Test Results of Bake Oven VOC Capture Efficiency and Paint Solids Transfer Efficiency for the Topcoat Operations

Chrysler Group LLC
Warren Truck Assembly Plant
21500 Mound Road
Warren, Michigan

Permit MI-ROP-B2767-2011

Prepared for
Chrysler Group LLC
Auburn Hills, Michigan

Bureau Veritas Project Nos. 11013-000181.00 and 11013-000184.00
December 12, 2013

BUREAU VERITAS

Move Forward with Confidence

Bureau Veritas North America, Inc.
22345 Roethel Drive
Novi, Michigan 48375-4710
248.344.1770
www.us.bureauveritas.com/hse

Contents

Table

Contents

Figure

Appendix

Appendix Table

Appendix Figure

Appendix

Contents

Executive Summary

Chrysler Group LLC retained Bureau Veritas North America, Inc. to conduct surface coating testing of the topcoat coating operations at the Warren Truck Assembly Plant (WTAP) in Warren, Michigan. Chrysler Group LLC operates a body shop, paint shop, and final assembly line to manufacture the Dodge Ram 1500 vehicle at this facility. Chrysler Group LLC operates four topcoat paint booths identified as Color 1, Color 2, Reprocess, and Tutone. The testing was performed from October 10 through 17, 2013, to measure the following parameters:

- Paint solids transfer efficiency (TE)—the percent of paint solids sprayed that deposit on the painted part. TE was measured when applying white solid basecoat, silver metallic basecoat, and standard clearcoat in the Color 2 line.

- Bake oven volatile organic compound (VOC) capture efficiency (CE)—the percent of VOC captured from the curing of the coating in the bake ovens. VOC CE is used to calculate the mass of VOCs captured per gallon of applied coating solids (lb VOC/gacs) —commonly referred to as oven solvent loading (OSL). Bake oven VOC CE was measured at Color 2, Reprocess, and Tutone when applying silver metallic basecoat and standard clearcoat.

The results of the testing will be used to calculate monthly emissions.

The testing was conducted in accordance with applicable procedures in the U.S. Environmental Protection Agency document "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Primer-Surfacer and Topcoat Operations" and Appendix A to Subpart IIII of 40 CFR 63, "Determination of Capture Efficiency of Automobile and Light-Duty Truck Spray Booth Emissions from Solvent-borne Coatings Using Panel Testing."

The results of the testing are summarized below. Detailed results are presented in Tables 1 through 5 after the Tables tab of this report.

Paint Solids Transfer Efficiency Results

Color 2 Coating Solids Transfer Efficiency Results Summary

Process	Result					Solids Transfer Efficiency
	Batch Vehicle Weight Gain (lb)	Batch Paint Sprayed (gal)	Coating Density (lb/gal)	Solids Weight Fraction (lb solids/lb coating)	Batch Solids Sprayed (lb)	(%)
Metallic Basecoat – Silver	6.13	2.03	8.29	0.51	8.61	**71.2**
Solid Basecoat – White	11.27	2.66	10.39	0.63	17.43	**64.6**
Clearcoat – Standard	8.64	2.73	8.62	0.57	13.50	**64.0**

VOC Capture Efficiency Results

VOC Capture Efficiency Results Summary

Section	Section VOC CE† (%)	Section VOC CE at 100% Transfer Efficiency (%)	Silver Metallic Loading (lb/gacs)	Clearcoat Loading (lb/gacs)
Color 2				
Basecoat Bake Oven VOC CE	**8.8**	**12.4**	**1.25**	**-**
Clearcoat Bake Oven VOC CE	**32.2**	**50.4**	**-**	**3.98**
Reprocess				
Basecoat Bake Oven VOC CE	**5.2**	**7.3**	**0.74**	**-**
Clearcoat Bake Oven VOC CE	**24.1**	**37.6**	**-**	**2.97**
Tutone				
Basecoat Bake Oven VOC CE	**9.2**	**12.9**	**1.31**	**-**
Clearcoat Bake Oven VOC CE	**29.5**	**46.0**	**-**	**3.64**
†: section VOC CE calculated using measured transfer efficiency				

1.0 Introduction

Chrysler Group LLC retained Bureau Veritas North America, Inc. to conduct surface coating testing of the topcoat coating operations at the Warren Truck Assembly Plant (WTAP) in Warren, Michigan. Chrysler Group LLC operates a body shop, paint shop, and final assembly line to manufacture the Dodge Ram 1500 vehicle at this facility. Chrysler Group LLC operates four topcoat paint booths identified as Color 1, Color 2, Reprocess, and Tutone. The compliance test program was performed from October 10 through 17, 2013, to measure the following parameters:

- Paint solids transfer efficiency (TE)—the percent of paint solids sprayed that deposit on the painted part. TE was measured when applying white solid basecoat, silver metallic basecoat, and standard clearcoat in the Color 2 line.

- Bake oven volatile organic compound (VOC) capture efficiency (CE)—the percent of VOC captured from the curing of the coating in the bake ovens. The bake oven VOC CE is used to calculate the mass of VOC captured per gallon of applied coating solids (lb VOC/gacs)—commonly referred to as oven solvent loading (OSL). Bake oven VOC CE was measured at Color 2, Reprocess, and Tutone when applying silver metallic basecoat and standard clearcoat.

The results of the testing will be used to calculate monthly emissions.

The testing program was conducted in accordance with applicable procedures in the U.S. Environmental Protection Agency document "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Primer-Surfacer and Topcoat Operations" and Appendix A to Subpart IIII of 40 CFR 63, "Determination of Capture Efficiency of Automobile and Light-Duty Truck Spray Booth Emissions from Solvent-borne Coatings Using Panel Testing."

1.1 Summary of Test Program

The topcoat paint process at WTAP is comprised of four topcoat paint lines in which basecoat and clearcoat are applied. Currently, coatings are applied to the Dodge Ram 1500 production models. Vehicles that were being prepared or assembled were used in the test program. The test program is summarized below.

VOC Capture Efficiency Testing

RECEIVED
DEC 1 6 2013
AIR QUALITY DIV.

Color 2, Reprocess, and Tutone. VOC CE testing was performed on these lines on October 10 and 11, 2013. Testing was conducted following procedures contained in Section 21, "Test Procedures for Determining Exhaust Control Device VOC Loading (Capture Efficiency) by Panel Test" of the USEPA document, "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Primer-Surfacer and Topcoat Operations."

The procedure measured the loss of VOC from freshly painted surface panels by weight difference. The panels were subjected to basecoat and clearcoat coatings and the weight of the panels were measured before entering and after exiting the controlled zone. The weight loss from organic compound volatilization and the volume of solids deposited on the test panels were used to calculate:

- The percent VOC captured and directed to VOC abatement from the coating zones
- The VOC captured in pounds of VOC per gallon of applied coating solids (lb VOC/gacs)

The panels were weighed to measure the percent of basecoat and/or clearcoat paint VOCs captured within the basecoat bake oven. Captured basecoat bake oven VOC emissions are directed to a regenerative thermal oxidizer for VOC abatement.

Paint Solids Transfer Efficiency Testing

Color 2. Paint solids transfer efficiency testing was performed on October 14 through 17, 2013, following the procedures in Section 18, "Transfer Efficiency Test Procedure—In Plant" of the USEPA document, "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Primer-Surfacer and Topcoat Operations." The procedure measures the weight of coating solids applied to vehicles.

The testing consisted of routing two pre-weighed control vehicles and three pre-weighed test vehicles through the Color 2 spray booths and bake oven. Three color families were evaluated: solid white basecoat, metallic silver basecoat, and standard clearcoat. After cured vehicles emerged from the oven, they were allowed to cool and re-weighed. Using the vehicle body weight gain, representing the weight of solids applied the percent paint solids transfer efficiency was calculated.

Table 1-1 summarizes the sources, parameters, and test dates.

Table 1-1
Identification of Sources, Parameters, and Test Dates

Emission Unit	Source	Parameter	Test Date	Coating Tested
EU - Color Two	Color 2	Bake Oven VOC CE	October 10, 2013	Metallic basecoat- silver Clearcoat- standard
		Paint solids TE	October 14 through 17, 2013	Metallic basecoat – silver Solid basecoat – white Clearcoat- standard
EU - Reprocess	Reprocess	Bake Oven VOC CE	October 10, 2013	Metallic basecoat- silver Clearcoat- standard
EU - Tutone	Tutone	Bake Oven VOC CE	October 11, 2013	Metallic basecoat- silver Clearcoat- standard

VOC CE = volatile organic compound capture efficiency
TE = transfer efficiency

1.2 Purpose of Testing

The testing was performed in order to satisfy requirements within MDEQ Renewable Operating Permit MI-ROP-B2767-2011 for the EU-Tutone and FG-Topcoat conditions. The effective date of the permit is January 1, 2011. The results of the testing will be used to calculate daily and monthly emissions. The permit emission limits are presented in Table 1-2.

Table 1-2
Emission Limits

Pollutant	Limit	Time Period and Operating Scenario	Equipment	Underlying Applicable Requirements
VOC	12.3 lb/gallon of applied coating solids	Calendar month average	FG-Topcoat	R336.1702(a) 40 CFR 60 Subpart MM
VOC	270.2 lb	Per hour operated in a calendar month	Spray booths of each topcoat line	R336.1220
VOC	582.11 ton	12-month rolling period	Spray booths of each topcoat line	R336.1220
VOC	6.8 lb	Per hour operated in a calendar month	Bake Ovens of each topcoat line	R336.1220
VOC	15.67 ton	12-month rolling period	Bake Ovens of each topcoat line	R336.1220
VOC	89.9 lb	Per hour operated in a calendar month	High Bake Repair Spray booth	R336.1220
VOC	193.74 ton	12-month rolling period	High Bake Repair Spray booth	R336.1220
VOC	2.3 lb	Per hour operated in a calendar month	High Bake Repair bake oven	R336.1220
VOC	5.22 ton	12-month rolling period	High Bake Repair bake oven	R336.1220
VOC	12.3 lb/gallon of applied coating solids	Calendar month average	EU-Tutone	40 CFR Subpart MM
VOC	381.1 lb	Per hour operated in a calendar month	Tutone Spray booth	R336.1220
VOC	821 ton	12-month rolling time period	Tutone Spray booth	R336.1220
VOC	9.51 lb	Per hour operated in a calendar month	Tutone bake oven	R336.1220
VOC	20.53 ton	12-month rolling time period	Tutone bake oven	R336.1220

1.3 Contact Information

Mr. Thomas Schmelter, Senior Project Manager, and Dillon King, Consultant, with Bureau Veritas, oversaw the environmental test program with the assistance of Mr. Jim Belanger, Manager with JLB Industries, Inc. Chrysler Group LLC personnel provided process coordination and recorded operating parameters. Messrs. Thomas Maza and Iranna Konanahalli, with Michigan Department of Environmental Quality witnessed the testing. Contact information for these individuals is presented in Table 1-3.

Table 1-3
Key Contact Information

Facility	Testing Company
Chrysler Group LLC	Bureau Veritas North America, Inc.
Rohit Patel Air Compliance Manager 800 Chrysler Drive Auburn Hills, Michigan 48326-2757 Telephone: 248.512.1599 Email: rgp6@chrysler.com	Thomas Schmelter, QSTI Senior Project Manager 22345 Roethel Drive Novi, Michigan 48375-4710 Telephone 248.344.3003 Email: thomas.schmelter@us.bureauveritas.com
Matthew Smith Environmental Specialist 21500 Mound Road Warren, Michigan 48091 Telephone: 586.497.2444 Email: mws54@chrysler.com	Dillon King Consultant 22345 Roethel Drive Novi, Michigan 48375-4710 Telephone 248.344.3002 Email: dillon.king@us.bureauveritas.com
Michigan Department of Environmental Quality	
Thomas Maza Environmental Quality Analyst Detroit Office Cadillac Place, Suite 2-300 3058 West Grand Boulevard Detroit, Michigan 48202-6058 Telephone: 313.456.4709 Email: mazat@michigan.gov	Iranna Konanahalli Environmental Quality Analyst Southeast Michigan District 27700 Donald Court Warren, Michigan 48092-2793 Telephone: 586.753.3741 Facsimile: 586.753.3731 Email: konanahallii@michigan.gov

2.0 Source and Sampling Locations

2.1 Process Description

The topcoat paint process at the WTAP facility is comprised of four topcoat paint systems in which basecoat and clearcoat coatings are applied. The normal operating production line speed throughout the paint shop is approximately 72 jobs per hour, however when the vehicle enters into the topcoat system paint booths the speed is reduced to 36 jobs per hour. The vehicles in the test were processed in the same manner as regular production vehicles and process data was recorded to confirm that testing is conducted under normal booth conditions. Currently, the paint shop applies coatings to the Dodge Ram 1500 truck.

The topcoat spray booths use a downdraft ventilation and water-wash system located below the booth grating to control paint overspray. Solvent-borne basecoat and clearcoat are applied by electrostatic applicators. Figures 1 through 3 present the Color 1, Color 2, Reprocess, and Tutone spraybooths process maps, which depict the process flow and coating zones directed to abatement for VOC control.

Paint is applied to vehicles automatically and manually in booths. Color 1 and Color 2 lines consist of a basecoat robot cut-in zone, basecoat manual cut-in zone, basecoat electrostatic bells, basecoat robots zone, manual pick-up zone, a clearcoat robot cut-in zone, clearcoat electrostatic bells zone, clearcoat manual pick-up zone, and bake oven. A summary of the spray gun applicator parameters is presented in Table 2-1. Closed loop beakering verification of the applicators at the Color 2 line is presented in Appendix A.

Table 2-1
Color 2 Applicator Parameter Summary

Operation	Manufacturer	Applicator	Fluid Tip/Bell Size (mm)	Air Cap	Gun Voltage (kV)	Revolutions per Minute	Gun-to-Target Distance (inch)
BC Robot Engine	ABB	Eco2 HX 1	1.1	N/A	N/A	25,000	6-10
BC Bell	Behr	EcoBell	1.1	N/A	60-80	50,000 Silver 55,000 White	10
BC Robot	ABB	Eco HX	.7 side/ .9	N/A	50	65,000 Silver/	10

Table 2-1
Color 2 Applicator Parameter Summary

Operation	Manufacturer	Applicator	Fluid Tip/Bell Size (mm)	Air Cap	Gun Voltage (kV)	Revolutions per Minute	Gun-to-Target Distance (inch)
			overhead			55,000 White	
CC Robot	ABB	EFC-2	3	A71L	80	N/A	10
CC Bell	Behr	EcoBell	1.1	N/A	60-80	55,000	10

mm: millimeter
kV: kilovolts
OH: overhead

2.2 Control Equipment

The topcoat spray booths use a downdraft ventilation system and water-wash system below the booth grating to control paint overspray. Captured basecoat bake oven VOC emissions are directed to a regenerative thermal oxidizer for VOC abatement. The downdraft ventilation and water wash system was not evaluated during this test program; however, they were in operation in accordance with the facility's Renewable Operating Permit.

2.3 Operating Parameters

The following operating parameters were recorded during the testing:

- Line speed
- Coating use
- Applicator information
- Bake oven temperature
- Spray booth relative humidity
- Spray booth temperature
- Spray booth airflow

Table 2-2 and Appendix E present the operating parameters recorded during testing.

Table 2-2
Operating Parameters

Source	Line Speed (ft/min)	Spray Booth Temperature (°F)	Spray Booth Relative Humidity	Bake Oven Temperature (°F)
Color 2	16.4 FPM	64-82	38-84%	229-344
ft/min: feet per minute				

2.4 Process Sampling Locations

Facility personnel collected seven process samples of the coatings applied during the testing. The coatings were collected following procedures in USEPA's "Standard Procedure for Collection of Coating and Ink Samples for Analysis by Methods 24 and 24A."

The coatings were collected at the point of application in 4-ounce glass containers with minimal headspace. The coating-as-applied samples were analyzed using USEPA Method 24 to measure VOC content, water content, and density. The Method 24 coating analytical results are summarized in Table 2-3 and included in Appendix F.

Table 2-3
Method 24 Coating Analytical Results

Sample	Parameter						
	Date	% Non-volatile	% Volatile	Density		VOC	
				g/ml	lb/gal	g/L	lb/gal
WTAP Silver Basecoat CE	10/10/13	51.71	48.29	0.992	8.27	478.8	4.00
WTAP Clearcoat CE	10/10/13	55.93	44.07	1.032	8.61	454.6	3.79
WTAP Silver Basecoat CE	10/11/13	51.59	48.41	0.989	8.25	478.6	3.99
WTAP Clearcoat CE	10/11/13	55.47	44.53	1.033	8.62	459.8	3.84
WTAP Silver Basecoat TE	10/14/13	51.16	48.84	0.994	8.29	485.3	4.05
WTAP White Basecoat TE	10/15/13	62.99	37.01	1.244	10.39	460.6	3.84
WTAP Clearcoat TE	10/16/13	57.49	42.51	1.033	8.62	439	3.66

3.0 Summary and Discussion of Results

3.1 Objectives and Test Matrix

The testing was performed as required by MDEQ Renewable Operating Permit MI-ROP-B2767-2011 for the EU-Tutone and FG-Topcoat conditions. The effective date of the permit is January 1, 2011. The results of the testing will be used to calculate daily and monthly emissions. The sources, parameters, processes, and test date are presented in Table 1-1 and the permit emission limits are presented in Table 1-2.

3.2 Field Test Changes and Issues

The following sections summarize the field test changes and issues.

3.2.1 Capture Efficiency Testing for Reprocessing and Tutone

Bureau Veritas proposed to measure capture efficiency and oven solvent loading on topcoat lines Color 1 and Color 2. Because the process of Color 1 and Color 2 is identical, the capture efficiency values from the Color 2 tested booth applies to the Color 1 line. MDEQ requested capture efficiency testing also be conducted on the Tutone and Reprocessing topcoat lines.

3.2.2 Transfer Efficiency Test Vehicle 2 Metallic Basecoat – Silver

During transfer efficiency testing on the Color 2 topcoat line, a production vehicle was inserted between Test Vehicles 3 and 1. The production vehicle was programmed to be sprayed with a different color coating and, as a result, after the production vehicle was coated, the paint applicators had to fill the lines with metallic basecoat - silver. This led to an increase in the coating measured by the applicators.

As approved by MDEQ, the average volume of coating for Test Vehicles 3 and 2 was used to calculate transfer efficiency for Test Vehicle 2.

3.2.3 Exclusion of Metallic Basecoat – Silver Capture Efficiency Panel Weight

During processing through the bake oven, a foreign material adhered to one of the test panels for the capture efficiency testing of metallic basecoat – silver on Color 2. This resulted in added mass and the panel weight was excluded from the average used in calculations.

RECEIVED
DEC 1 6 2013
AIR QUALITY DIV.

3.3 Presentation of Results

The results are summarized in Tables 3-1 and 3-2. Detailed VOC CE and paint solids TE test results are presented in Tables 1 through 5 after the Tables tab of this report. Sample calculations and calculation spreadsheets are presented in Appendix B with raw and computer generated field data sheets behind Appendix C and D. Facility operating data are included in Appendix E.

Paint Solids Transfer Efficiency Results

Table 3-1
Color 2 Coating Solids Transfer Efficiency Results Summary

Process	Result					Solids Transfer Efficiency (%)
	Batch Vehicle Weight Gain (lb)	Batch Paint Sprayed (gal)	Coating Density (lb/gal)	Solids Weight Fraction (lb solids/lb coating)	Batch Solids Sprayed (lb)	
Metallic Basecoat - Silver	6.13	2.03	8.29	0.51	8.61	**71.2**
Solid Basecoat - White	11.27	2.66	10.39	0.63	17.43	**64.6**
Clearcoat - Standard	8.64	2.73	8.62	0.57	13.50	**64.0**

VOC Capture Efficiency Results

Table 3-2
VOC Capture Efficiency Results Summary

Section	Section VOC CE† (%)	Section VOC CE at 100% Transfer Efficiency (%)	Silver Metallic Loading (lb/gacs)	Clearcoat Loading (lb/gacs)
Color 2				
Basecoat Bake Oven VOC CE	8.8	12.4	1.25	-
Clearcoat Bake Oven VOC CE	32.2	50.4	-	3.98
Reprocess				
Basecoat Bake Oven VOC CE	5.2	7.3	0.74	-
Clearcoat Bake Oven VOC CE	24.1	37.6	-	2.97
Tutone				
Basecoat Bake Oven VOC CE	9.2	12.9	1.31	-
Clearcoat Bake Oven VOC CE	29.5	46.0	-	3.64
†: section VOC CE calculated using measured transfer efficiency				

4.0 Sampling and Analytical Procedures

The testing was conducted in accordance with applicable procedures contained in the USEPA document "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Topcoat Operations" as referenced in 40 CFR 63, Subpart IIII. The parameters and analytical methods used are listed in Table 4-1.

Table 4-1
Sampling and Analytical Test Methods

Reference Method	Parameter	Analysis
Section 18, "Transfer Efficiency Test Procedure--In Plant" of the USEPA document, "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Primer-Surfacer and Topcoat Operations."	Paint solids transfer efficiency	Gravimetric
Section 21, "Test Procedures for Determining Exhaust Control Device VOC Loading (Capture Efficiency) by Panel Test" of the USEPA document, "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Primer-Surfacer and Topcoat Operations."	VOC Capture efficiency	Gravimetric
ASTM D2369-10e1, "Standard Test Method for Volatile Content of Coatings," and D1475-98(2012), "Standard Test Method for Density of Liquid Coatings, Inks, and Related Products," incorporated by reference in USEPA 24, "Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings."	Coating density, solids content	Gravimetric
ASTM D7091-12, "Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to a Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals"	Film build	Electromagnetic induction

4.1 Test and Analytical Methods

The test methods are summarized in the following sections.

4.1.1 Paint Solids Transfer Efficiency

Paint solids TE testing was conducted in accordance with the applicable procedures contained in Section 18 of the USEPA document "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Primer-Surfacer and Topcoat Operations" as referenced in 40 CFR 63, Subpart IIII, "National Emission Standards for Hazardous Air Pollutants: Surface Coating of Automobiles and Light-Duty Trucks."

TE was measured by comparing (1) the weight gain of the test vehicle batch after coating application and curing and (2) the weight of solids sprayed. For example, the vehicle weight gain measured after the solid basecoat application divided by the weight of the solid basecoat paint solids sprayed yields an overall TE for solid basecoat. Coating material use was monitored using integrated robot, bell, or manual in-line flow monitors. These devices measured material consumption in cubic centimeters (cc) on each applicator or at the corresponding gear pump. The summation of the coating applied through each applicator equals the total volume of paint sprayed.

TE was measured by three separate tests for metallic basecoat, solid basecoat, and clearcoat. The measured TE values are considered representative of coatings applied in each coating group (white basecoat TE was used as TE for the solid basecoats applied). As the process of each booth is identical, the TE values from the Color 2 tested booth applies to the Color 1 line at the facility.

Each test involved coating three car bodies. Two no-paint control vehicles were run through the process to account for sealer weight loss and measurement accuracy. The vehicles were weighed before and after solids were applied. Figure 4-1 presents a photograph of the vehicle weigh station.

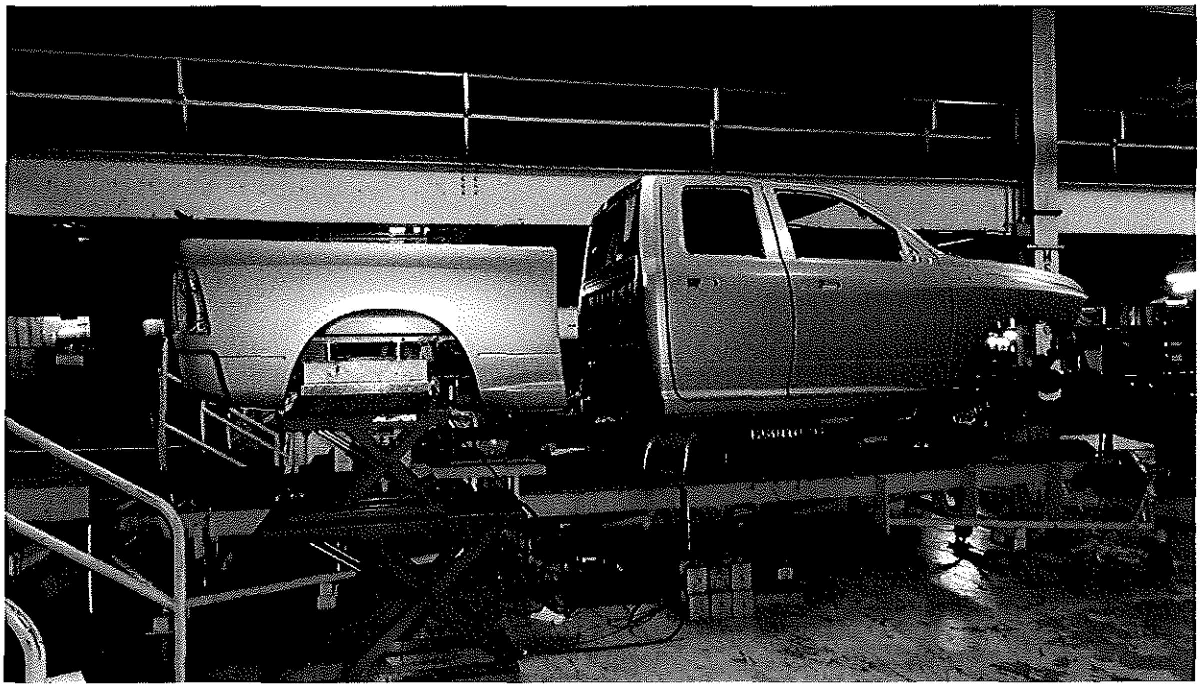


Figure 4-1. Paint solids transfer efficiency vehicle weigh station

During the test, vehicles were processed in the same manner as normal production vehicles and process data were recorded to evaluate that testing was conducted under normal booth conditions. The general test sequence for each TE measurement was:

- Configure vehicle weigh station (VWS) to achieve measurement accuracy to ±0.05 pounds.
- Pre-weigh batch of test vehicles and control vehicles.
- Load application equipment and route test vehicles to spray booth.
- Process test vehicles through spray booth as normal production vehicles.
- Record coating material use.
- Route test vehicles through bake oven.
- Allow test vehicles to cool and measure post-coating weight to calculate weight gain attributable to applied coating solids.
- Obtain coating samples for laboratory analysis to measure coating density and solids weight fraction.

Solids in each coating sample were analyzed by ASTM D2369, incorporated by reference in USEPA Method 24. Each coating sample was analyzed for density by ASTM D1475, incorporated by reference in USEPA Method 24.

4.1.2 VOC Capture Efficiency

CE testing was performed as defined in 40 CFR 63, Subpart IIII, Appendix A, "Determination of Capture Efficiency of Automobile and Light-Duty Truck Spray Booth Emissions from Solvent-borne Coatings Using Panel Testing." This procedure measures the loss of VOC from a freshly coated surface by weight difference attributable to the coating curing process in the oven, and is conducted in accordance with ASTM D5087 for solvent-borne coatings. The weight loss during the curing process is measured. The difference in weight between the wet and cured panels is attributable to the amount of VOC released in the oven. Measurements of oven VOC CE are also referenced as oven solvent loading.

The only variation to the protocol was that the panel testing took place on the paint line during actual vehicle coating and baking operations rather than in a laboratory environment.

One sample of each coating material used during the test was collected and analyzed to measure solids weight and density.

The VOC CE was measured by routing one test vehicle through each coating line with groups of clean, labeled, pre-weighed, electrocoated and baked 4-inch-by-12-inch panels attached to the body of the vehicle using magnets. The panels were positioned at locations where:

- The target film build for the process is most prevalent.
- The panels would be easily accessible for placement and removal.
- The vehicle areas were relatively flat and would accommodate panel placement.

Figure 4-2. Blank test panels

Photographs of the panels used during testing presented in Figures 4-2 and 4-3.

The vehicle was painted as a typical production unit during production hours.

VOC CE of the basecoat bake oven was measured during this test program. For the basecoat bake oven testing, the vehicle movement stopped after the coating had been applied just prior to the bake oven; the test panels were carefully removed and weighed. After weights for each panel were recorded, the panels were remounted on the vehicle for processing through the bake oven. When the panels emerged from the bake oven, they were removed from the vehicle, allowed to cool, and re-weighed on the same scale. The difference in weight between the wet and cured panels is attributable to the amount of VOC released in the oven.

Solids in each coating sample were analyzed by ASTM D2369 and D1475, incorporated by reference in USEPA Method 24 to measure the coating solids content and density.

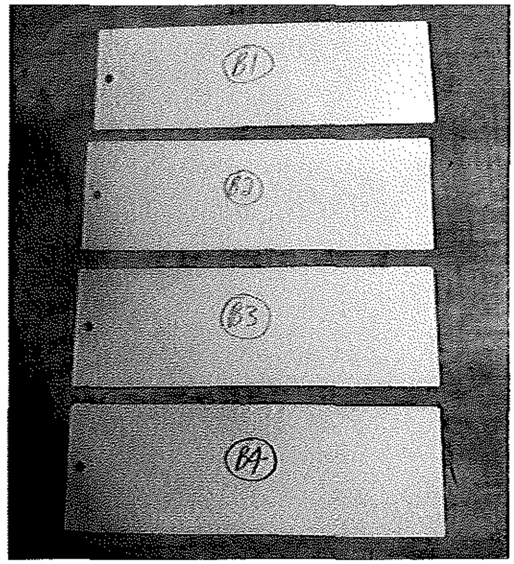


Figure 4-3. Coated test panels

4.1.3 Solids and Density Determination (USEPA Method 24)

Solids and density measurements followed USEPA Method 24, "Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings." The coating was collected following procedures in USEPA's "Standard Procedure for Collection of Coating and Ink Samples for Analysis by Methods 24 and 24A." Samples were collected at the point of application into a 1-quart glass container with minimal headspace.

The coating-as-applied samples were analyzed following USEPA Method 24 procedures to measure the non-volatile and volatile content, density, and VOC density. Laboratory results are included in Appendix F.

4.2 Procedures for Obtaining Process Data

Process data were recorded by Chrysler Group LLC personnel. The process data are summarized in Section 2.0 and included in Appendix E.

4.3 Sampling Identification and Custody

Detailed sampling and recovery procedures are described in Section 4.1. For each sample collected (i.e. coating), sample identification and custody procedures were completed as follows:

- Containers were sealed to prevent contamination.
- Containers were labeled with sample identification and date.
- Samples were logged using guidelines outlined in ASTM D4840-99(2004), "Standard Guide for Sampling Chain-of-Custody Procedures."
- Samples were delivered to the laboratory.

Chains of custody and laboratory analytical results are included in Appendix F.

5.0 QA/QC Activities

Equipment used in this environmental test program passed quality assurance/quality control (QA/QC) procedures. Refer to Appendix A for equipment calibration and inspection sheets.

5.1 Pretest QA/QC Activities

Before testing, the equipment was inspected and calibrated according to procedures outlined in the applicable procedures contained in the USEPA document "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Primer-Surfacer and Topcoat Operations" as referenced in 40 CFR 63, Subpart IIII. Refer to Appendix A for inspection and calibration sheets.

5.2 QA/QC Audits

The results of select sampling and equipment QA/QC audits are presented in the following sections. Calibration measurements for scales are presented in Appendix A.

5.3 TE QA/QC Blanks

Two no-paint control vehicles were run through the process with each test batch to account for weight-loss attributable to sealers. The results of the control vehicles are presented in the Table 5-1.

Table 5-1
QA/QC Blanks

Vehicle Identification	Vehicle Weight Gain (lb)	Vehicle Batch	Comment
TE4	-0.12	Metallic Basecoat- Silver	Corrected for three vehicles in test batch
TE5	-0.07		
TE4	-0.02	Solid Basecoat-White	Control vehicles within testing tolerances, not used to adjust batch vehicle weight gain value
TE5	-0.02		
TE4	-0.04	Clearcoat-Standard	Corrected for three vehicles in test batch
TE5	-0.15		

5.4 QA/QC Problems

No quality assurance/quality control problems were encountered during this test program.

Limitations

The information and opinions rendered in this report are exclusively for use by Chrysler Group LLC. Bureau Veritas North America, Inc. will not distribute or publish this report without Chrysler Group LLC's consent except as required by law or court order. The information and opinions are given in response to a limited assignment and should be implemented only in light of that assignment. Bureau Veritas North America, Inc. accepts responsibility for the competent performance of its duties in executing the assignment and preparing reports in accordance with the normal standards of the profession, but disclaims any responsibility for consequential damages.

This report prepared by: ______________________
Dillon King
Consultant
Health, Safety, and Environmental Services

This report reviewed by: ______________________
Thomas R. Schmelter, QSTI
Senior Project Manager
Health, Safety, and Environmental Services

____
Derek R. Wong, Ph.D., P.E.
Director and Vice President
Health, Safety, and Environmental Services

Tables

Table 1

Paint Solids Transfer Efficiency Results

Chrysler Group LLC - Warren Truck Assembly Plant

Warren, Michigan

Bureau Veritas Project No. 11013-000181.00

Date: October 14, 2013 through October 16, 2013

Parameter	Units	Source Color 2
Metallic Basecoat - Silver		
Batch Vehicle Weight Gain†	pounds	6.13
Batch Paint Sprayed	gallons	2.03
Coating Density	pounds per gallon	8.29
Weight Solids Fraction	percent	0.51
Batch Solids Sprayed	pounds	8.61
Solids Transfer Efficiency	percent	**71.2**
Solid Basecoat - White		
Batch Vehicle Weight Gain‡	pounds	11.27
Batch Paint Sprayed	gallons	2.66
Coating Density	pounds per gallon	10.39
Weight Solids Fraction	percent	0.63
Batch Solids Sprayed	pounds	17.43
Solids Transfer Efficiency	percent	**64.6**
Clearcoat - Standard		
Batch Vehicle Weight Gain†	pounds	8.64
Batch Paint Sprayed	gallons	2.73
Coating Density	pounds per gallon	8.62
Weight Solids Fraction	percent	0.57
Batch Solids Sprayed	pounds	13.50
Solids Transfer Efficiency	percent	**64.0**

†: corrected for sealer weight loss

‡: control vehicles not used to adjust batch vehicle weight gain

Table 2

Basecoat Bake Oven VOC CE Results - Color 2 and Reprocess

Chrysler Group LLC -Warren Truck Assembly Plant

Warren, Michigan

Bureau Veritas Project No. 11013-000184.00

Date: October 10, 2013

Parameter	Units	Source	
		Color 2	Reprocess
Average Blank Panel Weight	grams	187.670	187.233
Average Coated Panel Weight Before Bake Oven	grams	188.262	188.568
Average Coated Panel Weight After Bake Oven	grams	188.199	188.480
Weight of Coating Solids Deposited	grams	0.529	1.247
Weight of VOC's Available for Abatement	grams	0.063	0.088
Weight of VOC's Available per Volume of Coating Solids	lb/gacs	**1.25**	**0.74**
Mass of VOC's per Volume of Coating	lb/gal	4.12	4.12
Tansfer Efficiency	percent	71.2	71.2
Volume of Solids Deposited per Volume of Coating Sprayed	ratio	0.289	0.289
Basecoat Bake Oven VOC Capture Efficiency	percent	**8.8**	**5.2**
Basecoat Bake Oven VOC Capture Efficiency at 100% TE	percent	**12.4**	**7.3**

Coating Density (lb/gal): 8.27
Mass Fraction Solids: 0.517
Volume Fraction Solids: 0.406
VOC Mass Fraction: 0.498
Solids Density (lb/gal): 10.53
lb/gacs: pounds per gallons of applied coating solids
lb/gal: pounds per gallon

Table 3

Basecoat Bake Oven VOC CE Results - Tutone

Chrysler Group LLC -Warren Truck Assembly Plant

Warren, Michigan

Bureau Veritas Project No. 11013-000184.00

Date: October 11, 2013

Parameter	Units	Source
		Tutone
Average Blank Panel Weight	grams	188.016
Average Coated Panel Weight Before Bake Oven	grams	188.867
Average Coated Panel Weight After Bake Oven	grams	188.773
Weight of Coating Solids Deposited	grams	0.757
Weight of VOC's Available for Abatement	grams	0.095
Weight of VOC's Available per Volume of Coating Solids	lb/gacs	**1.31**
Mass of VOC's per Volume of Coating	lb/gal	4.12
Tansfer Efficiency	percent	71.2
Volume of Solids Deposited per Volume of Coating Sprayed	ratio	0.289
Basecoat Bake Oven VOC Capture Efficiency	percent	**9.2**
Basecoat Bake Oven VOC Capture Efficiency at 100% TE	percent	**12.9**

Coating Density (lb/gal): 8.25
Mass Fraction Solids: 0.516
Volume Fraction Solids: 0.406
VOC Mass Fraction: 0.499
Solids Density (lb/gal): 10.48
lb/gacs: pounds per gallons of applied coating solids
lb/gal: pounds per gallon

BUREAU VERITAS

Table 4

Clearcoat Bake Oven VOC CE Results - Color 2 and Reprocess

Chrysler Group LLC -Warren Truck Assembly Plant

Warren, Michigan

Bureau Veritas Project No. 11013-000184.00

Date: October 10, 2013

Parameter	Units	Source	
		Color 2	Reprocess
Average Blank Panel Weight	grams	188.005	187.784
Average Coated Panel Weight Before Bake Oven	grams	189.993	189.375
Average Coated Panel Weight After Bake Oven	grams	189.419	189.005
Weight of Coating Solids Deposited	grams	1.414	1.221
Weight of VOC's Available for Abatement	grams	0.574	0.370
Weight of VOC's Available per Volume of Coating Solids	lb/gacs	**3.98**	**2.97**
Mass of VOC's per Volume of Coating	lb/gal	3.88	3.88
Tansfer Efficiency	percent	64.0	64.0
Volume of Solids Deposited per Volume of Coating Sprayed	ratio	0.314	0.314
Clearcoat Bake Oven VOC Capture Efficiency	percent	**32.2**	**24.1**
Clearcoat Bake Oven VOC Capture Efficiency at 100% TE	percent	**50.4**	**37.6**

Coating Density (lb/gal): 8.61
Mass Fraction Solids: 0.559
Volume Fraction Solids: 0.491
VOC Mass Fraction: 0.451
Solids Density (lb/gal): 9.81
lb/gacs: pounds per gallons of applied coating solids
lb/gal: pounds per gallon

BUREAU VERITAS

Table 5

Clearcoat Bake Oven VOC CE Results - Tutone

Chrysler Group LLC -Warren Truck Assembly Plant

Warren, Michigan

Bureau Veritas Project No. 11013-000184.00

Date: October 11, 2013

Parameter	Units	Source
		Tutone
Average Blank Panel Weight	grams	187.903
Average Coated Panel Weight Before Bake Oven	grams	189.470
Average Coated Panel Weight After Bake Oven	grams	189.044
Weight of Coating Solids Deposited	grams	1.141
Weight of VOC's Available for Abatement	grams	0.426
Weight of VOC's Available per Volume of Coating Solids	lb/gacs	**3.64**
Mass of VOC's per Volume of Coating	lb/gal	3.88
Tansfer Efficiency	percent	64.0
Volume of Solids Deposited per Volume of Coating Sprayed	ratio	0.314
Clearcoat Bake Oven VOC Capture Efficiency	percent	**29.5**
Clearcoat Bake Oven VOC Capture Efficiency at 100% TE	percent	**46.0**

Coating Density (lb/gal): 8.62
Mass Fraction Solids: 0.555
Volume Fraction Solids: 0.491
VOC Mass Fraction: 0.450
Solids Density (lb/gal): 9.74
lb/gacs: pounds per gallons of applied coating solids
lb/gal: pounds per gallon

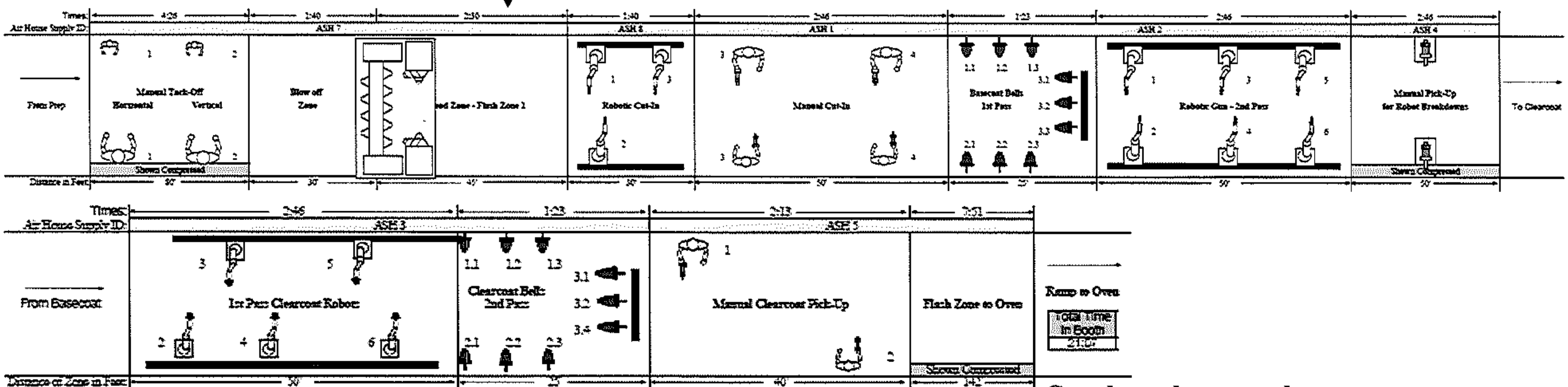
Figures

Tare Panel Weights	
Metallic basecoat - silver	
B1	187.185
B2	188.907
B3	Excluded from calculations
B4	186.918
Average	187.670

Tare Panel Weights	
Clearcoat - standard	
C1	187.779
C2	187.642
C3	188.788
C4	187.811
Average	188.005

Weight in grams

Panels mounted



Panels removed and weighed before being processed through oven

Cured panels removed and weighed after cooling

Coated Panel Weights	
Metallic basecoat - silver	
B1	187.712
B2	189.557
B4	187.517
Average	188.262

Coated Panel Weights	
Clearcoat - standard	
C1	189.369
C2	189.780
C3	190.990
C4	189.834
Average	189.993

Cured Panel Weights	
Metallic basecoat - silver	
B1	187.680
B2	189.477
B4	187.440
Average	188.199

Cured Panel Weights	
Clearcoat - standard	
C1	188.929
C2	189.161
C3	190.345
C4	189.242
Average	189.419

Figure 1
Color 1 and 2 Process Map

BUREAU VERITAS

Chrysler Group LLC
Warren Truck Assembly Plant
Warren, Michigan

Project No. 11013-0000181 and 184.00

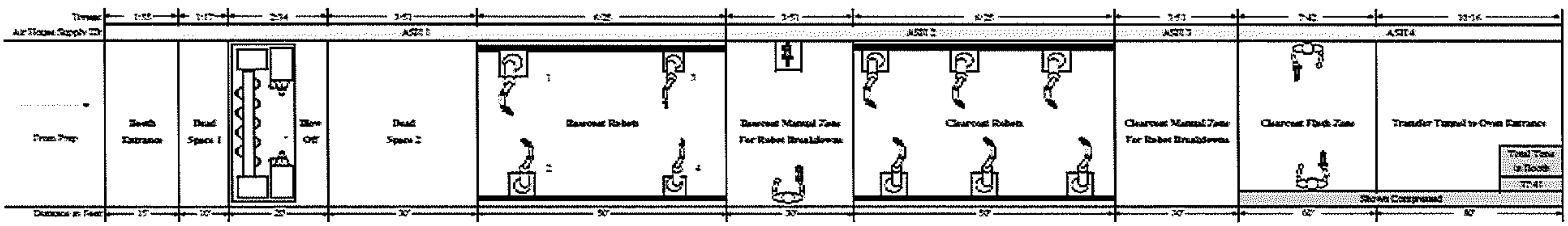
Last Revision:
November 11, 2013

Tare Panel Weights	
Metallic basecoat - silver	
B1	186.835
B2	187.506
B3	186.304
B4	188.287
Average	187.233

Tare Panel Weights	
Clearcoat - standard	
C1	187.510
C2	187.507
C3	187.844
C4	188.274
Average	187.784

Weight in grams

Panels mounted



Panels removed and weighed before being processed through oven

Cured panels removed and weighed after cooling

Coated Panel Weights	
Metallic basecoat - silver	
B1	187.680
B2	188.147
B3	189.113
B4	189.331
Average	188.568

Coated Panel Weights	
Clearcoat - standard	
C1	188.730
C2	188.996
C3	189.195
C4	190.580
Average	189.375

Cured Panel Weights	
Metallic basecoat - silver	
B1	187.634
B2	188.072
B3	189.010
B4	189.203
Average	188.480

Cured Panel Weights	
Clearcoat - standard	
C1	188.458
C2	188.657
C3	188.898
C4	190.007
Average	189.005

Figure 2
Reprocess process map

BUREAU VERITAS

Chrysler Group LLC
Warren Truck Assembly Plant
Warren, Michigan

Project No. 11013-0000181 and 184.00

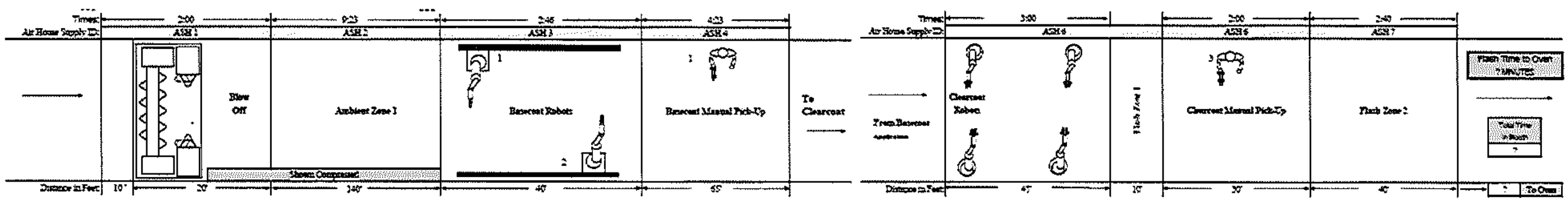
Last Revision:
November 11, 2013

Weight in grams

Tare Panel Weights	
Metallic basecoat - silver	
B1	187.106
B2	188.283
B3	188.440
B4	188.234
Average	188.016

Tare Panel Weights	
Clearcoat - standard	
C1	188.737
C2	187.258
C3	187.963
C4	187.652
Average	187.903

Panels mounted



Panels removed and weighed before being processed through oven

Cured panels removed and weighed after cooling

Coated Panel Weights	
Metallic basecoat - silver	
B1	188.019
B2	189.169
B3	189.391
B4	188.890
Average	188.867

Coated Panel Weights	
Clearcoat - standard	
C1	190.706
C2	189.199
C3	188.944
C4	189.031
Average	189.470

Cured Panel Weights	
Metallic basecoat - silver	
B1	187.891
B2	189.061
B3	189.325
B4	188.813
Average	188.773

Cured Panel Weights	
Clearcoat - standard	
C1	190.159
C2	188.662
C3	188.707
C4	188.647
Average	189.044

Figure 3
Tutone process map

BUREAU VERITAS

Chrysler Group LLC
Warren Truck Assembly Plant
Warren, Michigan

Project No. 11013-0000181 and 184.00

Last Revision:
November 11, 2013