September 2004

Environmental Technology Verification Report

Sharpe Manufacturing Titanium T1-CG 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

ETV ETV ETV

Notice

This document was prepared by Concurrent Technologies Corporation under Contract No. DAAE30-98-C-1050 with the U.S. Defense Contract Command – Washington, 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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Sharpe Manufacturing Titanium T1-CG Spray Gun

Prepared by

Robert Fisher
Lynn 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)
with the U.S. Defense Contract Command – Washington (DCC-W)
via EPA Interagency Agreement No. DW2193939801

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 seven technology areas. 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. Other pollutant releases are considered in less detail.

The following report describes the verification of the performance of Sharpe Manufacturing's Titanium T1-CG high transfer efficiency spray gun for automotive refinishing applications.

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T1-CG Data Notebook (Available from *CTC* upon request)

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV JOINT VERIFICATION STATEMENT

TECHNOLOGY TYPE:	**HIGH TRANSFER EFFICIENCY (TE) LIQUID COATING SPRAY APPLICATION EQUIPMENT**
APPLICATION:	**LIQUID ORGANIC COATINGS APPLICATION IN AUTOMOTIVE REFINISHING**
TECHNOLOGY NAME:	**T1-CG**

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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 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 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. The ETV CCEP has recently evaluated the performance of high transfer efficiency spray guns for automotive refinishing applications. This verification statement provides a summary of the test results for the T1-CG high TE spray gun, manufactured by Sharpe Manufacturing.

VERIFICATION TEST DESCRIPTION

The ETV CCEP evaluated the pollution prevention capabilities of a high transfer efficiency (TE) liquid spray gun. 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 Sharpe T1-CG gun was tested for comparability to the finish quality obtained by two baseline high-volume, low-pressure (HVLP) spray guns. 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. These environmental benefits include a reduction in paint usage and a subsequent reduction of VOC/HAP emissions and solid waste disposal costs when compared to traditional low-efficiency air spray guns.

In this test, the T1-CG high-TE spray gun was tested under conditions recommended by Sharpe Manufacturing, the gun's manufacturer. Two groups of targets were used. The first (large target) group consisted of 36 in. x 36 in. steel backboard panels, which were covered with heavy duty aluminum foil and suspended on a stand using magnets, and 12 in. x 18 in. steel finish quality panels. Three foils were coated for each gun and coating combination to determine the gun's TE. Then, the backboards were recovered with foil and three finish quality panels were coated, which were held in place on the surface of the backboards by the same magnets that held the backboards to the stand. The application pattern for all guns did not produce any direct overspray (i.e., there was no lead, lag, or overlap beyond the edges of the backboard. The second (small target) group consisted of 5 in. x 12 in. steel TE/finish quality panels. These panels were also attached to a stand using magnets. Three small panels were coated separately for each gun/coating combination and were used to determine both TE and finish quality. The application pattern for all guns allowed 50% of the first and last passes to be above and below the panel, respectively. The spray guns were mounted on a robotic translator to increase accuracy and repeatability of the test. The translator can move the spray gun horizontally or vertically. The TE improvement of the T1-CG spray gun over a HVLP gun baseline was verified using American Society for Testing and Materials (ASTM) method D 5286. The T1-CG and HVLP baseline guns were all gravity-feed guns. The finish quality data was incorporated to validate the comparison of the T1-CG and HVLP baseline TE data.

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 – Sharpe Manufacturing Titanium T1-CG Spray Gun," published by *CTC*. Contact Robert J. Fisher of *CTC* at (814) 269-2702 to obtain copies of this statement, the Verification Report, or the Data Notebook. The Verification Statement and Report may also be accessed via the Internet at http://www.epa.gov/etv/verifications/verification-index.html.

TECHNOLOGY DESCRIPTION

The T1-CG spray gun was tested, as received from Sharpe Manufacturing, to assess its capabilities. The T1-CG is not an HVLP gun, but is claimed to provide a TE equivalent or better than HVLP spray guns. The gun was equipped with a T1-02 #CG air cap and a 1.4 mm (0.055 in.) fluid tip. Because the T1-CG spray gun is marketed to automotive refinishers, Sharpe Manufacturing selected a three part coating system manufactured by PPG, which included the NCP-280 primer, the DBC-16640 basecoat, and the DCU-2010 clearcoat.

More information on the spray gun, including recommended air caps and fluid tips for various paint formulations, is available from Sharpe Manufacturing. At the time of this verification test, the list price of the T1-CG spray gun was $290.

VERIFICATION OF PERFORMANCE

The performance characteristics of the T1-CG spray gun included the following:

Environmental Factors

- Transfer Efficiency (TE): The TE was determined per ASTM D 5286. The following TEs and associated standard deviations were obtained using large foil covered steel backboards:

	Primer		Basecoat		Clearcoat	
	TE (%)	Std. Dev.	TE (%)	Std. Dev.	TE (%)	Std. Dev.
T1-CG	83.3	0.5	56.2	0.5	78.3	0.2
HVLP #1	84.5	0.7	57.0	1.2	77.2	1.6
HVLP #2	83.0	0.7	56.5	1.2	73.5	0.4

The next set of TEs and standard deviations were obtained using small steel panels.

	Primer		Basecoat		Clearcoat	
	TE (%)	Std. Dev.	TE (%)	Std. Dev.	TE (%)	Std. Dev.
T1-CG	27.8	0.2	15.9	0.2	29.3	0.5
HVLP #1	31.4	0.2	15.7	0.1	26.6	0.3
HVLP #2	27.9	0.7	13.7	0.3	27.1	0.4

The T1-CG is statistically equivalent or better than both HVLP spray guns at the 95% confidence interval, with one exception (small primer against HVLP #1). It should be noted that there was a large range in the percent solids data obtained during the primer tests (e.g., 64.1% -76.1%), which was due to the short pot life of the coating and the difference in time between mixing and solids analysis. If the TE data for the primer are normalized (i.e., all calculations use the same percent solids value), then the T1-CG is statistically better than HVLP #1 at the 95% confidence interval.

Marketability Factors

- Dry Film Thickness (DFT): The DFT data was obtained per ASTM B 499. Based on PPG's product data sheets, the following target DFTs were established for the three coatings: Primer, 1.0 – 1.5 mils in one coat; Basecoat, 0.2 – 0.3 mils in one coat; and Clearcoat, 2.0 – 2.5 mils in two coats. 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:

	Primer		Basecoat		Clearcoat	
	Large	Small	Large	Small	Large	Small
	DFT/Std .Dev. (mils)	DFT/Std. Dev. (mils)	DFT/Std. Dev. (mils)	DFT/Std. Dev. (mils)	DFT/Std. Dev. (mils)	DFT/Std. Dev. (mils)
T1-CG	0.4/0.1	0.8/0.1	0.1/0.0	0.2/0.1	2.5/0.1	1.8/0.1
HVLP #1	0.6/0.1	0.7/0.1	0.3/0.0	0.3/0.0	2.1/0.1	2.2/0.1
HVLP #2	0.6/0.1	0.8/0.1	0.3/0.0	0.3/0.0	1.8/0.1	1.6/0.1

- Gloss: The gloss was measured per ASTM D 523 at multiple points on each finish quality panel. The values range from 0–100 gloss units. The following gloss values and standard deviations were obtained:

	Primer		Basecoat		Clearcoat	
	Large	Small	Large	Small	Large	Small
	Gloss/Std. Dev.	Gloss/Std. Dev.	Gloss/Std. Dev.	Gloss/Std. Dev.	Gloss/Std. Dev.	Gloss/Std. Dev.
T1-CG	10 / 1	37 / 3	22 / 2	21 / 0	96 / 0	95 / 0
HVLP #1	14 / 4	19 / 4	23 / 0	24 / 0	84 / 1	88 / 1
HVLP #2	12 / 3	22 / 3	22 / 1	28 / 0	77 / 1	86 / 0

- Distinctness-Of-Image (DOI): The DOI was measured per ASTM D 5767 Test Method B at one point on each finish quality panel. DOI provides another measure of a coating's finish quality. The DOI analyses were performed by ACT Laboratories, Inc., of Hillsdale, MI. The sliding comb shutter was replaced with an eight-bladed rotating disc. The test method has a range of 0–100 DOI units. The following DOI values and associated standard deviations were obtained during this test:

	Primer		Basecoat		Clearcoat	
	Large	Small	Large	Small	Large	Small
	DOI/Std. Dev.	DOI/Std. Dev.	DOI/Std. Dev.	DOI/Std. Dev.	DOI/Std. Dev.	DOI/Std. Dev.
T1-CG	23 / 1	24 / 0	27 / 0	27 / 0	76 / 5	70 / 1
HVLP #1	23 / 1	23 / 0	27 / 0	27 / 0	62 / 3	72 /3
HVLP #2	24 / 1	23 / 0	26 / 1	28 / 0	36 / 1	67 / 1

- 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 operating conditions used for the three spray guns varied slightly, however, the goal was to obtain a comparable finish quality under representative conditions for each specific gun. The finish quality data indicate that the applied coating characteristics were comparable among the three guns. The test results also show that the T1-CG spray gun provides an environmental benefit comparable to HVLP spray equipment by providing the end user with the same or improved transfer efficiency as HVLP. 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
9/28/2004

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

CTC also expresses sincere gratitude to Sharpe Manufacturing, the manufacturer of the T1-CG 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 Mazzotta, General Manager, and Mr. Hub "Dr. Gun" Forsgren, both of Sharpe Manufacturing. Sharpe Manufacturing, a division of Graco, Inc., is based in Gardena, CA.

SI to English Conversions

SI Unit	English Unit	Multiply SI by factor to obtain English
°C	°F	1.8, then add 32
L	gal. (U.S.)	2.642×10^{-1}
m	ft	3.281
kg	lbm	2.205
kPa	psi	1.450×10^{-1}
cm	in.	3.937×10^{-1}
mm	mil (1 mil = 1/1000 in.)	3.937×10^{1}
m/s	ft/min	1.969×10^{2}
kg/L	lbm/gal. (U.S.)	8.345

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
DOI	distinctness-of-image
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
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
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 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 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 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, and 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 Sharpe Manufacturing Titanium T1-CG gravity-feed spray gun, hereafter referred to as the T1-CG, which is designed for use in automotive refinishing. This test compared the T1-CG against two HVLP spray guns using a primer, basecoat, and clearcoat from PPG Industries. 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.

1.3 Technology Description

The T1-CG 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.

The T1-CG is not classified as HVLP because the output air pressure exceeds 10 psig. However, Sharpe Manufacturing proposes that the T1-CG can provide a TE equivalent to or better than 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

The ETV CCEP 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.

Upon initiating agreements with interested vendors, a draft Generic Verification Protocol for high TE spray equipment was developed by the ETV CCEP. The ETV CCEP then developed a technology-specific Testing and Quality Assurance Project Plan (TQAPP) for each piece of equipment being verified, with significant input from the vendors. After the vendor concurred with, and the EPA and *CTC* approved, the TQAPP, *CTC* personnel performed the verification test. The Verification Statement, which 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.

1.5 Test Objectives and Approach

The testing was performed according to the Sharpe Manufacturing Titanium T1-CG TQAPP. This project was designed to verify that the T1-CG 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. The goal of this project is to supply the end users with the best available, unbiased technical data to assist them in determining whether the T1-CG 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, Sharpe Manufacturing, 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 T1-CG's TE is quantitatively and qualitatively compared to a HVLP baseline (see Section 4). The HVLP guns used for this verification test, like the T1-CG, were all gravity-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, distinctness-of-image (DOI), 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 T1-CG is capable of providing an environmental benefit equivalent or better than the HVLP guns it was compared with (see Table 1). This environmental benefit was demonstrated by the ability of the T1-CG to apply a coating at the same or higher TE. This verification test has also shown that the T1-CG 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 T1-CG was capable of meeting or exceeding the efficiency of two popular HVLP spray guns. The test utilized two targets of differing sizes (large and small) and three different coatings (primer, basecoat, and clearcoat) for each target size. For the large target, each gun coated three TE foils and three finish quality panels for each coating. For the small target, each gun coated three panels for each coating, which were used to determine both TE and finish quality. Table 1 summarizes the results for TE, DFT, gloss, and DOI for each of the gun-coating-target combinations.

Table 1. Verification Results for the T1-CG and HVLP Baseline

Transfer Efficiency (%)						
	Primer		Basecoat		Clearcoat	
	Large	Small	Large	Small	Large	Small
	TE/Std. Dev.	TE/Std. Dev.	TE/Std. Dev.	TE/Std. Dev.	TE/Std. Dev.	TE/Std. Dev.
T1-CG	83.3 / 0.5	27.8 / 0.2	56.2 / 0.5	15.9 / 0.2	78.3 / 0.2	29.3 / 0.5
HVLP #1	84.5 / 0.7	31.4 / 0.2	57.0 / 1.2	15.7 / 0.1	77.6 / 1.6	26.6 / 0.3
HVLP #2	83.0 / 0.7	27.9 / 0.7	56.5 / 1.2	13.7 / 0.3	73.5 / 0.4	27.1 / 0.4

Table 2. Verification Results for the T1-CG and HVLP Baseline (Cont'd)

Dry Film Thickness (mils)						
	Primer		Basecoat		Clearcoat	
	Large	Small	Large	Small	Large	Small
	DFT/Std. Dev.	DFT/Std. Dev.	DFT/Std. Dev.	DFT/Std. Dev.	DFT/Std. Dev.	DFT/Std. Dev.
T1-CG	0.4 / 0.1	0.8 / 0.1	0.1 / 0.0	0.2 / 0.1	2.5 / 0.1	1.8 / 0.1
HVLP #1	0.6 / 0.1	0.7 / 0.1	0.3 / 0.0	0.3 / 0.0	2.1 / 0.1	2.2 / 0.1
HVLP #2	0.6 / 0.1	0.8 / 0.1	0.3 / 0.0	0.3 / 0.0	1.8 / 0.1	1.6 / 0.1
Gloss (units)						
	Primer		Basecoat		Clearcoat	
	Large	Small	Large	Small	Large	Small
	Gloss/Std. Dev.	Gloss/Std. Dev.	Gloss/Std. Dev.	Gloss/Std. Dev.	Gloss/Std. Dev.	Gloss/Std. Dev.
T1-CG	10 / 1	37 / 3	22 / 2	21 / 0	96 / 0	95 / 0
HVLP #1	14 / 4	19 / 4	23 / 0	24 / 0	84 / 1	88 / 1
HVLP #2	12 / 3	22 / 3	22 / 1	28 / 0	77 / 1	86 / 0
Distinctness-Of-Image[(a)] (units)						
	Primer		Basecoat		Clearcoat	
	Large	Small	Large	Small	Large	Small
	DOI/Std. Dev.	DOI/Std. Dev.	DOI/Std. Dev.	DOI/Std. Dev.	DOI/Std. Dev.	DOI/Std. Dev.
T1-CG	23 / 1	24 / 0	27 / 0	27 / 0	76 / 5	70 / 1
HVLP #1	23 / 1	23 / 0	27 / 0	27 / 0	62 / 3	72 /3
HVLP #2	24 / 1	23 / 0	26 / 1	28 / 0	36 / 1	67 / 1

[a] The DOI analyses was completed by ACT Laboratories, Inc., of Hillsdale, MI. The sliding comb shutter was replaced by an eight-bladed rotating disc.

The T1-CG is statistically equivalent or better than both HVLP spray guns at the 95% confidence interval, with one exception (small primer against HVLP #1). It should be noted that there was a large range in the percent solids data obtained during the primer tests (e.g., 64.1% - 76.1%), which was due to the short pot life of the coating and the difference in time between mixing and solids analysis. If the TE data for the primer are normalized (i.e., all calculations use the same percent solids value), then the T1-CG is statistically better than HVLP #1 at the 95% confidence interval. In addition, the DFT, gloss, and DOI data are comparable or better for all comparisons.

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 T1-CG was $290, and the HVLP guns used for the baseline testing ranged in list price from $450 - $550.

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 T1-CG 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 0.6-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. Three PPG automotive refinishing coatings were used for this test: NCP-280 primer, DBC-16640 basecoat, and DCU-2010 clearcoat.

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 T1-CG Test

This verification test is based on the ETV CCEP Sharpe Manufacturing Titanium T1-CG TQAPP, which was reviewed by the EPA and the vendor. Sharpe Manufacturing, the manufacturer of the T1-CG, worked with *CTC* to identify the optimum performance settings for the gun. Sharpe Manufacturing had determined the parameters through tests that their personnel conducted at their facility and at *CTC*'s 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 then approved by the EPA and *CTC* prior to testing.

Testing was conducted under the direction of *CTC* personnel, with representatives for Sharpe Manufacturing present during a portion of the testing. The Sharpe Manufacturing representative aided *CTC* in the initial gun setup. The Sharpe Manufacturing representative served only as an observer during the actual verification test.

All information gathered during verification testing was analyzed, reduced, and documented in this report. TE and finish quality measurements of the T1-CG 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 T1-CG 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 T1-CG Spray Application Equipment

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 T1-CG uses a gravity-feed paint delivery system, as does each of the two HVLP guns used in this verification test. The product data sheets can be obtained from the manufacturer.

2.3.1 Applications of the Technology

The T1-CG can be used for many applications; however, an automotive refinishing application was the subject of this verification test. Automotive refinishers use the T1-CG because it is a drop-in substitute for conventional and HVLP spray guns, it is capable of high production rates, and its maintainability is comparable to other spray guns.

2.3.2 Advantages of the Technology

The T1-CG 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 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. High efficiency spray guns, like the T1-CG, 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 T1-CG is accepted by the appropriate local regulatory agencies as compliant with the automotive refinishing requirements, there are no apparent limitations on the T1-CG for automotive refinishing. However, some agencies may require approval prior to using the T1-CG in their jurisdiction. The use of the T1-CG would be limited in areas where approval is not granted.

2.3.4 Technology Deployment and Costs

The T1-CG has many potential applications, with few limitations on its distribution throughout the various finishing industries. The use of a gravity cup limits the amount of continuous spraying that can be accomplished using this type of spray gun. However, refilling the cup is a relatively simple and quick procedure. The T1-CG is cost effective because it is lower in capital and operating costs compared to HVLP; however, economic benefits are realized through reduced paint usage as a result of improved TE and finish quality. As TE increases, less paint is required to obtain the same film thickness, thereby increasing the number of parts that can be coated with a given volume of paint.

Section 3
Description and Rationale for the Test Design

3.1 Description of Test Site

The testing of the T1-CG 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.

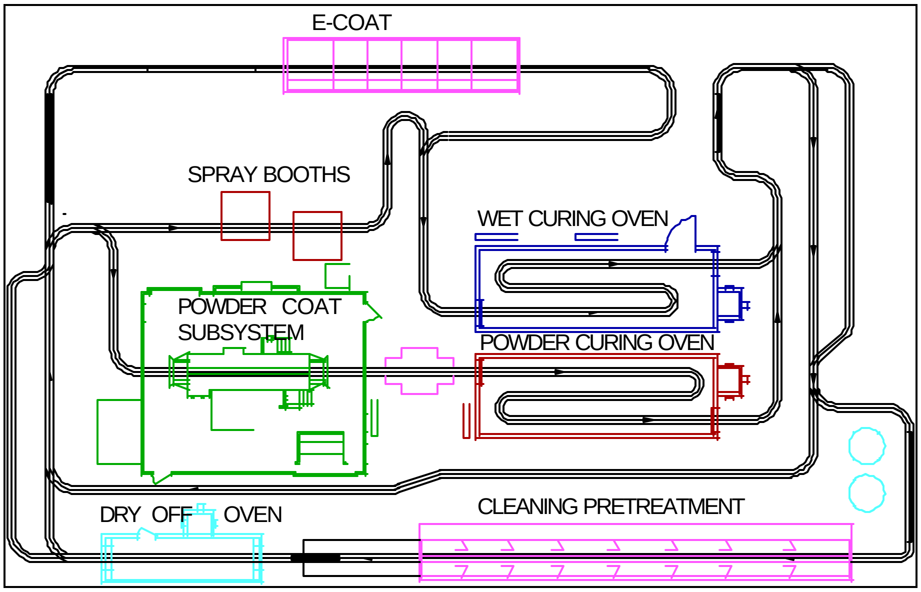

Figure 1. Organic Finishing Line at *CTC*

The finish quality test panels were pretreated in the seven-stage zinc-phosphate pretreatment process of the organic finishing line, 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 translator was used to move the spray guns vertically and horizontally when applying the coatings. The translator, operated through a programmable logic controller (PLC), was used to remove any operator bias. The foil and panels were manually transported to and from the spray booth and to the laboratory for curing.

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 T1-CG Performance

The overall objectives of the verification study were to evaluate the pollution prevention benefit of the T1-CG, relative to the TE of HVLP spray guns, and to determine the effectiveness of the T1-CG in providing an acceptable coating finish. Section 4 discusses the details of the HVLP baseline. The operating conditions used for the three spray guns varied slightly, however, the goal was to obtain a comparable finish quality under representative conditions for each specific gun. 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 T1-CG verification testing will benefit prospective end users by enabling them to better determine whether the T1-CG will provide a pollution prevention benefit while meeting the finish quality requirements for their application.

3.2.1 Test Operations at *CTC*

The T1-CG and HVLP baseline testing consisted of large TE foils, large finish quality panels, and small TE/finish quality panels using a PPG primer, basecoat, and clearcoat. Foils were used on the large targets to minimize the difference between the weight of the substrate and the weight of the applied coating to aid in the determination of TE. The small targets used steel panels instead of small foils for TE analysis since the differential between the mass of the small panels and the mass of foil that would have been used was not as significant as the large targets. Steel panels were used in both the large (used only for finish quality) and small targets (same panels for TE and finish quality) to determine finish quality.

The large TE foils measured approximately 121.9 cm by 101.6 cm (48 in. x 40 in.). All foils were wrapped onto steel panels measuring 91.4 cm by 91.4 cm (36 in. x 36 in.), which were attached to a backboard by magnets. The foil-covered panels were carried by hand to and from the booth. Once coated, the foils were carefully removed from the steel panels and sent to the laboratory oven for curing.

The large finish quality panels used for verification testing were flat, cold-rolled 22-gauge steel that meets Society of Automotive Engineers (SAE) 1008 specifications. The panel dimensions were 45.7 cm by 30.5 cm (18 in. x 12 in.). All panels were suspended on a foil covered 91.4 cm by 91.4 cm (36 in. x 36 in.) steel backboard. The panels were held onto the backboard by magnets. Once the panels were coated, they were removed from the booth by hand and sent to the laboratory for curing. Figure 2 illustrates the application pattern used for the large targets (clearcoat was applied using five passes and two coats).

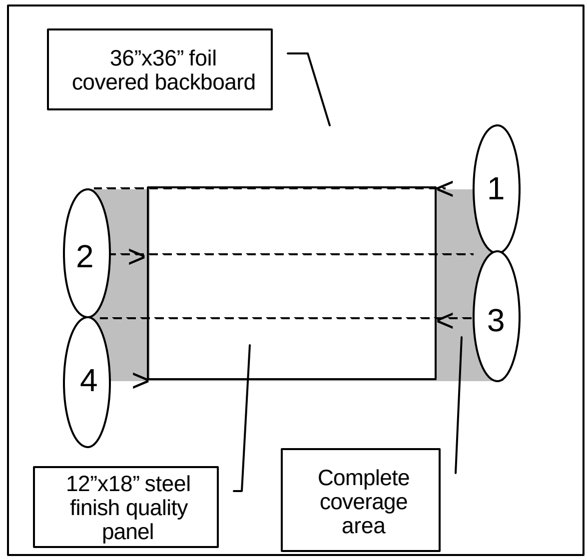

Figure 2. Large Target Application Diagram

The small TE and finish quality panels used for verification testing were flat, cold-rolled 22-gauge steel that meets Society of Automotive Engineers (SAE) 1008 specifications. The panel dimensions were 30.5 cm by 12.7 cm (12 in. x 5 in.). All panels were suspended on a stand using magnets. Once the panels were coated, they were removed from the booth by hand and sent to the laboratory for curing. Figure 3 illustrates the application pattern used for the small targets (clearcoat was applied using three passes and two coats).

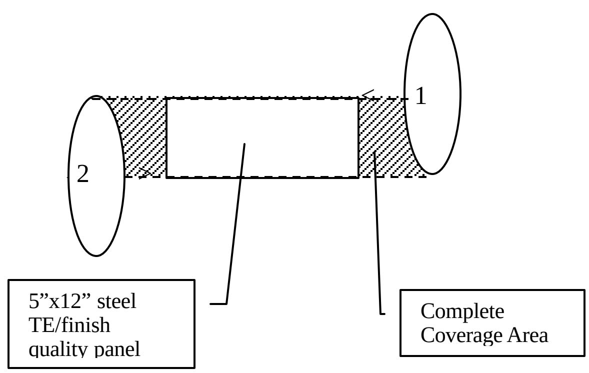

Figure 3. Small Target Application Diagram

The coatings used for this test were the PPG NCP-280 primer, the PPG DBC-16640 basecoat, and the PPG DCU-2010 clearcoat. The NCP-280 primer was mixed 2:1 with PPG NCX-285 catalyst, and then reduced 10% by volume with acetone. The mixed primer had an estimated pot life of 60 minutes. The DBC-16640 basecoat was mixed 1:1 with PPG DT-885 reducer. The mixed basecoat is reported to have an indefinite pot life by PPG, as the mixed coating may be refreshed with reducer as needed. The DCU-2010 clearcoat was mixed 4:1 with PPG DCX-2012 hardener. The mixed clearcoat had an estimated pot life of 90 minutes. Samples were taken just prior to coating the test panels to measure the temperature, viscosity, percent solids, volatile content, and density. A new batch was prepared for each gun-coating-target combination.

The T1-CG 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. 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 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 between 0.4 and 0.7 m/s (80 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 or panels 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 foils and panels were automatically sprayed using vertical overlap of the fan pattern. The foils and panels were manually transported to and from the booth and to the laboratory for curing. The laboratory oven was maintained at 110 ºC (230 ºF) and the samples were cured for 1 hour.

There were nine large combinations, where each of the three guns sprayed three separate coatings. Each large combination coated three large foils and three large panels, for a total of twenty-seven large foils and twenty-seven large panels. There were nine small combinations, where each of the three guns sprayed three separate coatings. Each small combination coated three small panels, for a total of twenty-seven small panels. TE was determined using the average weight gain of the foils or panels, per ASTM D 5286. Coated standard test panels were also analyzed for DFT, gloss, DOI, 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, and each panel was stamped with a unique alphanumeric identifier. The experimental design used 3 foils and 3 panels for the large target tests, and 3 panels for the small target tests.

The laboratory analyst recorded the date/time of each run and the time at which each measurement was taken. When the coated panels were removed from the booth, they were transported to the laboratory for curing in a calibrated oven.

3.2.3 Sample Handling and Quality Assurance/Quality Control Procedures

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.

After curing, 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.

Each apparatus used to assess the quality of a coating on a test panel was 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 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 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

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 and Verification Report were 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.

Section 4
Reference Data

4.1 HVLP Parameter Development

Each of the HVLP guns was set up in the same apparatus as the T1-CG. The guns were set at same distance from the surface of the large targets as the T1-CG, for each particular coating. The HVLP guns were setup so that the fan pattern, for each particular coating, was the same as that for the T1-CG for the small targets. The fluid and fan adjustments, along with the input air pressure, were set to produce fan patterns that were consistent for each particular coating.

The HVLP fan patterns were similar in visual appearance to the T1-CG fan pattern in terms of size, particle distribution, and atomization effects. Several three-panel sets were coated using similar conditions as the T1-CG. Each three-panel set was coated using different horizontal gun speeds. The trial-and-error method was used to achieve a wet film thickness comparable to the T1-CG setup. A wet film thickness gage was used to determine the amount of paint applied. If the wet film thickness for the panel sets were within the target range, the range of application speeds was adjusted and additional sets of panels were coated. The operating parameters for each of the two HVLP guns were determined in the same manner. Tables 2 and 3 lists the configuration and setup conditions the two HVLP guns.

Table 3. HVLP Baseline Gun #1 Configuration and Setup

Target Size	Large			Small		
Coating	Primer	Basecoat	Clear	Primer	Basecoat	Clear
Air Cap	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm
Fluid Tip (mm)	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm
Fluid Adjustment [a]	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.
Fan Adjustment [a]	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.
Fan Pattern (cm)[b]	21.6	22.9	15.2	25.4	25.4	12.7
Number Passes	4	4	5	2	2	3
Number Coats	1	1	2	1	1	2
Distance to Target (cm)	15.2	15.2	15.2	19.7	15.6	12.7
Horizontal Travel Distance (cm)	91.4	91.4	91.4	77.5	80.0	76.8
Horizontal Gun Speed (cm/s)	29.0	19.0	23.0	20.0	16.0	32.0

[a] W.O. means the adjustment knob was set to "wide open".
[b] The fan pattern for the clear coat was adjusted to 12.7 cm based on the inability of the spray guns to obtain a 25.4 cm pattern at a representative distance to the target. An additional pass was added to completely cover the target panels.

Table 4. HVLP Baseline Gun #2 Configuration and Setup

Target Size	Large			Small		
Coating	Primer	Basecoat	Clear	Primer	Basecoat	Clear
Air Cap	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm
Fluid Tip (mm)	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm
Fluid Adjustment [a]	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.
Fan Adjustment [a]	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.
Fan Pattern (cm)[b]	19.7	22.9	15.2	25.4	25.4	12.7
Number Passes	4	4	5	2	2	3
Number Coats	1	1	2	1	1	2
Distance to Target (cm)	15.2	15.2	15.2	20.3	16.5	12.7
Horizontal Travel Distance (cm)	91.4	91.4	91.4	77.5	80.0	76.2
Horizontal Gun Speed (cm/s)	31.0	15.0	28.0	18.0	11.0	40.0

[a] W.O. means the adjustment knob was set to "wide open".
[b] The fan pattern for the clear coat was adjusted to 12.7 cm based on the inability of the spray guns to obtain a 25.4 cm pattern at a representative distance to the target. An additional pass was added to completely cover the target panels.

4.2 HVLP Results

The data in Tables 4 and 5 show the operational characteristics obtained for each of the two 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 T1-CG is valid. Table 4 lists the test results for the first HVLP baseline gun, and Table 5 for the second.

Table 5. HVLP Baseline Gun #1 Response Factor Results

Target Size	Large			Small		
Coating	Primer	Basecoat	Clear	Primer	Basecoat	Clear
Dynamic Input Air Pressure (psig)	30	30	30	30	30	30
Dynamic Output Air Pressure (psig)	Horn – 9.5 Center – 10.7	Horn – 9.5 Center – 10.7	Horn – 9.5 Center – 10.7	Horn – 9.5 Center – 10.7	Horn – 9.5 Center – 10.7	Horn – 9.5 Center – 10.7
Air Flow (scfm)	13	13	13	13	13	13
Average DFT (mils)	0.6	0.3	2.1	0.7	0.3	2.2
Average Gloss (units)	14	23	84	19	24	88
DOI (units)	23	27	62	23	27	72
Average TE (%)	84.5	57.0	77.2	31.4	15.7	26.6

Note: The outlet pressure at the center position on the air cap exceeded 10 psig, but was obtained using the manufacturer's recommended dynamic inlet air pressure.

Table 6. HVLP Baseline Gun #2 Response Factor Results

Target Size	Large			Small		
Coating	Primer	Basecoat	Clear	Primer	Basecoat	Clear
Dynamic Input Air Pressure (psig)	29	29	29	29	29	29
Dynamic Output Air Pressure (psig)	Horn – 9.5 Center – 8	Horn – 9.5 Center – 8	Horn – 9.5 Center – 8	Horn – 9.5 Center – 8	Horn – 9.5 Center – 8	Horn – 9.5 Center – 8
Air Flow (scfm)	13	13	13	13	13	13
Average DFT (mils)	0.6	0.3	1.8	0.8	0.3	1.6
Average Gloss (units)	12	22	77	22	28	86
DOI (units)	24	26	36	23	28	67
Average TE (%)	83.0	56.5	73.5	27.9	13.7	27.1

Section 5
Results and Discussion

This section presents an overview of the verification test results, including an analysis of environmental benefits of the T1-CG 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 T1-CG Data Notebook.

5.1 Potential Environmental Benefits and Vendor Claims

The primary purpose of this test is to verify that the T1-CG spray gun provides a TE and finish quality comparable or better than and HVLP baseline. Sharpe Manufacturing makes no claims on the absolute TE obtainable by the T1-CG.

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 T1-CG 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 T1-CG Data Notebook.

- Factory relative humidity ranged from 9.8 to 12.7%
- Spray booth relative humidity ranged from 10.1 to 12.7%
- Factory temperature ranged from 21.0 to 23.7 °C
- Spray booth temperature ranged from 21.0 to 23.2 °C
- Spray booth air velocity ranged from 0.4 to 0.7 m/s
- Panel temperature ranged from 21.1 to 23.9 °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 T1-CG. The dynamic input air pressures varied from gun to gun. The T1-CG was operated at 30 psig, and the two HVLP baseline guns were run at

30 and 29 psig, respectively, based on the manufacturer's recommendation. The distance to target was maintained at 15.2 cm for all large target tests. The fan pattern obtained from each gun was maintained at 25.4 cm for the primer and basecoat and 12.7 cm for the clearcoat for the small target tests. A more detailed discussion of the data is presented in Section 3 of the T1-CG Data Notebook.

5.2.3 Parameters/Conditions Monitored

Other parameters and conditions were monitored to ensure that they remained relatively constant throughout T1-CG 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. However, the traverse speeds varied for each gun in order to obtain the desired DFTs. A more detailed discussion of the HVLP setup data is presented in Table 2 and 3 of this report and in Section 3 of the T1-CG Data Notebook. Table 6 presents the T1-CG configuration and setup information.

Table 7. T1-CG Configuration and Setup

Target Size	Large			Small		
Coating	Primer	Basecoat	Clear	Primer	Basecoat	Clear
Air Cap	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm
Fluid Tip (mm)	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm	1.4 mm
Fluid Adjustment	W.O.	W.O.	W.O.	W.O.	W.O.	W.O.
Fan Adjustment	W.O.	1 turn out	W.O.	W.O.	1 turn out	W.O.
Fan Pattern (cm)	20.3	25.4	15.2	25.4	25.4	12.7
Number Passes	4	4	5	2	2	3
Number Coats	1	1	2	1	1	2
Distance to Target (cm)	15.2	15.2	15.2	19.1	15.2	10.2
Horizontal Travel Distance (cm)	91.4	91.4	91.4	76.2	80.0	76.2
Horizontal Gun Speed (cm/s)	30.0	19.0	22.0	23.0	18.0	31.0

5.3 Overall Performance Evaluation of the T1-CG Spray Gun

The DFT and gloss obtained using the T1-CG are comparable to the finish quality of the HVLP baseline. Therefore, it was determined that the T1-CG was able to meet the finish quality requirements of the test coating, and that the TE values obtained for the T1-CG test are representative of the actual operation of the equipment. The DFT, gloss, and DOI values 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, gloss, and DOI values obtained for the HVLP baseline are similar to those for the panels from the T1-CG test; therefore, the comparison of the TE data from the T1-CG and the HVLP baseline is valid.

This test attempted to determine if the T1-CG was better than, or equivalent to HVLP spray guns. Based on information presented in Table 1, 4, 5, and 7, the T1-CG is better than the individual HVLP guns and the average of the two HVLP guns for some of the comparisons. In order to determine equivalency, a 95% confidence interval is being utilized to statistically evaluate the data. Appendix D of the T1-CG Data Notebook shows that the T1-CG is statistically equivalent or better than the individual HVLP guns and the HVLP average for all but one combination (Small-Primer-HVLP #1). However, there was a large variation in percent solids between the T1-CG sample and the HVLP samples, due to the difference in time between mixing and solids analysis. The short pot life of the primer is characterized by increasing viscosity and decreasing percent solids over time. If the percent solids data was normalized between the T1-CG and the HVLP guns (use the same value for all primer calculations), the revised TE for the T1-CG for this combination (Small-Primer) is greater than the revised HVLP TE data.

The test results indicate that the T1-CG 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 7 presents the average results for the response factors for the T1-CG spray gun. A more detailed discussion of the data is presented in Section 3 of the T1-CG Data Notebook.

Table 8. T1-CG Response Factor Results

Target Size	Large			Small		
Coating	**Primer**	**Basecoat**	**Clear**	**Primer**	**Basecoat**	**Clear**
Dynamic Input Air Pressure (psig)	30	30	30	30	30	30
Dynamic Output Air Pressure (psig)	N/A Not HVLP	N/A Not HVLP	N/A Not HVLP	N/A Not HVLP	N/A Not HVLP	N/A Not HVLP
Air Flow (scfm)	8	8	8	8	8	8
Average DFT (mils)	0.4	0.1	2.5	0.8	0.2	1.8
Average Gloss (units)	10	22	96	37	21	95
DOI (units)	23	27	76	24	27	70
Average TE (%)	83.3	56.2	78.3	27.8	15.9	29.3

The initial large and small clearcoat combinations using the T1-CG were found to have DFTs well below the range of both HVLP spray guns. In order to ensure comparability, those two combinations were re-run at new horizontal gun speeds and the new data is presented in this report. Although the average DFT varied between the T1-CG and each of the HVLP guns, no corresponding variation in the associated TE was shown in the verification tests. If a direct correlation between these parameters does exist, detailed testing is required to establish that correlation, an activity that is beyond the scope of this project. No corrective action was taken for this deviation from the TQAPP.

The gloss data indicate that the coating finish applied by the T1-CG is comparable to the HVLP baseline data 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 between the panels and outside the boundaries of the racks. 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.

5.3.2 Assessment of Laboratory Data Quality

The T1-CG TE results were compared to the HVLP baseline data. The T1-CG 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 T1-CG, per these test conditions, could be identified with a high degree of confidence. It can be stated with greater than 95% confidence that the T1-CG provided an equivalent or 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 and parameters met the accuracy, precision, and completeness requirements specified in the TQAPP. 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 T1-CG 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 the T1-CG 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 the T1-CG 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 the T1-CG Data Notebook.

5.4.2 Audits

The ETV CCEP QA Officer conducted an internal technical systems audit (TSA) of the T1-CG verification test. Also, prior to the certification of the data, the ETV CCEP QA Officer audited a portion of the data generated during the T1-CG 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 T1-CG 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 are discussed in Section 2 of the T1-CG Data Notebook. Those deviations included:

- Some of the gun configurations and settings are different than the TQAPP due to changes made during gun set up.
- Some of the anticipated variations in density, viscosity, and percent solids were exceeded for the NCP-280 Primer due to the short pot life of that coating.
- The curing step was conducted in a laboratory oven as opposed to the factory floor.
- The fan pattern for the clear coat over the small panels was set at 12.7 cm. Also, the clear coat combinations required the addition of one extra pass, based on changes made during gun set up.
- Some of the DFT obtained were below the target range.

Section 6
Vendor Forum

[Sharpe Manufacturing has been offered the opportunity to comment on the findings of this report. No comments were received at the time this report was published.]

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.