FINAL REPORT

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FCA US LLC

STERLING HIEGHTS, MICHIGAN

STERLING HEIGHTS ASSEMBLY PLANT – NORTH PAINT SHOP TRANSFER EFFICIENCY AND CAPTURE EFFICIENCY TESTING

RWDI #2306844

November 20, 2023

SUBMITTED TO

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EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) and JLB Industries, LLC were retained by FCA US LLC (FCA) to complete compliance testing of the Topcoat operations at their Sterling Heights Assembly Plant (SHAP) North Paint Shop located at 38111 Van Dyke, Sterling Heights, Michigan. The scope of the test program was to complete paint solids transfer efficiency (TE) and Capture Efficiency (CE) testing of the Topcoat operations (FG-AUTO MACT), for one (1) representative Topcoat Booth (EU-TOPCOAT1-NORTH or EU-TOPCOAT2-NORTH or EU-TOPCOAT3-NORTH), on the following coatings:

- Metallic Basecoat (Black);
- Solid Basecoat (White); and
- Clearcoat.

SHAP North Paint Shop currently operates under Title V Renewable Operating Permit (ROP) Permit # MI-ROP-B7248-2020a dated August 3, 2022. Results of the testing are considered representative of plant conditions. The testing program consisted of Transfer Efficiency (TE) testing and Capture Efficiency (CE) testing. Determination of TE and CE were conducted in accordance with all applicable procedures contained in USEPA document "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Topcoat Operations". The testing was completed on October 3rd and 4th, 2023. The testing consisted of the following:

- Paint solids transfer efficiency (TE) – the percent of paint solids sprayed that deposit on the painted part was measured when applying White solid basecoat, Black metallic basecoat and standard clearcoat in the "EU-TOPCOAT2-NORTH" line and are considered to be representative for all Topcoat Operations.

- Volatile Organic Compound (VOC) capture efficiency (CE) was completed on the flash zone, controlled booth zone and bake oven for the "EU-TOPCOAT2-NORTH" line. This includes the percent of VOC captured from the curing of the coating in the flash zone and bake oven. The flash and bake oven VOC CE is used to calculate the mass of VOC captured per gallon of applied coating solids (lb VOC/gacs) and is also referred to as oven solvent loading. Flash and Oven VOC CE was measured at "EU-TOPCOAT2-North" Spraybooth when applying solid White basecoat, Black metallic basecoat and standard clearcoat and are considered to be representative for all Topcoat Operations.

RWDI/JLB Industries used highly accurate weighing systems to determine the vehicle and panel weights before and after coating application. Calibrated volumetric flow meters, located on each applicator, were used to measure paint usage.

Material samples were collected from the paint circulation tanks directly after vehicle spray out. Determination of percent solids by weight and density was performed by JLB Industries, LLC.

Executive Summary Table i: Transfer Efficiency (TE) Results Summary

Tested Coating	Solids Transfer Efficiency (%)
Basecoat (White Solid Basecoat)	69.8%
Basecoat (Black Metallic)	74.5%
Clearcoat	75.7%

Executive Summary Table ii: Capture Efficiency (CE) Results Summary

		Loading (Lb/GACS)	Capture Efficiency
		EU-TOPCOAT-NORTH	EU-TOPCOAT-NORTH
Solid Basecoat (White)	**Flash**	3.06	**59.7%**
	Oven	1.60	
	Total	**4.66**	
Metallic Basecoat (Black)	**Flash**	4.30	**69.2%**
	Oven	1.48	
	Total	**5.79**	
Clearcoat	**Booth**	5.18	55.6%
	Oven	2.99	32.5%
	Total	**8.17**	**88.1%**

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1 INTRODUCTION

RWDI USA LLC (RWDI) and JLB Industries, LLC were retained by FCA US LLC (FCA) to complete compliance testing of the Topcoat operations at their Sterling Heights Assembly Plant (SHAP) North Paint Shop located at 38111 Van Dyke, Sterling Heights, Michigan. The scope of the test program was to complete paint solids transfer efficiency (TE) and Capture Efficiency (CE) testing of the Topcoat operations (FG-AUTO MACT), for one (1) representative Topcoat Booth (EU-TOPCOAT1-NORTH or EU-TOPCOAT2-NORTH or EU-TOPCOAT3-NORTH), on the following coatings:

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A Source Testing Plan for the testing was submitted to the Michigan Department of Environment, Great Lakes & Energy (EGLE) on August 28, 2023. Testing was successfully completed while all process equipment was operating under normal maximum operating conditions on October 3rd and 4th, 2023. A copy of the Source Testing Plan is provided in **Appendix A**.

Testing of emissions was conducted by Mr. Jim Belanger, Mr. Jeff Monache and Mr. Kyle Lyons of JLB, and Mr. Hunter Griggs of RWDI. Mr. Adekunle Sanni and Mr. Thomas Caltrider were on-site to monitor the process operation and witness the testing on behalf of FCA US LLC.

2 SOURCE AND SAMPLING LOCATIONS

2.1 Process Description

SHAP is located at 38111 Van Dyke in Sterling Heights, Michigan. The facility completes assembly and paint operations for FCA US LLC. Vehicle body panels are stamped and assembled on site from sheet metal components. The bodies are cleaned, treated, and prepared for painting in the phosphate system. Drawing compounds, mill oils, and dirt are removed from the vehicle bodies utilizing both high pressure spray and immersion cleaning/rinsing techniques. Vehicle bodies then are dip coated in electro deposition corrosion primer paint for protection. The electro primer (E-coat) is heat-cured to the vehicle body in a high-temperature bake oven. After completing the E-coat operation, vehicle bodies are conveyed to the sealer area for application of various sealants to body seams and joints. Vehicle bodies are then conveyed to an oven to cure the sealers.

After the sealer oven, the vehicles are routed to the powder prime system and then topcoat operations. In the topcoat system, the bodies receive a combination of waterborne and solvent borne coatings: basecoat and clearcoat coatings. After topcoat is applied, the vehicle is baked in the topcoat oven. After exiting the topcoat oven, the vehicles are routed to inspection.

An overview of the process to be sampled and associated sampling sites is provided below.

Figure 1: Process and Sampling Location Overview

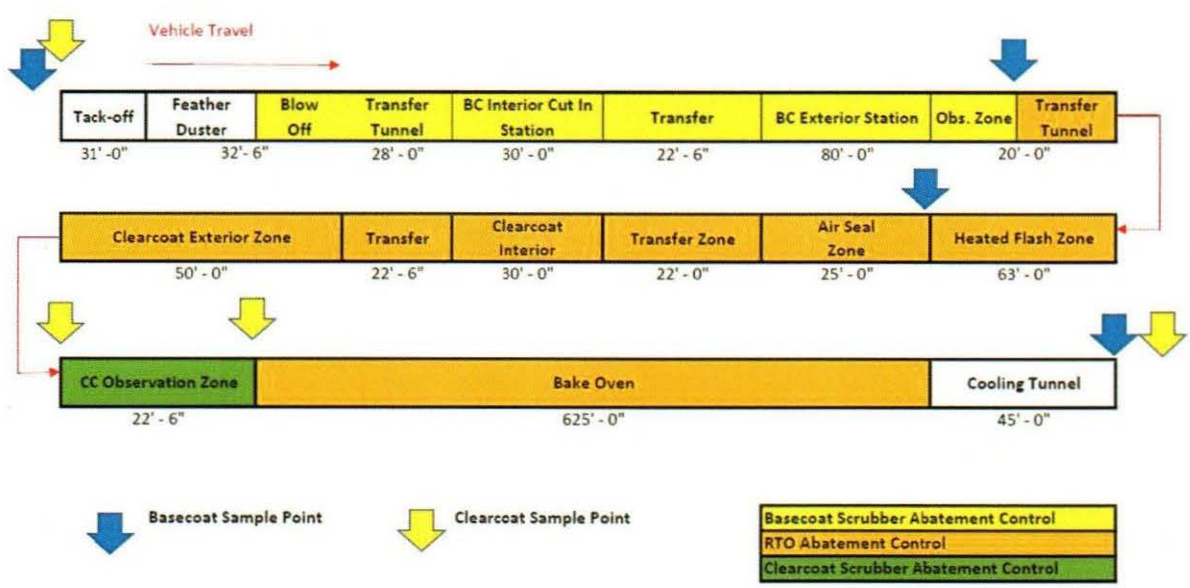


Table 2.1-1: Summary of Applicator Parameters

Operation	Manufacturer	Applicator	Fluid Tip/ Bell Size	Air Cap	Gun Voltage (kV)	RPM	Gun-to-Target Distance (inch)	Remarks
Basecoat Interior	Fanuc	P700	1.2 mm	N/A	40 kV	50,000	10 inch	Waterborne
Basecoat Exterior	Fanuc	250	0.9 mm	N/A	80 kV	75,000	8 inch	Waterborne
Clearcoat Interior	Fanuc	P700	1.2 mm	N/A	40 kV	50,000	10 inch	Solvent
Clearcoat Exterior	Fanuc	250	1.2 mm	N/A	80 kV	75,000	8 inch	Solvent

Notes: mm - millimetres
kV - kilovolts
RPM - revolutions per minute

2.2 Control Equipment

Topcoat Spray Booths are controlled using a downdraft ventilation system and water wash system below the booth grate to control paint overspray. Captured basecoat heated flash zone and bake oven VOC emission are directed to regenerative thermal oxidizer for VOC abatement. Clearcoat from the booth, flash zone and oven are directed to the same regenerative thermal oxidizer for VOC abatement. All controls were functioning during the testing period.

2.3 Operating Parameters

The following process control measures were recorded during the testing:

- Coating usage;
- Application information;
- Bake Oven Temperature;
- Spray booth relative humidity; and
- Spray booth temperature.

The following summarizes the Spray Booth and Bake Oven process conditions.

Table 2.3-1: Summary of Operating Conditions

Source	Spray Booth Temperature			Spray Booth Relative Humidity			Bake Oven Temperature		
	Unit	10/3/23	10/4/23	Unit	10/3/23	10/4/23	Unit	10/3/23	10/4/23
EU-Topcoat2 - NORTH Spray Booth	FA 1	75°F	76°F	FA 1	60%	60%	Zone 1	340°F	341°F
	R2	81°F	80°F	R2	80%	80%	Zone 2	370°F	370°F
	R3	80°F	79°F	R3	62%	62%	Zone 3	285°F	287°F
	HF	130°F	130°F	HF	N/A	N/A	Zone 4	281°F	279°F
	FA 7	77°F	76°F	FA 7	62%	62%	Zone 5	268°F	269°F
	R4	77°F	77°F	R4	62%	63%	Sill 1	270°F	270°F
	R5	82°F	82°F	R5	58%	57%	Sill 2	271°F	270°F
	R6	82°F	81°F	R6	62%	62%	Cooling	90 °F	84 °F

2.4 Process Sampling Locations

A process sample of each coating applied during the testing was collected for analysis. The coatings were collected following procedures in USEPA's "Standard Procedure for Collection of Coating and Ink Samples for Analysis by Method 24 and 24A".

Coating samples were collected at the application point into four (4) ounce glass sampling jars with minimal headspace. The coating-as-applied samples were analyzed using USEPA Method 24 to measure percent VOC, percent water and density. The results are summarized in **Appendix C**.

In addition, samples were collected by RWDI/JLB of waterborne coatings to analyze for percent moisture. The samples were collected at the point of application on foil panels attached to the test vehicles. The coated foils were then transferred into a four (4) ounce glass sampling jar and anhydrous methanol was added to the sampling jar to allow the coating to disperse. The sample was then allowed to separate and analyzed for percent water using ASTM E203-08 "Standard Test Method for Water Using Volumetric Karl Fischer Titration". The ASTM E203 -08 coating analysis is summarized in **Appendix C.**

3 SAMPLING AND ANALYTICAL PROCEDURES

3.1 Summary of Test Program

The topcoat process at SHAP North is comprised of three (3) topcoat paint lines consisting of the "EU-TOPCOAT1-NORTH", "EU-TOPCOAT2-NORTH" and "EU-TOPCOAT3-NORTH". The topcoat system consists of several spray sections followed by an associated curing oven. The spray booth operations are defined as follows:

- Basecoat Robots – Basecoat was applied to the exterior and interior surfaces; and
- Clearcoat Robots - Clearcoat was applied to the exterior and interior surfaces.

Skidded vehicles are conveyed through the booth and coated with topcoat materials (basecoat and clearcoat). The vehicles are processed through a bake oven where the coating is cured.

Currently, coatings are applied to the new RAM 1500 Cab production models. Production units on which an electrocoat corrosion inhibiting primer had been applied were used in the test program for the transfer efficiency testing. For the CE testing, scrap vehicles were used for the testing program. The test program is summarized below.

3.2 Transfer Efficiency Test

Transfer Efficiency testing was conducted in the Topcoat Spray Booth where White solid basecoat, Black metallic basecoat and clearcoat were applied. Applicator and environmental conditions were monitored to ensure that the testing accurately reflected production conditions. Measured parameters included: Vehicle weight gain, material usage, material analysis (percent solids by weight and density), applicator settings, film build and oven heat settings.

A total of four (4) vehicle bodies were used in calculating test results. Three (3) vehicles were processed as normal production vehicles, and one vehicle were dedicated as no-paint, control vehicles in conjunction with the testing. All units were production vehicles with sealer.

An off-line vehicle weigh station (VWS) was constructed to measure the weight of the test units before and after each painting process. Test vehicles were routed to a dedicated conveyor spur. A fixed stop was secured to assure repeatable positioning of the vehicles. Test vehicles were lifted free from their carriers by two lift-table mounted scale bases. Ultra-high molecular weight (UHMW) plastic blocks were strategically placed on the scale bases to lift the vehicle at the center of gravity locations. The UHMW blocks minimized friction loading on vehicles and scale bases.

Vehicle weights were measured several times and recorded. All test vehicles were weighed with production fixtures (door hooks and hood props) installed. The vehicle weigh station scales were calibrated using Class-F calibration weights conforming to the National Bureau of Standards handbook 105-1. A one or two-pound avoirdupois, Class F stainless steel weight was added periodically during pre- and post-process weighing to verify scale linearity.

Coating thickness was measured on a representative test vehicle to verify paint film-build was within the production specification. The data was taken with a handheld Elcometer gauge.

Coating material usage was monitored via volumetric flow measurement devices located on each applicator. A verification of each applicator was performed by FCA personnel to ensure accurate usage measurement. Material samples of applied coatings were collected from the respective systems directly after testing. Samples were analyzed by JLB to determine density by ASTM D1475 and weight solids content by ASTM D2369 (referenced in EPA Method 24). The laboratory results were used in calculating the Transfer Efficiency and Capture Efficiency values.

Production vehicles with paint shop sealer were prepared with prime and processed through the Topcoat Spray Booth. The test sequence for the Transfer Efficiency test was:

White Solid Basecoat:

1. Test Unit ID TE1 – Carrier 878
2. Test Unit ID TE2 – Carrier 920
3. Test Unit ID TE3 – Carrier 379
4. Test Unit ID TE4 – Carrier 311 (no-paint control)

Black Metallic Basecoat:

1. Test Unit ID TE1 – Carrier 878
2. Test Unit ID TE2 – Carrier 920
3. Test Unit ID TE3 – Carrier 379
4. Test Unit ID TE4 – Carrier 311 (no-paint control)

Clearcoat:

1. Test Unit ID TE1 – Carrier 878
2. Test Unit ID TE2 – Carrier 920
3. Test Unit ID TE3 – Carrier 379
4. Test Unit ID TE4 – Carrier 311 (no-paint control)

Test Vehicles were routed through the bake oven and back to the vehicle weigh station. After cooling, the test vehicles were weighed and released to production.

3.3 Capture Efficiency Tests

A panel weigh station (PWS) was assembled at the Topcoat Spray Booth. A precision balance with measurement capability to 0.001 gram was placed on an isolation platform inside an enclosure to minimize vibration and air movement.

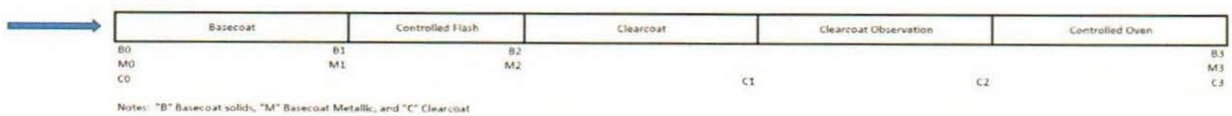
The testing conformed to the methods described in ASTM 5087-02 for solvent borne coatings and ASTM 6266-00a (Reapproved 2005) for waterborne coatings.

Test panels were placed on a test vehicle and processed with normal production spray programming.

Four (4) electrocoated panels were used for each test. Each group of test panels was weighed in four locations (see panel test diagram) to determine the relative distribution of VOC that is released in the controlled booth zone and bake oven. The panels were attached to test vehicles by magnet, which allowed for removal of the wet panels with minimal disturbance to the coating during handling. Panel mounting locations were chosen to achieve a representative coating film based on the observation of normal vehicle production.

Before the panels were coated, they were marked (1, 2, 3, 4, blank) and weighed to establish the initial unpainted panel weights (B0, M0 and C0). The panels were then attached to a test vehicle and routed through the Spray Booth. After coating, the panels were carefully removed from the test vehicle and brought to the balance for weighing immediately upon exit from the controlled booth zone (B1, M1 and C1). For Basecoat (Solids and Metallic), Panels were weighed again before entering the Controlled Flash (B2 and M2) and again after the controlled flash (B3 and M3) prior to the controlled bake oven. The panels were then placed on the test vehicle for travel through the curing oven. Upon exiting the oven, the panels were allowed to cool and then weighed a final time (B4 and M4). For the clearcoat samples, after clearcoat application (C1), panels are weighed prior to the controlled oven (C2) and after the controlled oven C3).

Figure 2: Panel Testing Diagram



4 TEST EQUIPMENT AND QA/QC PROCEDURES

Equipment used in this program passed the Quality Assurance /Quality Control (QA/QC) procedures. **Appendix D** contains the calibration records of the equipment and inspection sheets.

4.1 Pretest QA/QC Activities and Audits

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

The results of select sampling and equipment QA/QC audits are presented in the following sections. Refer to **Appendix D** for inspection and calibration sheets.

4.2 Test Equipment and QA/QC Procedures

4.2.1 Vehicle Weigh Station (VWS)

A dedicated vehicle weigh station (VWS) equipped with two 1,000 lb. capacity scale bases was used to obtain pre- and post-process vehicle weights. The VWS is accurate to better than 0.05 pounds.

The scales were calibrated as directed by the operating instruction manual. Scales were powered up and exercised by placing 250 pounds of Class F calibration weights on each scale platform. Then, the VWS was calibrated with 500 pounds of Class F calibration weights. VWS linearity was checked using a one-pound, Class F stainless steel calibration weight. The one-pound weight was also added to each test vehicle during pre- and post-process weighing to verify scale linearity.

4.2.2 Material Usage

Coating material usage was monitored via volumetric flow measurement devices located on each applicator. A verification of the applicators was performed by FCA personnel before testing to ensure accurate usage data. Paint usage was measured at each applicator in a graduated cylinder and compared to the expected volume.

A sample of each material was taken after each test and analyzed by JLB at their facility in Rochester Hills, Michigan. These values were used in calculating the paint solids sprayed and the transfer efficiency. ASTM Method D-2369 was used to determine paint solids. ASTM Method D-1475 was used to determine paint density.

4.2.3 Panel Weigh Station

A panel weigh station (PWS) with measurement capability to 0.001 gram was used to measure panel weights. The balance was warmed up and then calibrated with a 300 gram test weight. The balance was tested with 100, 50, 10 and 1 gram weights before commencing weighing operations. A blank panel weight was measured at the beginning of the testing program and again at the time of each subsequent panel weight measurement. The balance was placed on an isolation platform and inside an enclosure to minimize vibration and airflow at the measurement point.

5 RESULTS

The testing program consisted of Transfer Efficiency (TE) testing and Oven Capture Efficiency (CE) testing. Determination of TE and CE were conducted in accordance with all applicable procedures contained in USEPA document "Protocol for Determining the Daily Volatile Organic Compound Emission Rate of Automobile and Light-Duty Truck Topcoat Operations".

5.1 Results

Results are summarized in Tables 5.1-1 and 5.1-2 for TE and CE. Detailed VOC CE and paint solids TE results are presented in Table Section. All sampling field notes are provided in **Appendix F**. Sample Calculations are provided in **Appendix G**. All laboratory results are included in **Appendix C**. Process Data is provided in **Appendix B**.

Table 5.1-1: Transfer Efficiency (TE) Results Summary

Tested Coating	Solids Transfer Efficiency (%)
Basecoat (White Solid Basecoat)	69.8%
Basecoat (Black Metallic)	74.5%
Clearcoat	75.7%

Table 5.1-2: Capture Efficiency (CE) Results Summary

		Loading (Lb/GACS)	Capture Efficiency
		EU-TOPCOAT-NORTH	EU-TOPCOAT-NORTH
Solid Basecoat (White)	Flash	3.06	59.7%
	Oven	1.60	
	Total	4.66	
Metallic Basecoat (Black)	Flash	4.30	69.2%
	Oven	1.48	
	Total	5.79	
Clearcoat	Booth	5.18	55.6%
	Oven	2.99	32.5%
	Total	8.17	88.1%

5.2 Discussion of Results

There were no significant disruptions to the testing program.

6 PROCESS CONDITIONS

Operating conditions during the sampling were monitored by FCA personnel. All equipment was operated under normal maximum operating conditions. Process Data is provided in **Appendix B**.

Contact was maintained between the operator and the sampling team. A member of the RWDI/JLB sampling team was in contact with FCA staff during the entire sampling program.

7 CONCLUSIONS

Testing was successfully completed October 3rd and 4th, 2023. All parameters were tested in accordance with referenced methodologies.

TABLES

FCA US LLC SHAP North
October 2023
Summary

Table 1: VOC Loading and Capture Efficiency

Process	Loading (Lb VOC/GACS)	Capture Efficiency (%)
Clearcoat Booth	5.18	55.6%
Clearcoat Oven	2.99	32.5%
Total Clearcoat	**8.17**	**88.1%**
Metallic Basecoat Flash	4.30	
Metallic Basecoat Oven	1.48	
Total Metallic Basecoat Flash and Oven	**5.79**	**69.2%**
Solid Basecoat Flash	3.06	
Solid Basecoat Oven	1.60	
Total Solid Basecoat Flash and Oven	**4.66**	**59.7%**

Table 2: Transfer Efficiency

Process	Transfer Efficiency (%)
Solid Basecoat	69.8%
Metallic Basecoat	74.5%
Clearcoat	75.7%

Table 3: White Solid Basecoat Transfer Efficiency Summary
SHAP North, October 2023

Vehicle ID	Vehicle Weight Gain (lb.)	Average Vehicle Weight Gain (lb.)	Average Paint Sprayed (gal)	Coating Density (lb/gal)	Weight Solids Fraction	Average Solids Sprayed	Transfer Efficiency (%)
Variable:	VWG	AVWG	APS	CD	WSF	SS	TE
Calculation:	(W2-W1)	(sumVWG-SWL)	(PS)	(Method 24)	(Method 24)	(APS*CD*WSF)	(AVWG/SS)
TE 1	2.07	1.99	0.583	10.32	0.4740	2.85	**69.8%**
TE 2	1.92						
TE 3	1.98						

Table 4: Black Metallic Basecoat Transfer Efficiency Summary

SHAP North, October 2023

Vehicle ID	Vehicle Weight Gain (lb.)	Average Vehicle Weight Gain (lb.)	Average Paint Sprayed (gal)	Coating Density (lb/gal)	Weight Solids Fraction	Average Solids Sprayed	Transfer Efficiency (%)
Variable:	VWG	AVWG	APS	CD	WSF	SS	TE
Calculation:	(W2-W1)	(sumVWG-SWL)	(PS)	(Method 24)	(Method 24)	(APS*CD*WSF)	(AVWG/SS)
TE 1	1.05	1.03	0.511	8.64	0.3129	1.38	**74.5%**
TE 2	1.05						
TE 3	0.99						

Table 5: Clearcoat Transfer Efficiency Summary
SHAP North, October 2023

Vehicle ID	Vehicle Weight Gain (lb.)	Average Vehicle Weight Gain (lb.)	Average Paint Sprayed (gal)	Coating Density (lb/gal)	Weight Solids Fraction	Average Solids Sprayed	Transfer Efficiency (%)
Variable:	VWG	AVWG	APS	CD	WSF	SS	TE
Calculation:	(W2-W1)	(sumVWG-SWL)	(PS)	(Method 24)	(Method 24)	(APS*CD*WSF)	(AVWG/SS)
TE 1	2.09	2.16	0.574	8.65	0.5746	2.85	**75.7%**
TE 2	2.19						
TE 3	2.20						

Note: Clearcoat is applied at a 1A:1B Ratio. Coating solids and density reflect an average of Clearcoat Part A and Part B.