September 2003

Environmental Technology Verification Report

ANEST IWATA Corporation LPH400-LV HVLP 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. DAAE30-98-C-1050

with the U.S. Defense Contract Command – Washington (DCC-W)

via EPA Interagency Agreement No. DW2193939801

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Notice

This document was prepared by Concurrent Technologies Corporation (*CTC*) under Contract No. DAAE30-98-C-1050 with the U.S. Defense Contract Command – Washington (DCC-W), Task N.306, SOW Task 4. The U.S. Environmental Protection Agency (EPA) and the U.S. Army are working together under EPA Interagency Agreement No. DW2193939801. This document has been subjected to EPA's technical peer and administrative reviews and has been approved for publication. Mention of corporation names, trade names, or commercial products does not constitute endorsement or recommendation for use of specific products.

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ANEST IWATA Corporation LPH400-LV HVLP Spray Gun

Prepared by

Brian D. Schweitzer
Jacob E. Molchany
Robert J. Fisher
Lynn A. Summerson

of the
National Defense Center for Environmental Excellence

Operated by
Concurrent Technologies Corporation
Johnstown, PA 15904

Under Contract No. DAAE30-98-C-1050 (Task N.306, SOW Task 4)
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EPA Project Officer:
Michael Kosusko
Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
Research Triangle Park, NC 27711

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/.

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

The following report describes the verification of the performance of the ANEST IWATA Corporation's LPH400-LV HVLP spray gun for automotive refinishing applications.

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LPH400-LV Data Notebook (Available from *CTC* upon request)

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV JOINT VERIFICATION STATEMENT

TECHNOLOGY TYPE:	**HIGH VOLUME, LOW PRESSURE (HVLP) LIQUID COATING SPRAY APPLICATION EQUIPMENT**
APPLICATION:	**LIQUID ORGANIC COATINGS APPLICATION IN AUTOMOTIVE REFINISHING**
TECHNOLOGY NAME:	**LPH400-LV**

COMPANY: **ANEST IWATA Corporation**
POC: **S. Nishimura, Manager**
European, American, Oceanian Sales Group
Overseas Department

ADDRESS: **3176, Shinyoshida-cho, Kohoku-ku**
Yokohama 223-8501 Japan
PHONE: **81-(0)-45-591-9358**
FAX: **81-(0)-45-591-9362**

EMAIL: **snishi@anest-iwata.co.jp**

The United States Environmental Protection Agency (EPA) has created the Environmental Technology Verification Program (ETV) 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 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, with 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 seven technology areas 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. This verification statement provides a summary of the test results for the LPH400-LV HVLP spray gun, manufactured by ANEST IWATA Corporation.

VERIFICATION TEST DESCRIPTION

The ETV CCEP evaluated the pollution prevention capabilities of ANEST IWATA LPH400-LV HVLP liquid spray gun. The test was conducted under representative factory conditions at *CTC*. It was designed to verify the environmental benefit of the high-volume, low-pressure (HVLP) spray gun with specific quality requirements for the resulting finish. If an HVLP spray gun cannot provide an acceptable finish while operating under HVLP conditions, the end users may have a tendency to raise the input air pressure to meet their finishing requirements. However, these adjustments eliminate the environmental benefits of HVLP. These environmental benefits include a significant drop in paint usage and subsequent reduction of volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions and solid waste disposal.

In this test, the LPH400-LV HVLP spray gun was tested under conditions recommended by ANEST IWATA, the gun's manufacturer. Flat cold-rolled steel panels measuring 10.2 cm x 30.5 cm (4 in. x 12 in.) received an automotive refinishing coating selected by ANEST IWATA. The HVLP gun was mounted on a robotic translator to increase accuracy and repeatability of the test. The translator can move the spray gun horizontally and/or vertically. The coating was sprayed with an overlap of 67%. The panels were sprayed in a single row of eight per rack, with three racks coated per run, and a total of five runs per test. Coated test panels were used for transfer efficiency (TE) and finish quality analyses. TE is the percentage of the paint sprayed that lands on the substrate. The TE improvement of the HVLP spray gun over a conventional air spray (CAS) gun baseline (conducted in 1999) was verified using American Society for Testing and Materials (ASTM) method D 5286. The CAS baseline guns were gravity-feed, non-HVLP spray guns. The HVLP panels' finish quality was compared to a reference panel prepared by the coating manufacturer using CAS equipment and to the finish quality of the CAS baseline panels. An equivalent or improved finish quality from the HVLP gun would validate the comparison of the HVLP and CAS baseline TE data.

The details of the test, including a summary of the data and a discussion of results, may be found in Sections 4 and 5 of "Environmental Technology Verification Report – ANEST IWATA Corporation LPH400-LV HVLP Spray Gun," which is available at http://www.epa.gov/etv/verifications/verification-index.html. A more detailed discussion of the test conditions, test results, and data analyses can be found in "Environmental Technology Verification Data Notebook: ANEST IWATA Corporation LPH400-LV HVLP Spray Gun," which is available from *CTC*.

QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

The ETV CCEP QA officer conducted an internal technical systems audit to assure that testing was conducted in compliance with the approved test plan and a performance evaluation audit to assure that the measurement systems employed were adequate to produce reliable data. Prior to the certification of the data, the ETV CCEP QA officer and the EPA ETV CCEP QA manager both audited at least 10% of the data generated during the LPH400-LV test to assure that the reported data represented the data generated during testing. In addition, the EPA ETV CCEP QA manager has conducted a quality systems audit of the ETV CCEP Quality Management Plan and onsite visits during previous tests.

TECHNOLOGY DESCRIPTION

The LPH400-LV HVLP liquid spray gun was tested, as received from ANEST IWATA, to assess its capabilities. The gun was equipped with an LPH-400-LV4 air cap and a 1.4 mm (0.055 in.) fluid tip, and was set to obtain a fan pattern of 22.9 cm (9 in.). Because this HVLP spray gun is marketed to automotive refinishers, ANEST IWATA selected an exterior coating used on automotive equipment. The coating was PPG Deltron 2000 DBC-4185 automotive basecoat, mixed with equal parts of PPG DT885 reducer.

The LPH400-LV HVLP liquid spray gun is a gravity-feed gun. More information on the spray gun, including recommended air caps and fluid tips for various paint formulations, is available from ANEST IWATA.

VERIFICATION OF PERFORMANCE

The performance characteristics of the LPH400-LV HVLP spray gun include the following:

Environmental Factors

The absolute TE for each gun is a representation of the exact verification test conditions, which includes the paint that was sprayed while the guns were between the panels and outside the boundaries of the racks. The weight of paint sprayed for the calculation of the absolute TE equals the total amount of paint sprayed during each run, as was determined through gravimetric weight measurements. The absolute TE is a representation of the efficiency achievable when coating small parts with distinct separations between the individual parts.

The applied TE for each gun is a normalization of the verification test conditions. The applied TE only includes that amount of the coating that was sprayed while each gun was directly in front of any portion of a standard test panel. This calculation eliminates all coating that was sprayed while the gun was not directly over a test panel. The portion of the coating overspray during the first and last passes was also eliminated. The applied TE is a representation of the efficiency achievable when coating large, contiguous surfaces.

- Relative Transfer Efficiency (TE) Improvement: The LPH400-LV HVLP spray gun provided a 63.9% relative improvement in absolute TE when compared to the CAS baseline. The LPH400-LV HVLP spray gun provided a 52.7% relative improvement in applied TE over the CAS baseline. The applied TE represents what would be expected if one contiguous, 81.3 cm x 30.5 cm (32 in. x 12 in.) panel were coated. The absolute TE standard deviation was 1.1% and the applied TE standard deviation was 2.5%.

- Emissions Reduction: The absolute TE improvement equates to a reduction of volatile emissions of 6.1 kg per kg of solids applied to the substrate when compared to CAS guns, a 41% reduction. The applied TE improvement equates to a reduction of volatile emissions of 2.0 kg per kg of solids applied when compared to CAS guns, a 36% reduction. This value is calculated based on the TE for each gun as well as the solids and VOC contents of the coating. (See Table 2 of the Verification Report.) The specific quantitative reduction in paint usage, VOC or HAP emissions, solid waste, and cost due to increased TE depends on numerous factors such as paint formulation, process line and paint booth design, and the products being coated.

- Cost Savings: The increased TE of the HVLP spray gun provides an economic advantage in terms of reduced paint usage and solid waste generation. In this verification test, the absolute TE improvement equates to a reduction of 8.3 L or 41% of paint used and 2.6 kg or 40% of solid waste generated per kg of solids applied to the substrate when compared to CAS guns. Also, the applied TE improvement equates to a reduction of 2.7 L or 36% of paint used and 0.8 kg or 33% of solid waste generated per kg of solids applied when compared to CAS guns.

- Output Air Pressure: The output air pressure is a function of the spray gun design and depends on the coating being sprayed. The operational pressure of the HVLP gun at the air cap was verified to be <10 psig as specified in the definition of HVLP application equipment. In this verification test, the output air pressure was measured with a pressure gage and test air cap provided by ANEST IWATA and calibrated by *CTC* prior to testing. The dynamic output air pressure was set at 5 psi at the air horns and 9 psi at the center of the air cap by adjusting the input air pressure.

Marketability Factors

- Dry Film Thickness (DFT): Based on their preliminary testing and discussion with PPG, ANEST IWATA recommended the target DFT to be 0.5–1.5 mils. The DFTs for all tests were determined from nine points measured on one random panel selected from each run. The DFT of the HVLP test averaged 0.8 mil with a standard deviation of 0.1 mil. The reference panel was found to have an average DFT of 0.8 mil. The average CAS baseline DFT was 0.7 mil with a standard deviation of 0.2 mil.

- Gloss: The gloss was measured per ASTM D 523 Test Method at three points on one panel per run. The test method has a range of 0–100 gloss units. The target value was based on the results of the reference panel prepared by the coating manufacturer and was found to be 10.4 gloss units measured at a 60° angle. The HVLP test had an average of 16.5 gloss units with a standard deviation of 2.8 gloss units. The average CAS baseline gloss was 13.3 gloss units with a standard deviation of 2.2 gloss units. At 95% confidence interval, there is no separation between the gloss values for the HVLP and CAS baseline (i.e., the upper limit of the CAS baseline is higher than the lower limit of the HVLP data).

- Visual Appearance: *CTC* personnel assessed the visual appearance of all 120 panels sprayed. 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 LPH400-LV HVLP spray gun provides significant environmental benefit by reducing VOC/HAP emissions, paint usage rates, and solid waste generated and by producing a comparable finish to conventional paint spray guns when applying an organic coating under HVLP conditions. 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

September 30, 2003

Lee A. Mulkey
Acting Director
National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency

Original signed on

September 30, 2003

Brian D. Schweitzer
Manager
ETV CCEP
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.

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 (QA) Manager, both of EPA's National Risk Management Research Laboratory in Research Triangle Park, North Carolina.

CTC also expresses sincere gratitude to ANEST IWATA Corporation, the manufacturer of the LPH400-LV HVLP 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 K. Tomita, President of ANEST IWATA USA Inc., S. Nishimura, Sales Group Manager with ANEST IWATA Corporation, and N. Morita, Engineer with ANEST IWATA Corporation. ANEST IWATA Corporation is based in Yokohama, Japan, and ANEST IWATA USA Inc. is based in Cincinnati, OH.

SI to English Conversions

SI Unit	English Unit	Multiply SI by factor to obtain English
°C	°F	1.80, then add 32
L	gal, liq (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, liq (U.S.)	8.345

List of Abbreviations and Acronyms

APPCD	Air Pollution Prevention and Control Division
ASTM	American Society for Testing and Materials
CAS	conventional air spray
CCEP	Coatings and Coating Equipment Program
CTC	Concurrent Technologies Corporation
DEP	Department of Environmental Protection
DFT	dry film thickness
DOI	distinctness-of-image
EPA	U.S. Environmental Protection Agency
ETF	Environmental Technology Facility
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
NRMRL	National Risk Management Research Laboratory
P2	pollution prevention
PEA	performance evaluation audit
PLC	programmable logic controller
QA/QC	quality assurance/quality control
RTI	Research Triangle Institute
SAE	Society of Automotive Engineers
SCAQMD	South Coast Air Quality Management District
SD	standard deviation
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 U.S. 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 former President Clinton'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 P2 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 established 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 partnership among the EPA, *CTC*, the vendors of the technologies being verified, and a stakeholders group. The stakeholders group consists of 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 ANEST IWATA Corporation LPH400-LV high-volume, low-pressure (HVLP) gravity-feed spray gun, hereafter referred to as the LPH400-LV, which is designed for use in automotive refinishing. The test coating chosen by ANEST IWATA was PPG Deltron 2000 DBC-4185 automotive basecoat. Where possible, 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 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.

CTC is serving as the verification organization for the ETV CCEP and their 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 HVLP Technology Description

HVLP spray application equipment was developed to reduce air pollution that typically results from organic finishing operations by improving paint transfer efficiency (TE). TE is the percentage of the paint sprayed that lands on the substrate. Legislation requiring the use of spray equipment that is at least as efficient as HVLP spray guns has been adopted throughout the nation, with the intention of reducing VOC and HAP emissions. For example, Rule 1511 of California's South Coast Air Quality Management District (SCAQMD) established the following definition of HVLP spray equipment on June 13, 1997:

> *Equipment used to apply coatings by means of a spray gun which is designed to be operated and which is operated between 0.1 and 10 pounds per square inch gauge (psig) air pressure measured dynamically at the center of the air cap and at the air horns.*

The low air pressure of HVLP spray equipment results in a low velocity air stream that leads to larger average paint droplet size and reduced paint particle momentum, causing less overspray and bounceback, improving TE. Improved TE reduces paint usage, VOC and HAP emissions, solid waste disposal, and spray booth maintenance costs. Reduced overspray and bounceback 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. In 1999, a Generic Verification Protocol for HVLP equipment was developed by ETV CCEP.[4] As a result of ANEST IWATA's interest in verification, ETV CCEP developed a technology-specific Testing and Quality Assurance Project Plan (TQAPP) for the ANEST IWATA LPH400-LV HVLP spray gun, with significant input from the vendor.[5] After the vendor concurred with, and the EPA and *CTC* approved, the TQAPP, *CTC* personnel performed the verification test. The Verification Statement, produced as a result of this test, may be used by the technology vendor for marketing purposes or by end users selecting HVLP equipment. The Verification Statement for this product is included on pages v–viii of this report.

1.4.1 Technology Selection

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 P2 potential of each candidate technology and considered the interests of industry. HVLP spray equipment was found to have one of the greatest P2 potentials, was being widely considered by industry in organic finishing replacement activities, and is being mandated for use by many regulating agencies and government specifications. As a result, HVLP spray equipment received the highest ranking and, thus, was the first technology selected for verification.

1.5 Test Objectives and Approach

Testing was performed according to the ANEST IWATA LPH400-LV HVLP Spray Gun TQAPP. This project was designed to verify the performance of the LPH400-LV spray gun and that it is capable of providing the end user with a P2 benefit and an acceptable quality finish, while operating under the current definition of HVLP spray equipment. It can be argued that nearly all spray guns are designed to operate at low output pressures when the input air pressure is sufficiently low. A spray gun that is operated under the definition of HVLP solely by decreasing the input air pressure (with the exception of turbine spray guns), will most likely provide an unacceptable coating finish under those conditions; therefore, the operator may be inclined to increase the input air pressure to those spray guns to meet their finish requirements, subsequently raising the output air pressure above the 10-psig limit. This project supplies the end users with the best available, unbiased technical data to assist them in determining whether the LPH400-LV meets their needs. The quantitative P2 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, *CTC*, EPA, ANEST IWATA, and the ETV CCEP stakeholders selected a specific combination of these factors. 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 P2 benefits and performance of the technology. To determine the environmental benefit of the LPH400-LV, the HVLP TE is quantitatively and qualitatively compared to a conventional air spray (CAS), or non-HVLP, baseline (see Section 4). The CAS guns used for this verification test were gravity-feed.

All processing and laboratory analyses were performed at NDCEE. TE was calculated to determine the relative P2 benefit of the technology. Gloss, and visual appearance were evaluated to verify finish quality. The finish quality of the HVLP panels was compared to a reference panel prepared by the coating manufacturer using CAS equipment. The finish quality of the CAS 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 LPH400-LV is capable of providing an environmental benefit over CAS guns (see Table 1). This environmental benefit was quantified through the ability of the LPH400-LV to apply a coating at a higher TE (i.e., put more of the sprayed paint on the part). This verification test has also shown that the LPH400-LV does not require output pressures greater than 10 psig in order to provide 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.

Absolute TE is defined for this test as the actual, unadjusted TE obtained from this verification test. Absolute TE includes the coating that was sprayed between panels and when the gun was traveling outside of the racks.

Applied TE takes into account only the coating that was sprayed while the gun was directly in front of a panel. Applied TE estimates the results that would be obtained if each rack consisted of a single panel, 81.3 cm x 30.5 cm (32 in. x 12 in.), and that the gun begins, or stops, spraying as the vertical axis of the spray gun crosses the leading, or trailing, edge of the panel.

Table 1. Verification Factors for the LPH400-LV

Factor	Target	Result
Relative Transfer Efficiency Improvement[a] (%)	Improvement over CAS Baseline	Absolute – 63.9 Applied – 52.7
Output Air Pressure (psig)	< 10 (according to definition)	5 at air horns, 9 at center of cap
Dry Film Thickness (mil)	0.5 to 1.5 (as recommended by PPG)	Average/SD[b]: 0.8 / 0.1
Gloss, gloss units (at a 60° angle)	10.4 out of 100 (per Reference Panel)	Average/SD: 16.5 / 2.8
Visual Appearance	Acceptable for target industry application	Acceptable for automotive refinishing applications

[a] Reported in terms of the absolute TE improvement of the test (including the coating sprayed into dead space) and applied TE improvement (which factors into the equation only when the spray gun is directly in front of a panel).
[b] SD = standard deviation

The capital costs of HVLP spray guns are generally higher than for comparable CAS guns. At the time of this verification test, the list price of the LPH400-LV was $420. In 1999, the CAS guns used for the baseline testing ranged in price from $120 to $360. Although no modifications were necessary to perform this verification test, changing from CAS guns to HVLP spray guns sometimes requires a modification to the existing air delivery system to ensure that the increased volume of air is available to operate the HVLP spray gun. The operating costs of the HVLP and CAS guns, however, are very similar. The economic advantage of the HVLP spray gun is realized when reduced paint usage and solid waste generation are considered.

Table 2 summarizes the emission and usage reductions resulting from the relative TE improvement.

Table 2. Benefits Realized from Relative TE Improvement

Absolute TE				
	LPH400-LV	**CAS**	**Reduction[a]**	**% Improvement[b]**
TE (%)	25.4	15.5	N/A[c]	63.9
Solids Sprayed (kg)[d,e]	3.9	6.5	2.6	40.0
Paint Usage (L)[d,f]	11.8	20.1	8.3	41.3
VOC Emissions (kg)[d,g]	8.8	14.9	6.1	40.9
Applied TE				
	LPH400-LV	**CAS**	**Reduction[a]**	**% Improvement[b]**
TE (%)	64.0	41.9	N/A	52.7
Solids Sprayed (kg)[d,e]	1.6	2.4	0.8	33.3
Paint Usage (L)[d,f]	4.7	7.4	2.7	36.5
VOC Emissions (kg)[d,g]	3.5	5.5	2.0	36.4

[a] Material reduction due to use of LPH400-LV HVLP rather than conventional air spray (CAS) guns
[b] Relative Percent Improvement of the HVLP spray gun over the CAS baseline guns
[c] N/A – Not applicable
[d] Per kg of solids applied to the substrate
[e] Solids Sprayed ($kg_{solids,\ total}/kg_{solids,\ applied}$) = 100 / TE
[f] Paint Usage ($L_{sprayed}/kg_{solids,\ applied}$) = (100/TE) * (100/% Solids),
where % Solids for LPH400-LV = 31.33% and CAS = 30.15%
[g] VOC Emissions ($kg_{VOC,\ total}/kg_{\ solids,\ applied}$) = (Paint Usage) * (VOC Content),
where VOC Content for LPH400-LV = 0.746 kg/L and CAS = 0.744 kg/L

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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 P2 characteristics and performance of HVLP 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 LPH400-LV is designed for use in automotive refinishing 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 gun used a gravity-feed fluid delivery system consisting of a 1.0-L gravity cup. The fluid adjustment determines the distance that the needle retracts from the fluid tip, which in turn determines the amount of paint that can pass through the orifice. The farther the needle retracts, the greater the paint flow. The PPG DBC-4185 automotive basecoat was chosen by ANEST IWATA as the test coating. The ETV CCEP generated a CAS baseline using the PPG DBC-4185 basecoat in 1999 under nearly identical process conditions, and will use this existing baseline to establish the relative P2 benefit of the LPH400-LV, in terms of improved TE.

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 HVLP Test

This verification test is based on the ETV CCEP HVLP Coating Equipment - Generic Verification Protocol, which was reviewed by the ETV CCEP stakeholders. ANEST IWATA, the manufacturer of the LPH400-LV, worked with *CTC* to identify the optimum performance settings for the gun. ANEST IWATA had determined the parameters through tests that their personnel conducted at their facility in Japan and at the NDCEE facility in Johnstown, PA. A preliminary TQAPP was generated using the vendor-supplied information and was submitted to EPA for review of content. Following the initial EPA review and incorporation of their comments, the vendor was given the opportunity to comment on the specifics of the TQAPP. Any information pertinent to maintaining the quality of the study was incorporated into the TQAPP. A final draft of the TQAPP was reviewed by the vendor and technical peer reviewers and then approved by EPA and *CTC* prior to the start of verification testing.

Testing was conducted under the direction of ETV CCEP personnel, with representatives for ANEST IWATA present during testing. ANEST IWATA representatives aided the initial air cap pressure measurement and setting the gun-to-target distance. All information gathered during verification testing was analyzed, reduced, and documented in this report. TE and finish quality measurements of the LPH400-LV and the relative TE improvement over a CAS baseline were the primary objectives of this report. The data comparison highlights the P2 benefit of the HVLP spray gun as well as its ability to provide the required finish quality. A randomly selected portion of at least 10% of the test data has been quality audited by EPA and the ETV CCEP QA officer to ensure the validity of the data.

2.3 HVLP Spray Application Equipment

This section contains information on the HVLP spray equipment, its current applications in industry, the advantages and benefits of the technology, and information on technology deployment.

HVLP spray equipment is divided into two main categories: turbine and conversion. The turbine HVLP spray guns use a turbine compressor to generate large volumes of low-pressure air that is fed to the spray gun. The turbines are designed so that the input air pressure is consistently below 10 psig. The HVLP turbine compressor intrinsically transfers heat to the atomizing air that is supplied to the spray gun, which helps atomize paints that have a high viscosity. Turbine guns primarily use pressure-, or force-feed systems to deliver the paint to the gun. Conversion HVLP spray guns use the existing high-pressure air supply that non-HVLP spray guns use. Conversion guns convert the low volume of air supplied at high pressure to a larger volume of air at lower pressure. Conversion HVLP spray guns use three types of paint delivery systems. First, pressure-feed or force-feed systems consist of a pressure pot that contains a drawtube that travels from the bottom of the pressure pot to the connection that leads to the spray gun. Air pressure in the pot forces coating through the drawtube and supply lines to the spray gun. A constant paint flow rate is achieved by maintaining constant air pressure to the delivery system. Second, gravity-feed systems consist of a cup mounted on top of the spray gun. Hydrostatic pressure, as a result of gravitational forces, is the driving force behind the paint flow rate to the spray gun. As the volume of paint in the gravity cup decreases, the paint flow rate decreases. The LPH400-LV is a conversion gun that uses a gravity-feed paint delivery system, as does each of the three CAS guns used in this verification test. Third, a siphon, or suction, feed system consists of a cup attached to the bottom of the spray gun, located near the air cap. The siphon cup contains a drawtube that travels from the spray gun connection to the bottom of the cup. The air pressure passing through the spray gun creates a negative pressure in the drawtube, drawing the paint up towards the spray gun. In general, paints with a higher viscosity require increased air pressure through the spray gun to induce paint flow.

2.3.1 Applications of the Technology

HVLP spray gun equipment is relatively universal in its applications, with the results superior in some applications. The LPH400-LV can be used for many applications; however, an automotive refinishing application was the subject of this verification test. Automotive refinishers use the LPH400-LV because it is a drop-in substitute for CAS guns, it is capable of high production rates, and its maintainability is comparable to and interchangeable with other ANEST IWATA HVLP and CAS guns.

2.3.2 Advantages of the Technology

HVLP spray application equipment is designed to reduce VOC emissions that typically result from spray painting operations by increasing paint TE. HVLP equipment use is legislated as a requirement in many states, such as, California SCAQMD's Rules 1151 and 1145, the Texas Natural Resources Conservation Commission's (TNRCC) Title 30, Section 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 U.S.

A low velocity air stream is used to atomize the coating, which leads to larger paint droplets and reduced paint particle momentum, resulting in less coating overspray and bounceback. Less overspray and bounceback lead to improved TE and sustain a cleaner environment for the operator. Improved TE leads to lessened VOC emissions, paint consumption, waste disposal, material costs, and spray booth maintenance.

2.3.3 Limitations of the Technology

For some applications, HVLP spray guns may experience difficulties in spraying paints with very high solids content or high viscosity. The restriction on atomizing air input places a theoretical limit on the types of coatings that can be sprayed with acceptable results; however, one of the largest criticisms that has prevented wide-scale acceptance by all industries is the claim that HVLP spray guns cannot maintain high production rates. Based on this verification test, the LPH400-LV applied the target film thickness at speeds similar to the CAS baseline tests, provided an improvement in TE over the CAS baseline, and maintained a finish quality comparable to the coating reference panel.

2.3.4 Technology Deployment and Costs

HVLP spray equipment has many applications, with few limitations on its distribution throughout the various finishing industries. One area of concern is the efficient application of high-viscosity coatings, which are harder to atomize at lower air pressures. Although the equipment is not significantly different from CAS guns in its operation, ANEST IWATA offers training sessions, as do most trade schools. The equipment is cost effective because it is similar in capital and operating costs to CAS guns; however, economic benefits are displayed through reduced paint usage as a result of improved TE and reduced solid waste, as a result of less frequent dry filter replacements or a lower volume of wash water entrapment.

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Section 3
Description and Rationale for the Test Design

3.1 Description of Test Site

The testing of the LPH400-LV was conducted at the organic finishing line, in *CTC*'s Environmental Technology Facility (ETF) Demonstration Factory. The layout of the organic finishing line is shown in Figure 1.

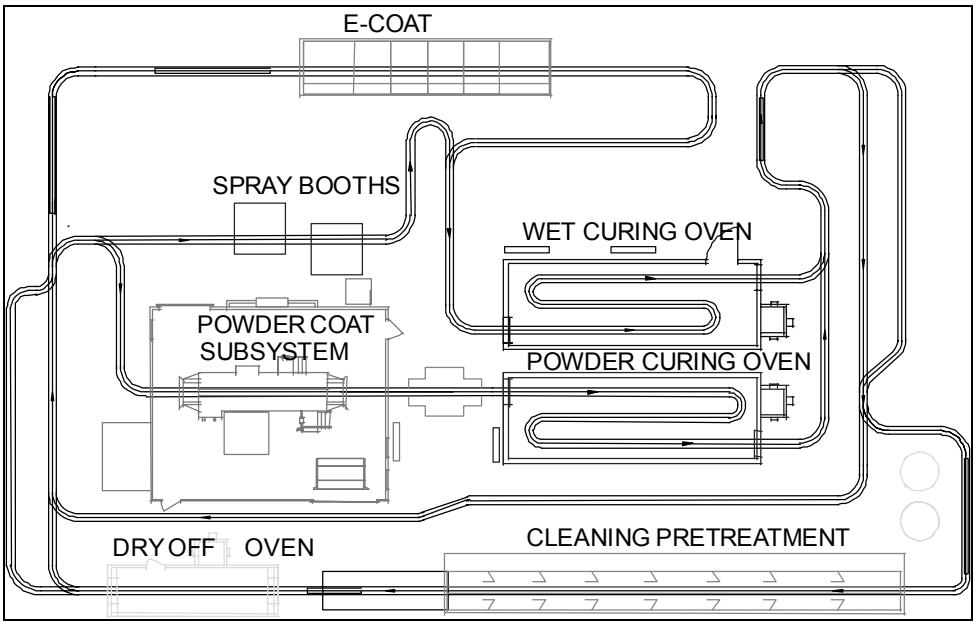

Figure 1. Organic Finishing Line at *CTC*

Coating application involves transporting test panels through the organic finishing line using an automatic conveyor. The test panels were pretreated in the seven-stage pretreatment process of the organic finishing line, weighed, stored until needed for testing, placed back on the racks, and then transported through the organic finishing line to the wet spray booth. The spray booths are capable of producing air velocities of up to 0.63 m/s (125 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 translator was procured to move the spray guns vertically and horizontally when applying the coating. The translator, operated through a programmable logic controller (PLC), was used to remove any operator bias. A drawing of the rack setup is shown in Figure 2. Figure 2 shows the location of the two support bars that were positioned behind the test panels. These support bars helped to minimize the motion of the test panels during the application of the test coating.

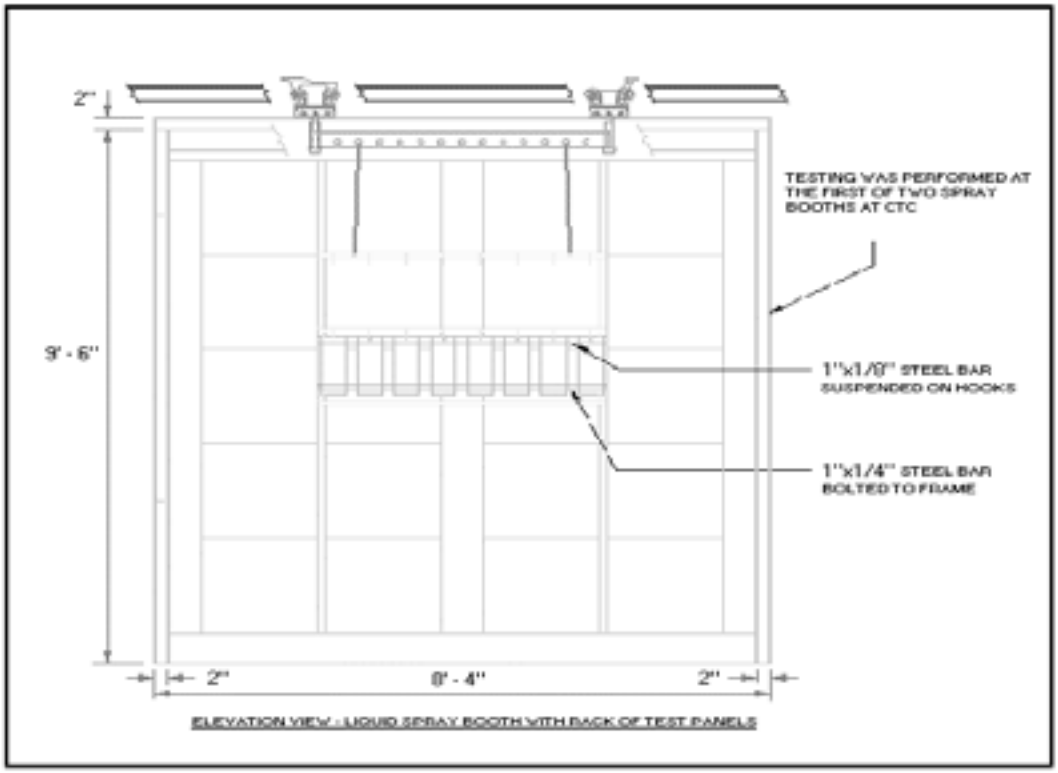

Figure 2. Rack Setup Diagram

3.2 Evaluation of LPH400-LV's Performance

The overall objectives of the verification study were to establish the P2 benefit of the LPH400-LV, relative to the TE of CAS spray guns, and to determine the effectiveness of the LPH400-LV in providing an acceptable coating finish. Section 4 discusses the details of the CAS 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 HVLP spray gun verification testing will benefit prospective end users by enabling them to better determine whether the LPH400-LV will provide a P2 benefit while meeting the finish quality requirements for their application.

3.2.1 Test Operations at CTC

The TQAPPs for the LPH400-LV and CAS baseline identified that testing would consist of coating eight panels per rack, three racks per run, and five runs per test. This enabled both total and run-to-run variation to be determined for each response factor. The statistical analyses for all response factors were performed using a statistical software package.

The standard test panels used for verification testing were flat, cold-rolled 22-gauge steel with a 0.6-cm (1/4-in.) hole in one end that meets Society of Automotive Engineers (SAE) 1008 specifications. The panel dimensions were 30.5 cm by 10.2 cm (12 in. x 4 in.). The panels were received treated with a zinc phosphate pretreatment. Five random test panels were removed prior to the test for pretreatment analysis. All panels were suspended on the rack by placing the

panels on hooks attached to the rack. Two bars were fixed to the rack, one near the top of the panels and one near the bottom of the panels. The bars were used to minimize movement during paint application.

The test coating chosen by ANEST IWATA was the PPG Deltron 2000 DBC-4185 automotive basecoat that contains less than 791 g/L VOC, as applied. The VOC content was determined by assuming that all volatiles in the coating were regulated compounds. The coating was within the VOC content limit of its target industry, a requirement identified by the ETV CCEP. The test coating was chosen because it is a common coating used in automotive refinishing. The coating data sheet is shown in Appendix B of the LPH400-LV Data Notebook. Prior to each run, the test coating was prepared in the laboratory according to the manufacturer's instructions. The exact coating preparation procedures were recorded and are listed in Appendix C of the LPH400-LV Data Notebook. To ensure comparability among tests, the test coating was prepared using the same procedures for the HVLP test and all CAS tests. Due to the long pot life of the DBC-4185 basecoat, one large batch was mixed to supply paint for several runs. The total amount of coating mixed for this test was 5.0 L. Viscosity and temperature measurements were taken before and after each run. Samples were taken at the beginning of each run for weight percent solids, density, and volatile content measurements (all data are listed in LPH400-LV Data Notebook). After the coating was mixed, it was transferred to a batch container, which was used to fill the gravity cup on the LPH400-LV spray gun. As the panels were coated, the level of coating in the gravity cup dropped. The batch container was then used to refill the gravity cup before the coating level dropped below the two-thirds level in the cup. The cup was refilled to maintain a consistent fluid flow rate from the gravity cup. A metal plate and gun stand were weighed, then the empty gun and gravity cup were added and another weight taken. The whole system (plate/stand/gun/cup/coating) was weighed immediately before and after each rack. The gravity cup was refilled between final and initial weights.

Prior to testing, the test panels were weighed and stored until they were needed. The morning of the test, the panels were placed on the racks and transferred to the spray booth area by an overhead conveyor. A mechanical stop mechanism aligned the racks of test panels in the proper position relative to the spraying mechanism. The rack of panels remained stationary during spraying. The LPH400-LV was mounted on a nylon arm extending from the carrier plate of the robotic translator, which was controlled by a remote PLC. The PLC also controlled the pneumatic cylinder that triggered the gun. A 1.4 mm fluid tip and an LPH-400-LV4 air cap were used on the LPH400-LV. The fan pattern width was set at 22.9 cm (9 in.). The product data sheets for the LPH400-LV can be found in Appendix A of the LPH400-LV Data Notebook. The fan and fluid adjustments were set at full open, and the dynamic input pressure was set at 16 psig to obtain an output pressure of 5 psig at the air horns and 9 psig at the center of the air cap. The LPH400-LV settings are summarized in Table 3. The air traveled from a quick disconnect at the shop line to a quick disconnect at the air inlet to the spray gun using 9.5-mm (3/8-in.) inside diameter air hose. The paint was applied in three coats, as recommended by ANEST IWATA. The horizontal traverse speed of the gun/translator system was set so that the gun traveled at 38.1 cm/s (15.0 in./s) while in front of the panels. Due to the acceleration and deceleration for each pass, the average speed measured for the entire range of motion will be lower. Each coat required five passes of the gun. The vertical drop between passes was set at 7.6 cm (3.0 in.), resulting in an overlap of 67%. The gun-to-target distance was set at 12.7 cm. (5 in.). ANEST

IWATA established the parameters for traverse speed, number of passes, vertical drop, and gun-to-target distance. These parameters were verified with ANEST IWATA representatives present, prior to testing.

Table 3. LPH400-LV Gun Configuration and Setup

	LPH400-LV
Air Cap	LPH-400-LV4
Fluid Tip (mm)	1.4
Fluid Needle (mm)	1.4
Fluid Adjustment	Full open
Fan Adjustment	Full open
Distance to Target (cm)	12.7
Horizontal Gun Speed (cm/s)	38.1
Average Dynamic Input Air Pressure (psig)	16

New, clean spray booth filters were installed before testing the HVLP and each of the CAS spray guns. The spray booth air filters were changed prior to setting up the standard apparatus for each gun to minimize the difference in the initial booth air velocity between the guns. The booth air velocity was measured in close proximity to the panels. The air velocity through the booth was between 0.3 and 0.7 m/s (58 and 138 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 0.35 cm of water indicated that the system required service.

Once the racks were in position, all pertinent measurements taken, and equipment adjustments made, the PLC activated the motors that drove the linear motion translators and the pneumatic cylinder that triggered the gun. The translator traveled 142.2 cm (56 in.) horizontally and dropped a total of 30.5 cm (12 in.) vertically during the five passes on each rack. The panels were automatically sprayed using vertical overlap of the fan pattern. The target dry film thickness (DFT) requirement was 0.5–1.5 mils. Five passes and three coats were recommended by ANEST IWATA to achieve the required thickness. During the dwell time between passes, paint flow was interrupted to minimize paint usage. All three coats were applied to each rack before moving to the next rack in the run. The flash time between coats was 3 minutes. Once the painting was complete, the PLC released the mechanical stop maintaining the position of the rack on the overhead conveyor. The processed rack was moved to the cure oven to air-dry and the next rack was moved into position within the spray booth. The cure oven was maintained at ambient temperature and was used solely for the purpose of minimizing contact with foreign objects or contaminants. The panels were air-dried at ambient temperature in the cure oven for at least 2 hours.

Twenty-four panels were coated during each run. Five additional panels from the same batch as the coated panels were used for zinc phosphate coating weight determination. TE was determined using the average weight gain of the 24 coated panels, as recommended in the ASTM

standard. Coated standard test panels were also analyzed for DFT, gloss, and visual appearance. Distinctness-of-image (DOI) was not analyzed for the LPH400-LV test panels. The DOI data from the baseline were very low for this coating, and it would have been difficult to discern any improvement between the HVLP and baseline panels.

3.2.2 Test Sampling Operations at CTC*'s ETF*

Standard test panels were used in this project, and each panel was stamped with a unique alphanumeric identifier. The experimental design used 125 samples for the test (5 runs with 3 racks per run and 8 panels per rack plus 5 for pretreatment analysis).

The laboratory analyst recorded the date and time of each run and the time at which each measurement was taken. Upon removing processed panels from the racks, they were stacked, each being separated by a layer of packing material, and transported to the laboratory.

3.2.3 Sample Handling and Quality Assurance/Quality Control Procedures

Prior to performing the required analyses, the laboratory analyst logged panels, 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 (ambient room temperature and humidity), and created a work order to initiate testing.

The test coating components were mixed in the laboratory. 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.

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 or the appropriate reference methods. Actual sample analysis was performed only after setup was verified according to 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. 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.

3.3.2 Data Reduction and Verification

The primary analyst(s) assembled a preliminary data package. 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 ETV CCEP laboratory leader, who then reviewed all final results for adequacy to project QA objectives. After the EPA reviewed the results and conclusions from the ETV CCEP 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 will be disseminated only after agreement by the vendor.

Section 4
Reference Data

4.1 Coating Reference Panel

The reference panel for the test coating was supplied by PPG, the coating manufacturer. PPG applied the DBC-4185 automotive basecoat to the reference panel using CAS equipment. The panel shows what characteristics PPG intended the coating finish to have. PPG coated a 30.5 cm x 10.2 cm flat cold-rolled steel panel as the reference panel. The DFT was checked at nine points on the panel, and the average DFT was found to be 0.83 mil, which was within the range that PPG recommended for this coating. The gloss was checked at three points on the panel, and the average gloss was found to be 10.4 gloss units, on a scale of 0–100. The reference panel serves as the finish quality benchmark for the LPH400-LV panels.

4.2 CAS Parameter Development

In 1999, three gravity-feed CAS guns were used to establish a TE baseline for the PPG DBC-4185 basecoat. This existing data set will be used to determine the relative improvement of the LPH400-LV over CAS guns. The operating parameters were developed from gun manufacturers' literature and through experimental trials conducted by ETV CCEP personnel. The manufacturers' literature was used to identify the spray gun components appropriate for the PPG DBC-4185 test coating and also served as a starting point for determining the input air pressure required to atomize the coating.

Each of the CAS guns was set up in the same apparatus as the LPH400-LV. The guns were set at 20.3 cm (8 in.) from the panel surface, compared to 12.7 cm (5 in.) for the LPH400-LV. This increase in distance-to-target is consistent with normal production operating conditions, in which it is recommended that the HVLP spray guns be held closer to the product. The fluid and fan adjustments, along with the input air pressure, were set to produce fan patterns that were very similar to the LPH400-LV conditions. The fan pattern width was 22.9 cm (9 in.), resulting in an overlap of 67%.

The LPH400-LV fan pattern was similar in visual appearance to the CAS fan patterns in terms of size, particle distribution, and atomization effects. Several three-panel sets were coated by the LPH400-LV using the same pattern (three coats, five passes per coat), vertical drop [7.6 cm (3 in.)], and flash times (3 minutes), as the CAS baseline tests. Each three-panel set was coated using different horizontal gun speeds. The trial-and-error method was used to achieve a DFT comparable to the CAS baseline. The panel sets were allowed to air-dry for at least 2 hours. After they were cured, the average DFT of each set of panels was determined. If none of the average DFTs for the panel sets were within the target range, the range of application speeds was adjusted and additional sets of panels were coated. This process was repeated until a speed was identified that provided a DFT similar to that obtained from the CAS baseline. Once the appropriate speed was identified, that speed was entered into the LPH400-LV TQAPP and used for the verification test. The operating parameters for each of the three CAS guns were determined in a similar manner. Table 4 lists the configuration and setup conditions for each of the three CAS guns.

Table 4. CAS Gun Configuration and Setup

	CAS Gun #1	CAS Gun #2	CAS Gun #3
Air Cap	General Purpose	General Purpose	Low Solids
Fluid Tip (mm)	1.6	1.4	1.4
Fluid Needle (mm)	1.6	1.4	1.4
Fluid Adjustment	Full open	Full open	4 turns plus 340° out
Fan Adjustment	2-1/2 turns out	1-1/2 turns out	120° out
Distance to Target (cm)	20.3	20.3	20.3
Horizontal Gun Speed (cm/s)	81.3	45.7	58.4
Average Dynamic Input Air Pressure (psig)	59	57	66

4.3 CAS Results

The finish quality data in Table 5 show the operational characteristics obtained for each of the three CAS guns. The data indicate that TE was maximized, but not at the expense of finish quality. Therefore, the comparison of the TE data from the CAS baseline and the LPH400-LV is valid. Table 5 lists the test results for the three CAS baseline guns.

Table 5. CAS Baseline Response Factor Results

	CAS Gun #1	CAS Gun #2	CAS Gun #3
Average DFT (mil)	0.6	0.9	0.7
Average Gloss (units)	11.2	15.9	12.9
Average Absolute TE (%)	13.4	17.8	15.4
Average Applied TE (%)	41.0	44.1	40.5

Section 5
Results and Discussion

This section presents an overview of the verification test results, including an analysis of environmental benefits of the LPH400-LV HVLP spray gun and a summary of data quality. HVLP data generated during this test are being compared to CAS baseline data in order to establish the relative environmental benefit of the product, and to data obtained from the coating manufacturer's reference panel to determine the acceptability of the finish quality of the applied coating. 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 LPH400-LV Data Notebook.

5.1 Potential Environmental Benefits and Vendor Claims

The primary purpose of this test is to verify that the LPH400-LV HVLP spray gun operates at HVLP conditions (<10 psig output pressure) with high finish quality. ANEST IWATA makes no claims on the absolute TE obtainable by the LPH400-LV. ANEST IWATA has stated that the use of HVLP spray equipment results in improvement in TE when compared to CAS guns, while maintaining finish quality and productivity. The finish quality provided by the LPH400-LV may be similar to, or better than, the reference panel prepared by the coating supplier using CAS equipment. The secondary purpose of this verification study was to confirm that HVLP spray guns are capable of improving TE over CAS guns, thereby reducing VOC and HAP emissions while providing an acceptable finish.

5.2 Selection of Test Methods and Parameters Monitored

CTC, the ETV CCEP partner organization, performed all the laboratory testing required for this verification test. *CTC* possesses the skills, experience, and 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 HVLP verification test and the CAS baseline tests. No significant differences were recorded. A more detailed discussion of the data is presented in Section 3 of the LPH400-LV Data Notebook.

- Factory relative humidity ranged from 14.0 to 51.7 %
- Spray booth relative humidity ranged from 14.2 to 51.7 %
- Factory temperature ranged from 21.0 to 23.7 °C
- Spray booth temperature ranged from 22.2 to 23.9 °C
- Spray booth air velocity ranged from 0.2 to 0.7 m/s
- Panel temperature ranged from 21.1 to 23.9 °C
- Zinc phosphate weight ranged from 2.0 to 2.7 g/m^2

5.2.2 Operational Parameters

A number of operational parameters were monitored because they often vary from gun to gun. These parameters were documented to track TE and finish quality changes from the CAS guns and to identify parameters that are likely to change when replacing CAS guns with HVLP spray guns. The dynamic input air pressures varied from gun to gun. The LPH400-LV was operated at 16 psig, and the CAS baseline guns averaged 61 psig. Also, the recommended distance to target is also different for the two types of spray guns, such that the LPH400-LV was operated at 12.7 cm from the panel surface, and all three CAS guns were operated at 20.3 cm from the panel surface. A more detailed discussion of the data is presented in Section 3 of the LPH400-LV Data Notebook.

5.2.3 Parameters/Conditions Monitored

Other parameters and conditions were monitored to ensure that they remained relatively constant throughout HVLP verification testing and CAS 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. Although the traverse speeds were constant for each test, the speed varied from gun to gun in order to obtain the desired DFT. The LPH400-LV was operated at 38.1 cm/s while the gun was in front of the panels. The CAS baseline guns were operated at an average speed of 61.8 cm/s while the gun was in front of the panels. A more detailed discussion of the CAS setup data is presented in Table 4 of this report and in Section 3 of the LPH400-LV Data Notebook.

5.3 Overall Performance Evaluation of the LPH400-LV HVLP Spray Gun

The DFT and gloss obtained using the LPH400-LV are comparable to the finish quality of the reference panel provided by the coating manufacturer. Therefore, it was determined that the LPH400-LV was able to meet the finish quality requirements of the test coating, and that the TE values obtained for the LPH400-LV test are representative of the actual operation of the equipment. The DFT and gloss of the CAS baseline panels are considered to be representative of the actual operation of the equipment, and the TE values obtained from the CAS baseline are determined to be representative of the CAS guns tested. The DFT and gloss values obtained for the CAS baseline are similar to those for the panels from the LPH400-LV test; therefore, the comparison of the TE data from the LPH400-LV and the CAS baseline is valid.

The test results indicate that the LPH400-LV was able to provide an environmental benefit over a CAS 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 6 presents the average results for the response factors. A more detailed discussion of the data is presented in Section 3 of the LPH400-LV Data Notebook.

Table 6. LPH400-LV Response Factor Results

	Reference Panel	LPH400-LV	CAS Baseline Average
Average Output Pressure (psig)	N/A	5 at the air horns 9 at the center of the air cap	N/A
Average DFT (mil)	0.8	0.8	0.7
Average Gloss (units)	10.4	16.5	13.3
Average Absolute TE (%)	N/A	25.4	15.5
Average Applied TE (%)	N/A	64.0	41.9

N/A - Not available

The average DFT for each test met the coating manufacturer's recommended target range. It should be noted that a low DFT bias was found to exist at one location on the reference panel, the LPH400-LV panels, and the CAS baseline panels. The consistently low DFT reading at the bottom of the panels may be caused by increased air velocity at the bottom of the racks or a process condition related to the spray pattern overlap. The low bias at the bottom of the panels was consistent for all panels.

The gloss data indicate that the coating finish applied by the LPH400-LV is comparable to the PPG reference panel based on the intended application of the test coating.

The absolute TE for each gun is a representation of the exact verification test conditions, which includes the paint that was sprayed while the guns were between the panels and outside the boundaries of the racks. The calculation of the absolute TE uses the total amount of paint sprayed and the weight gain of the coated panels, both determined through gravimetric weight measurements. The relative improvement of the absolute TE was calculated as 63.9% over the CAS baseline.

The applied TE for each gun is a normalization of the verification test conditions. The applied TE includes only that amount of coating that was sprayed while each gun was directly in front of any portion of a standard test panel. Applied TE adjusts the absolute TE by removing the amount of coating sprayed while the gun was in front of the dead space between the panels or outside the racks. The applied TE represents what would be expected if the eight panels on a rack were one contiguous, 81.3 cm x 30.5 cm panel. The relative improvement of the applied TE was calculated as 52.7% over the CAS baseline.

5.3.2 Assessment of Laboratory Data Quality

The LPH400-LV TE results were compared to the CAS baseline data. The LPH400-LV results for DFT and gloss were compared to the paint manufacturer's (PPG) reference panel. The information gathered was considered to be statistically valid and significant such that the advantages and limitations of HVLP, under these test conditions, could be identified with a high

degree of confidence. It can be stated with greater than 95% confidence that the LPH400-LV provided a higher TE than the CAS baseline and provided comparable finish quality.

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 LPH400-LV Data Notebook. 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 LPH400-LV 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 Table 22 of the LPH400-LV 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 Tables 24 through 27 of the LPH400-LV 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. Evaluating precision and accuracy data during analysis ensures completeness. All laboratory results for finish quality were 100% complete. All results were reviewed and considered usable for statistical analysis. Completeness results are shown in Table 23 of the LPH400-LV Data Notebook.

5.4.2 Audits

The ETV CCEP QA officer conducted an internal technical systems audit (TSA) and a performance evaluation audit (PEA) of the LPH400-LV verification test. Also, prior to the certification of the data, the ETV CCEP QA officer audited a portion of the data generated during the LPH400-LV 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 also reviewed laboratory bench sheets showing data for coating pretreatment weights, densities, and percent nonvolatile matter.

The ETV CCEP QA officer audit found that the LPH400-LV 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 LPH400-LV Data Notebook.

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Section 6
Vendor Forum

[ANEST IWATA Corporation has been offered the opportunity to comment on the findings of this report. Its 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.]

Introduction

Anest Iwata Corporation agrees with the findings contained in this report.

A unique spray gun head design with a wedge cut nozzle (US Patent No. 6,494,387) offers higher transfer efficiency and high quality finishing even at low air pressure (16 psi) and low air consumption (9.6 CFM). Also, a unique tulip shape wider spray pattern allows painter to spray closer to the finishing surface, while achieving the same spray pattern width of CAS base line guns. These features of the LPH400-LV series HVLP gun offer less overspray and less compressed air consumption. They save both paint material and operating costs, such as booth filter maintenance and electric power consumption of air compressors. This will reduce both VOC and carbon dioxide (CO_2) emissions.

Because of the low airflow requirement, LPH400-LV HVLP spray guns do not need a high flow air hose or high flow type quick air disconnects.

More information on the spray gun, including recommended air caps and fluid tips for various paint formulations, is available from ANEST IWATA. At the time of this verification test, the list price of the LPH400-LV HVLP spray gun was $420.

Transfer Efficiency (TE) Results

The average applied TE of 64% referenced in the report was slightly lower than the 65% TE. Anest Iwata recognizes the result was obtained from this known specific test plan, which was developed by ETV CCEP traceable to other recognized standards in the U.S. Anest Iwata understands that TE value in actual shops might be varied depending upon the type of coating material, spraying parameters including size and shape of the coated objects, as well as skill of the painter.

As a vendor of spray guns, Anest Iwata is committed to offer products of high quality, easier operation, and optimum selection for the painters' application. The company understands that one of the key factors in reducing VOCs and hazardous air pollutants from the coating processes is in training painters in the proper operation and maintenance of spray guns.

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Section 7
References

1. Curran, T., et al., National Air Quality and Emissions Trends Report, 1990, EPA-450/4-91-023, NTIS PB92-141555, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, November 1991.

2. Clean Air Act Amendments of 1990, Title III - Hazardous Air Pollutants, November 15, 1990.

3. Clean Air Act Amendments of 1990, Title I - Attainment/Maintenance of National Ambient Air Quality Standards (NAAQS), November 15, 1990.

4. Environmental Technology Verification Coatings and Coating Equipment Program (ETV CCEP): HVLP Coating Equipment – Generic Testing and Quality Assurance Protocol, Revision 1, December 1999, http://www.epa.gov/etv/pdfs/vp/06_vp_hvlp.pdf.

5. Environmental Technology Verification Coatings and Coating Equipment Program (ETV CCEP): ANEST IWATA Corporation LPH 400-LV HVLP Spray Gun – Testing and Quality Assurance Project Plan (TQAPP), May 1, 2003, http://www.epa.gov/etv/pdfs/testplan/06_tp_anest.pdf.