	1.2
Average Gloss (units)	34	32	33
Visual Appearance	ND[a]	ND	ND
Average TE (%)	51.6	53.1	52.2

[a] ND – No Defects

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Section 5
Results and Discussion

This section presents an overview of the verification test results, including an analysis of environmental benefits of the Airmix® spray gun and a summary of data quality. Data generated during this test are being compared to an HVLP baseline in order to establish the relative environmental benefit of the product. An explanation of the manner in which the data were compared is provided. Subsequently, the actual tabulation, assessment, and evaluation of the data are presented. The accuracy, precision, and completeness data, the process and laboratory bench sheets, raw data tables, and calculated data tables are included in Section 5 of the Kremlin Airmix® Data Notebook.

5.1 Potential Environmental Benefits and Vendor Claims

The primary purpose of this test is to verify that the Airmix® spray gun provides a TE and finish quality comparable or better than and HVLP baseline. EXEL Industrial, Inc. makes no claims on the absolute TE obtainable by the Airmix®.

5.2 Selection of Test Methods and Parameters Monitored

CTC, the ETV CCEP partner organization, performed the laboratory testing required for this verification test. *CTC* possesses the skills, experience, and most of the laboratory equipment required by this verification study. The ETV CCEP selected test procedures, process conditions, and parameters to be monitored based on their correlation to, or impact on, TE or finish quality.

5.2.1 Process Conditions Monitored

The conditions listed below were documented to ensure that there were no significant fluctuations in conditions during the Airmix® verification test and the HVLP baseline tests. No significant differences were recorded. A more detailed discussion of the data is presented in Section 3 of the Kremlin Airmix® Data Notebook.

- Coating area relative humidity ranged from 22.3% to 28.4%
- Curing area relative humidity ranged from 21.8% to 28.6%
- Coating area temperature ranged from 22.0 to 23.3 °C
- Curing area temperature ranged from 21.0 to 24.8 °C
- Spray booth air velocity ranged from 0.6 to 0.7 m/s
- Panel temperature ranged from 22.2 to 22.8 °C

5.2.2 Operational Parameters

A number of operational parameters were also monitored because they often vary from gun to gun. These parameters were documented to explain TE and finish quality improvements over HVLP guns, and to identify parameters that are likely to change when replacing HVLP guns with the Airmix®. The dynamic input air pressures varied from gun to gun. The Airmix® was operated at 10 psig, and the three HVLP baseline guns

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were run at 40, 40, and 50 psig, respectively. The distance to target was maintained at 17.8 cm for all HVLP spray guns, and 20.3 cm for the Airmix®, in order to maintain the same fan pattern size for all four spray guns. The fan pattern obtained from each gun was maintained at 30.5 cm. The horizontal gun speed was maintained at 61.0 cm/s for all spray guns. A more detailed discussion of the data is presented in Section 3 of the Kremlin Airmix® Data Notebook.

5.2.3 Parameters/Conditions Monitored

Other parameters and conditions were monitored to ensure that they remained relatively constant throughout Airmix® verification testing and HVLP baseline testing. Constancy was desired in order to reduce the number of factors that could significantly influence TE calculations and evaluation of finish quality. Most of these parameters were relatively constant within each test and from gun to gun. Table 4 lists the configuration and setup conditions of the Airmix® gun.

Table 4. Airmix® Configuration and Setup

Air Cap	VX14
Fluid Tip (mm)	14-174+
Fluid Pressure (psig)	380
Fluid Flow Rate (g/min)	468
Fluid Adjustment	N/A
Fan Adjustment	Wide Open
Fan Pattern (cm)	30.5
Number Passes	5
Number Coats	1
Distance to Target (cm)	20.3
Horizontal Travel Distance per Pass (cm) [Foil / Wood Panels]	106.7 / 76.2
Spray Distance per Pass (cm) [Foil / Wood Panels]	76.2 / 45.7
Vertical Drop Between Passes (cm)	15.2
Horizontal Gun Speed (cm/s)	61.0
Paint Temperature (°C)	21.4
Viscosity (s)	29.9
Density (g/L)	960
Weight % solids (%)	34.0

5.3 Overall Performance Evaluation of the Airmix® Spray Gun

The DFT and gloss obtained using the Airmix® are both within 10% of the HVLP baseline averages. Therefore, the finish quality of the Airmix® is determined to be comparable to the finish quality of the HVLP baseline and was able to meet the finish quality requirements of the test coating; thus, the TE values obtained for the Airmix® test are representative of the actual operation of the equipment. The DFT and gloss of the HVLP baseline panels are considered to be representative of the actual operation of the equipment, and the TE values obtained from the HVLP baseline are determined to be representative of the HVLP guns tested. The DFT and gloss

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values obtained for the HVLP baseline are similar to those for the panels from the Airmix® test; therefore, the comparison of the TE data from the Airmix® and the HVLP baseline is valid.

This test determined that the Airmix® provided a direct environmental benefit, in terms of higher TE than the baseline HVLP spray guns. Tables 3 and 5 show that the Airmix® achieved a higher transfer efficiency than each of the individual HVLP guns, while maintaining a finish quality similar to the baseline. The increased TE leads to reduced air emissions, paint usage, and solid waste generation. In addition, reduced Dynamic Input Air Pressure and Air Flow provide an indirect environmental benefit since they represent lower energy usage. A 95% confidence interval is being utilized to statistically evaluate the data. Section 5 of the Kremlin Airmix® Data Notebook shows that the Airmix® is statistically better than the individual HVLP guns and the HVLP average for all combinations.

The test results indicate that the Airmix® was able to provide an environmental benefit equivalent to or better than an HVLP baseline and maintain the required finish quality of the applied coating.

5.3.1 Response Factors

Responses to the process conditions and parameters were considered to be important due to their effect on, or ability to evaluate, TE and finish quality; therefore, these responses were documented, and the appropriate tests required to identify these characteristics were performed. Any response that was characterized using laboratory equipment followed accepted industrial and ASTM standards. Table 5 presents the average results for the response factors for the Airmix® spray gun. A more detailed discussion of the data is presented in Section 3 of the Kremlin Airmix® Data Notebook.

Table 5. Airmix® Response Factor Results

Dynamic Input Air Pressure (psig)	10
Air Flow (scfm)	3-5
Average DFT (mils)	1.1
Average Gloss (units)	30
Visual Appearance	ND[a]
Average TE (%)	54.4

[a] ND – No Defects

The DFT and gloss data indicate that the coating finish applied by the Airmix® is comparable to the HVLP baseline based on the intended application of the test coating.

The TE for each gun is a representation of the exact verification test conditions, which includes the paint that was sprayed while the guns were outside the boundaries of the panels. The calculation of the TE uses the total amount of paint sprayed and the weight gain of the coated panels, both determined through gravimetric weight measurements.

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5.3.2 Assessment of Laboratory Data Quality

The Airmix® TE results were compared to the HVLP baseline data. The Airmix® results for DFT and gloss were compared to the HVLP baseline data. The information gathered was considered to be statistically valid and significant such that the advantages and limitations of Airmix®, per these test conditions, could be identified with a high degree of confidence. It can be stated with greater than 95% confidence that the Airmix® provided a higher TE than the HVLP baseline.

5.4 Technology Data Quality Assessment

Accuracy, precision, and completeness goals were established for each process parameter and condition of interest, as well as each test method used. The goals are outlined in the TQAPP.

All laboratory analyses and monitored process conditions/parameters met the accuracy, precision, and completeness requirements specified in the TQAPP, except for the deviations listed in Section 2 of the Kremlin Airmix® Data Notebook. These deviations did not significantly affect the results and conclusions of this test. The definition of accuracy, precision, and completeness, as well as the methodology used to maintain the limits placed on each in the TQAPP, are presented below. The actual accuracy, precision, and completeness values, where applicable, are presented in Section 5 of the Kremlin Airmix® Data Notebook.

5.4.1 Accuracy, Precision, and Completeness

Accuracy is defined as exactness of a measurement; i.e., the degree to which a measured value corresponds with that of the actual value. To ensure that measurements were accurate, standard reference materials, traceable to the National Institute of Standards and Technology (NIST), were used for instrument calibration and periodic calibration verification. Accuracy was determined to be within the expected values listed in the TQAPP. Accuracy results are located in Section 5 of the Kremlin Airmix® Data Notebook.

Precision is defined as the agreement of two or more measurements that have been performed in exactly the same manner. Ensuring that measurements are performed with precision is an important aspect of verification testing. The exact number of test parts coated is identified in the TQAPP, and the analysis of replicate test parts for each coating property at each of the experimental conditions occurred by design. Precision was determined to be within the expected values listed in the TQAPP. All precision data are listed in Section 5 of the Kremlin Airmix® Data Notebook.

Completeness is defined as the number of valid determinations and expressed as a percentage of the total number of analyses conducted, by analysis type. *CTC*'s laboratory was striving for at least 90% completeness. Completeness is ensured by evaluating precision and accuracy data during analysis. All laboratory results for finish quality were 100% complete. All results were reviewed and considered usable for statistical analysis. Completeness results are shown in Section 5 of the Kremlin Airmix® Data Notebook.

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5.4.2 Audits

The ETV CCEP QA Officer conducted an internal technical systems audit (TSA) and a performance evaluation audit (PEA) of the Airmix® verification test. Also, prior to the certification of the data, the ETV CCEP QA Officer audited a portion of the data generated during the Airmix® test.

The TSAs verified that *CTC*'s personnel were adequately trained and prepared to perform their assigned duties, and that routine procedures were adequately documented. The ETV CCEP QA Officer examined copies of test data sheets that recorded information such as process conditions, spray booth conditions, equipment setup, and coating preparation and reviewed laboratory bench sheets showing data for coating pretreatment weights, densities, and percent nonvolatile matter.

The ETV CCEP QA Officer audit found that the Airmix® test was conducted in a manner that provides valid data to support this Verification Statement/Report. Several deviations from the original TQAPP were identified by the TSA and PEA and are discussed in Section 2 of the Kremlin Airmix® Data Notebook.

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Section 6
Vendor Forum

[EXEL Industrial, Inc. has been offered the opportunity to comment on the findings of this report. Their comments are presented in this section of the report and reflect their opinions. *CTC* and EPA do not necessarily agree or disagree with the vendor's comments and opinions.]

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Section 7
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