EXECUTIVE SUMMARY

RWDI USA LLC (RWDI) was retained by FCA US LLC (FCA) to complete the emission sampling program at their Chrysler Technology Center (CTC) located at 800 Chrysler Drive, Auburn Hills, Michigan. CTC is primarily used as research and development center for automobiles and light duty trucks. Operations and equipment at CTC include dynamometer test cells used for engines and engine component testing. This report contains all information pertaining to two test plans submitted:

- Chrysler Technology Center: Source Testing Plan: FG-UNTRLDCELLS Powertrain
- Chrysler Technology Center: Source Testing Plan Addendum: FG-CNTRLDCELLS Powertrain

Testing on FG-UNTRLDCELLS was executed to show compliance with Michigan Department of Environment, Great Lakes, and Energy (EGLE) PTI 155-18. Testing consisted of triplicate 60-minute tests on two (2) representative cells for Nitrogen Oxides (NO_x), Carbon Monoxide (CO), and Volatile Organic Compounds (VOCs). EU-CELL-B10 (Cell B10) and EU-CELL-B11 were both tested on August 9, 2021.

Testing on FG-CNTRLDCELLS was executed to show compliance with EGLE PTI 155-18. Testing consisted of triplicate 60-minute test run on two (2) oxidizers (one (1) from the C-Wing (C-Wing 4.01) and one (1) from the D-Wing (D-Wing 4.03)) for VOCs. Testing for C-Wing 4.01 was done on August 11, 2021, and D-Wing 4.03 was completed on August 10, 2021.

The following tables represent a summary of the stack testing results.

Summary of EU-CELL-B10 Emission Data:

Parameter	Symbol	Units	Average
Nitrogen Oxides Emission Rate	NO_x	lb NOx/gal	<0.01
Carbon Monoxide Emission Rate	CO	lb CO/gal	0.19
VOCs (as propane) Emission Rate	VOC	lb VOC/gal	0.025

Summary of EU-CELL-B11 Emission Data:

Parameter	Symbol	Units	Average
Nitrogen Oxides Emission Rate	NO_x	lb NOx/gal	0.012
Carbon Monoxide Emission Rate	CO	lb CO/gal	0.027
VOCs (as propane) Emission Rate	VOC	lb VOC/gal	0.031

Summary of C-Wing 4.01 Emission Data:

Parameter	Symbol	Units	Average
VOCs (as propane) Emission Rate	VOC	lb VOC/gal	0.0010

Summary of D-Wing 4.03 Emission Data:

Parameter	Symbol	Units	Average
VOCs (as propane) Emission Rate	VOC	lb VOC/gal	0.0007

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1 INTRODUCTION

RWDI USA LLC (RWDI) was retained by FCA US LLC (FCA) to complete the emission sampling program at their Chrysler Technology Center (CTC) located at 800 Chrysler Drive, Auburn Hills, Michigan. CTC is primarily used as research and development center for automobiles and light duty trucks. Operations and equipment at CTC include dynamometer test cells used for engines and engine component testing. This report contains all information pertaining to two test plans submitted:

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Testing on FG-CNTRLDCELLS was executed to show compliance with EGLE PTI 155-18. Testing consisted of triplicate 60-minute test run on two (2) oxidizers (one (1) from the C-Wing (C-Wing 4.01) and one (1) from the D-Wing (D-Wing 4.03)) for VOCs. Testing for C-Wing 4.01 was done on August 11, 2021, and D-Wing 4.03 was completed on August 10, 2021. A copy of the two test plans and PTI are provided in **Appendix A**.

Results from the sampling program are presented in the **Tables Section** of the report, with more detailed sampling results provided in the **Appendices**. Copies of the approval letter and related correspondence are provided in **Appendix A**.

2 SOURCE DESCRIPTION

2.1 Facility Description

CTC is primarily used as a research and development center for automobiles and light-duty trucks. Operations and equipment at CTC under the current PTI include dynamometer test cells used for engines, vehicle drive trains, and engine component testing. Test cells are in operation in five (5) wings of the Powertrain division (A-Wing, B-Wing, C-Wing, D-Wing and E-Wing).

Uncontrolled testing cells in flexible group FG-UNTRLDCELLS include all the B-Wing dynamometer test cells and some of the test cells in C-Wing and E-Wing (performance test cells). These test cells do not have emission control equipment associated with the Emission Units. Depending on the engine test program conducted on a given test stand, the engine may or may not be operated with a catalytic converter.

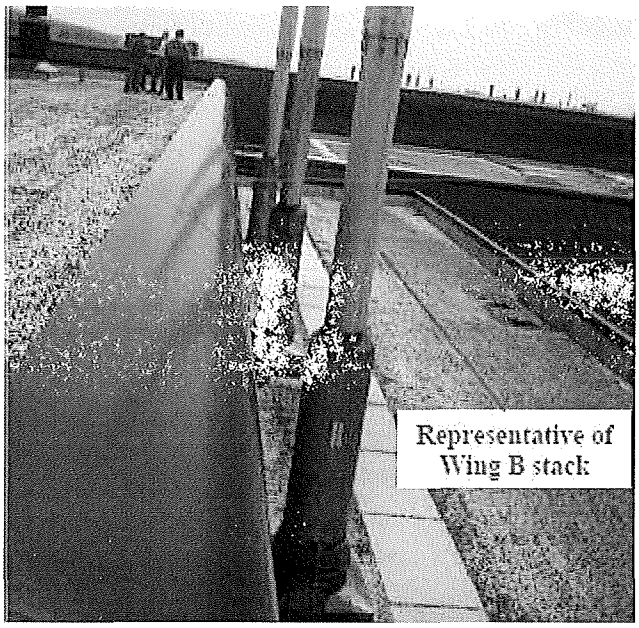
As noted in the PTI, within the C-Wing, D-Wing and E-Wing, up to forty-six (46) engine dynamometer test cells house a total of eighty (80) dynamometer test stands. The test cells in C-Wing, D-Wing and E-Wing in flexible group FG-CNTRLDCELLS are controlled using Thermal Oxidizers. There are a total of eleven (11) thermal oxidizers for the durability and transmission test cells.

3 SAMPLING LOCATION

3.1 Sample Location Description

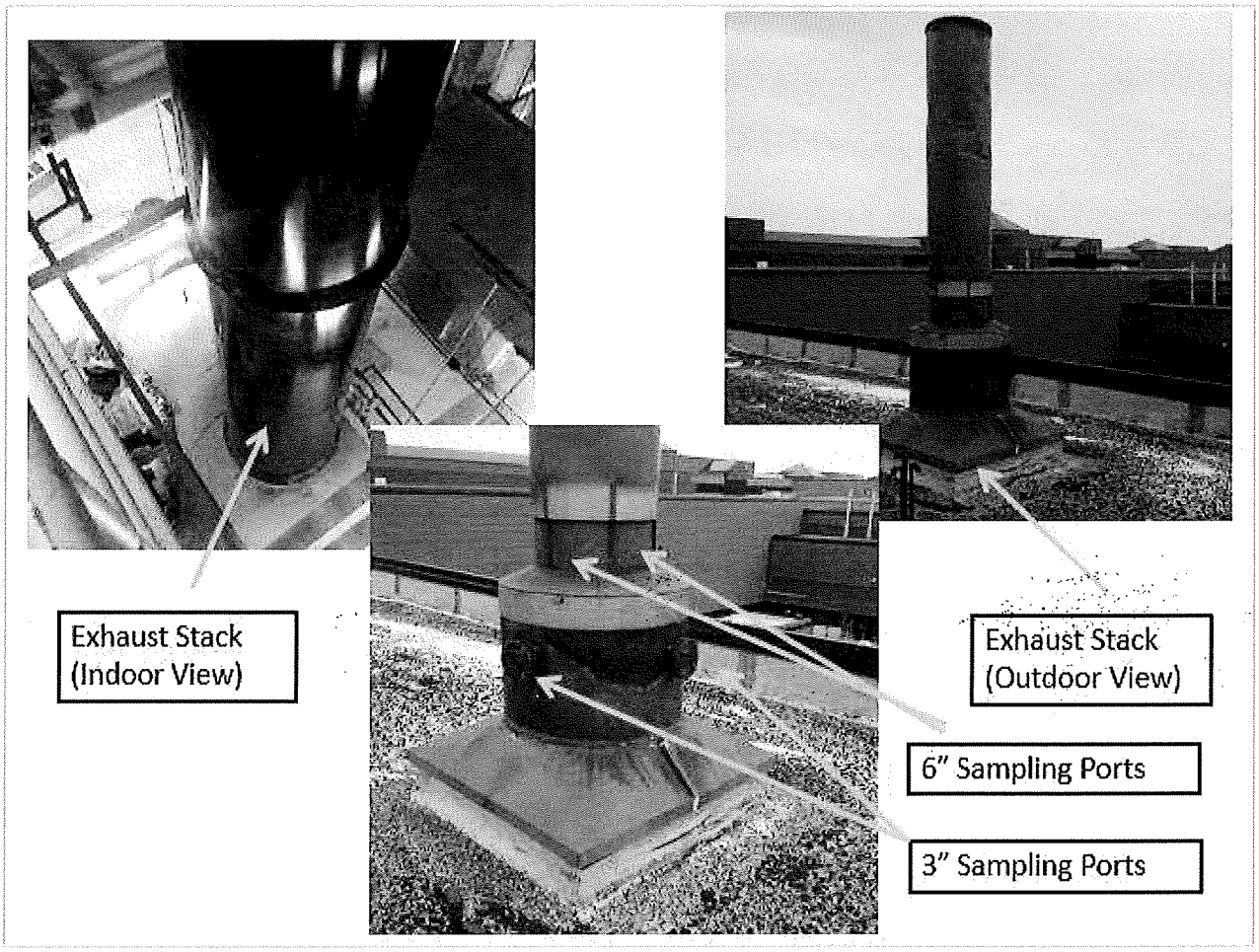
The sampling locations for each source are located outside. The outlet sampling location for Cell-B10 and Cell-B11 meet the USEPA Method 1 criteria. Samples were extracted from sampling ports in the exhaust stack. Both stacks were 10.5 inches in diameter and were at least 2 diameters upstream and 8 diameters downstream from any flow disturbance.

Figure 1: Wing B Exhaust Stack Photo



The outlet sampling locations for C-Wing and D-Wing thermal oxidizers are identical. Each stack has an inside diameter of 22 inches and has a set of 2 sampling ports set at 90 degrees apart. The sampling ports are located at least 8 duct diameters downstream from any flow disturbance and at least 2 duct diameter upstream from any flow disturbance.

Figure 2: Thermal Oxidizer Exhaust Stack Photo



The sampling point selection and stratification test was performed in accordance with EPA Reference Method 7E section 8.1.2. (applicable to instrumental analyzer methods).

4 SAMPLING METHODOLOGY

The following section provides an overview of the sampling methodologies used in this program.

4.1 Stack Velocity, Temperature, and Volumetric Flow Rate Determination

The exhaust velocities and flow rates were determined following the US EPA Method 2, "Determination of Stack Gas Velocity and Flow Rate (Type S Pitot Tube)". Velocity measurements were taken with a pre-calibrated S-Type pitot tube and incline manometer. Volumetric flow rates were determined following the equal area method as outlined in US EPA Method 1. Temperature measurements were made simultaneously with the velocity measurements and will be conducted using a chromel-alumel type "k" thermocouple in conjunction with a digital temperature indicator.

The dry molecular weight of the stack gas was determined following calculations outlined in US EPA Method 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)" for Oxygen content. Stack moisture content and carbon dioxide content was determined using an extractive Fourier Transform Infrared (FTIR) spectroscopy and according to US EPA Method 320, "Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR Spectroscopy)". Moisture was collected at a single point during each test.

4.2 Continuous Emissions Monitoring for O_2, CO_2, CO, NOx, and VOCs

Testing for O_2, CO_2, CO, NO_X, and VOCs was accomplished using continuous emission monitors (CEM) and the FTIR. The exhaust gas sample was sampled by drawing a sample stream of flue gases through a stainless-steel probe attached to a heated filter and a heated sample line that is attached to the Automated Sampling Console (ASC-10ST). The ASC-10ST sampling console delivers a continuous sample to the MKS MultiGas 2030 FTIR for analysis.

The heated line was maintained at approximately 375°F and the MKS MultiGas 2030 FTIR and MAX Analytical ASC-10ST gas components were at 375°F. The end of the probe was connected to a heated Teflon sample line, which delivers the sample gases from the stack to the FTIR system. The heated sample line is designed to maintain the gas temperature 375°F in order to prevent condensation of stack gas moisture within the line and as recommended by EGLE. The sample was then routed through a manifold system and introduced to the individual CEM's for measurement.

The ASC-10ST was used to deliver calibration gases (Calibration Transfer Standard (CTS), QA Spike and Nitrogen) to the FTIR in direct (to analyzer) and system (to probe) modes.

A laptop computer was utilized for operating the MKS MultiGas 2030 FTIR and MAX Analytical ASC-10ST sampling console and logging the multi-gas FTIR data. Data was logged as one-minute averages for the actual test period (FTIR PRN files and Spectra). All concentration data were determined using the MKS 2030 MultiGas FTIR software. A typical MKS 2030 FTIR and ASC-10 ST configuration is depicted in **Figure 3**.

For oxygen measurement, an EPA Method 3A compliant Brand Gaus Model 4710 wet O_2 analyzer was used. Prior to testing, sample system bias checks and instrument linearity checks (calibration error) were completed in compliance with EPA Method 3A. In addition, the analysers were calibrated (zeroed and span checked) at the completion of each run. A data logger system programmed to collect and record data at 1- second intervals was used to compute and record one-minute average concentrations. The average was drift corrected using pre and post drift checks and changed from wet to dry using stack moisture content.

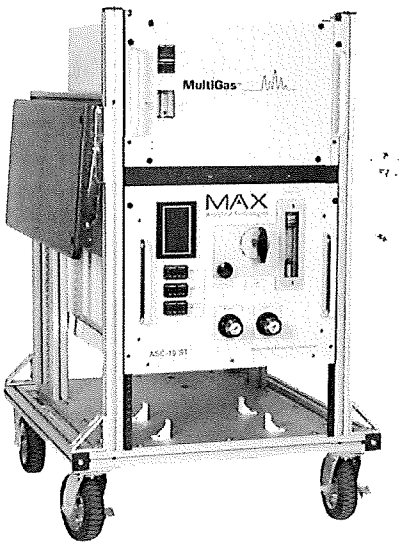


Figure 3: Typical MKS MultiGas 2030 FTIR and ASC-10ST measurement system

Figure 4 provides a schematic of the MKS MultiGas 2030 FTIR/ASC-10ST/Model 4710 Oxygen Analyzer Sampling System.

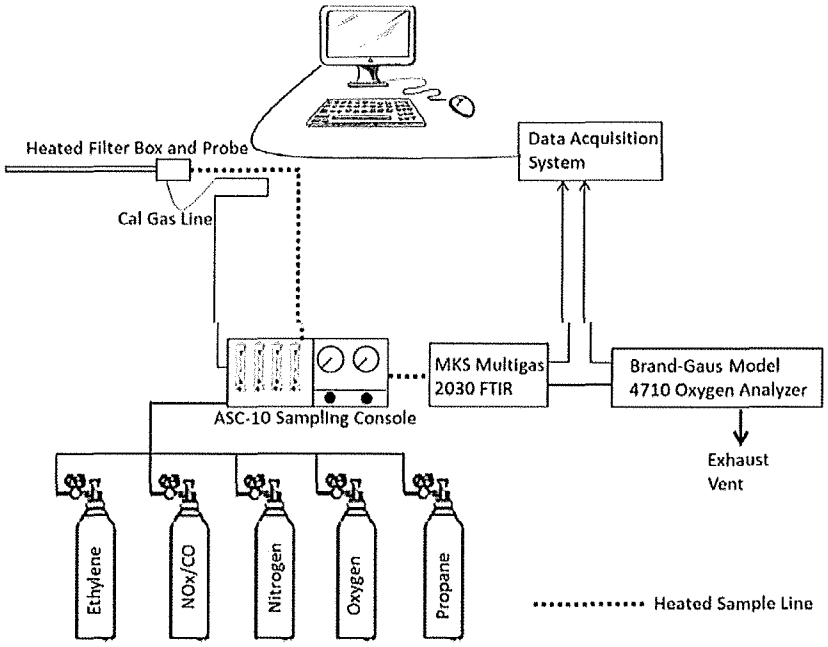


Figure 4: MKS MultiGas 2030 FTIR/ASC-10ST/Model 4710 Oxygen Analyzer Sampling System

4.3 Quality Assurance/Quality Control Activities

Applicable quality assurance measures were implemented during the sampling program to ensure the integrity of the results. These measures included detailed documentation of field data, and equipment calibrations for all measured parameters.

Quality control procedures specific to the CEM monitoring equipment included linearity checks to determine the instrument performance and reproducibility checks prior to its use in the field. Regular performance checks on the analyser were also carried out during the testing program by performing hourly zero checks and span calibration checks using primary gas standards. Sample system bias checks were also done. These checks were used to verify the ongoing accuracy of the monitor and sampling system over time. Pollutant-free nitrogen was introduced to perform the zero checks, followed by a known calibration (span) gas into the monitor. The response of the monitor to pollutant-free air and the corresponding sensitivity to the span gas were recorded regularly during the tests.

Pre and post test leak checks were done on the flow system by pressurizing and plugging the positive and negative side of the pitot separately. Daily temperature sensor audits were completed by noting the ambient temperature, as measured by a reference thermometer, and comparing these values to those obtained from the stack sensor.

The FTIR test method follows the US EPA Method 320 test procedures. The primary control check for the FTIR (EPA Method 320) is a Calibration Transfer Standard (CTS) check which was performed before and after each test run.

Initial background spectrum using dry nitrogen gas was obtained per Section 8.5 of EPA Method 320. A CTS was performed pre-test using procedures outlined in Section 8.6.1 of EPA Method 320. A post-test CTS per source was also performed. CTS result averages were measured to be within ±5% of the calibration gas standard.

In addition, a known calibration spike was introduced into the FTIR once per day for the source to confirm the FTIR is working properly and verify the ability to quantify the target analytes in the presence of the stack gas. Three replicate data sets of QA spike were measured during the testing period.

A known calibration spike gas was introduced prior to the first run to measure FTIR analyzer response as part of the quality assurance (QA) spiking procedure. The FTIR analyzer response will need to be between 70% and 130% of the expected value and as such determined to be acceptable (Section 8.6.2 of EPA Method 320 requires the average QA spiked percent recovery to be between 70% and 130%). Results of this procedure are provided in the final test report.

Propane (mixed with SF_6 as a tracer) and CO/NOx (mixed with SF_6 as a tracer) were used as the spiked recovery gas for VOC and CO/NOx testing. Also, ethylene was used as the CTS gas.

Finally, the off-site QA/QC included a data review and a data comparison using MKS "Method Analyzer" software. Method validation was conducted for each test run by pulling a random spectrum sample and results have been included in the appendices.

5 RESULTS

The flow and emissions data for this study are presented in the '**Tables**' section of this report. Detailed information regarding each test run can be found in the corresponding appendix. Below is a summary of the applicable Table ID for each corresponding test parameter.

Source	Table	Appendix
Cell B-10	1 & 5	B and C
Cell B-11	2 & 6	B and C
C-Wing 4.01 Thermal Oxidizer	3 & 7	B and C
D Wing 4.03 Thermal Oxidizer	4 & 8	B and C

Field notes are presented in **Appendix D**. All calibration information for the equipment used for the program is included in **Appendix E**. Detailed example calculations for each measured pollutant is provided in **Appendix G**.

5.1 Discussion of Results

The measured concentrations for all contaminants were less than the maximum limits outlined in EGLE PTI 155-18. The **Tables** section of the report has information on emissions.

6 OPERATING CONDITIONS

Operating conditions during the sampling were monitored by FCA Operations and RWDI personnel. All process data is provided in **Appendix F**.

Fuel usage, test cells in use, type of testing and engine type, , rpm and displacement data were documented to verify representative testing conditions for Cell B-10 and Cell B-11. For the thermal oxidizers, fuel usage and temperature were recorded for each test.

Radio contact was maintained between the process operators and the sampling team throughout the testing. A member of the RWDI sampling team contacted the operator before each test, to ensure that the process was at normal operating conditions.

7 CONCLUSIONS

Testing was successfully completed on August 9-11th of 2021. All sources were tested in accordance with referenced methodologies following the EGLE approved test protocol.

TABLES

TABLE 1: EU-CELL-B10 Emission Results

FCA US,LLC- Chrysler Technology Center

Facility: Chrysler Technology Center
City: Auburn Hills, MI
Source: EU-CELL-B10
Date: 09/08/2021

Parameter	Symbol	Units	Test #1	Test #2	Test #3	Average	Limits
Nitrogen Oxides Concentration	NO_x	ppmvd	-0.3	-0.2	-0.2	-0.2	-
Carbon Monoxide Concentration	CO	ppmvd	9.0	66.4	49.7	41.7	-
VOCs (as propane) Concentration	VOC	ppmvd	2.4	2.1	2.0	2.2	-
Oxygen Concentration	O_2	$\%_{dry}$	21.2	20.9	20.7	20.9	-
Nitrogen Oxides Emission Rate	NO_x	lbs/hr	-0.004	-0.003	-0.002	-0.003	-
Carbon Monoxide Emission Rate	CO	lbs/hr	0.085	0.617	0.452	0.385	-
VOCs (as propane) Emission Rate	VOC	lbs/hr	0.036	0.031	0.028	0.032	-
Nitrogen Oxides Emission Rate	NO_x	lb NOx/gal	-0.007	-0.001	-0.001	-0.003	0.20
Carbon Monoxide Emission Rate	CO	lb CO/gal	0.124	0.292	0.144	0.187	3.12
VOCs (as propane) Emission Rate	VOC	lb VOC/gal	0.052	0.015	0.009	0.025	0.16

TABLE 2: EU-CELL-B11 Uncontrolled Emission Results

FCA US,LLC- Chrysler Technology Center

Facility: Chrysler Technology Center
City: Auburn Hills, MI
Source: EU-CELL-B11
Date: 09/08/2021

Parameter	Symbol	Units	Test #1	Test #2	Test #3	Average	Limits
Nitrogen Oxides Concentration	NO_x	ppmvd	-0.3	0.4	7.1	2.4	-
Carbon Monoxide Concentration	CO	ppmvd	3.0	2.8	2.8	2.8	-
VOCs (as propane) Concentration	VOC	ppmvd	2.3	1.7	1.8	1.9	-
Oxygen Concentration	O_2	$\%_{dry}$	21.0	21.0	20.8	20.9	-
Nitrogen Oxides Emission Rate	NO_x	lbs/hr	-0.004	0.005	0.104	0.035	-
Carbon Monoxide Emission Rate	CO	lbs/hr	0.027	0.025	0.024	0.025	-
VOCs (as propane) Emission Rate	VOC	lbs/hr	0.033	0.024	0.025	0.027	-
Nitrogen Oxides Emission Rate	NO_x	lb NOx/gal	-0.009	0.004	0.042	0.012	0.20
Carbon Monoxide Emission Rate	CO	lb CO/gal	0.053	0.019	0.010	0.027	3.12
VOCs (as propane) Emission Rate	VOC	lb VOC/gal	0.066	0.018	0.010	0.031	0.16

TABLE 3: C-Wing (4.01) Controlled Emission Results

FCA US,LLC- Chrysler Technology Center

Facility: Chrysler Technology Center
City: Auburn Hills, MI
Source: C-Wing 4.01
Date: 11/08/2021

Parameter	Symbol	Units	Test #1	Test #2	Test #3	Average	Limits
VOCs (as propane) Concentration	VOC	ppmvd	2.0	1.8	1.5	1.7	-
Oxygen Concentration	O_2	$\%_{dry}$	12.0	12.0	10.8	11.6	-
VOCs (as propane) Emission Rate	VOC	lbs/hr	0.047	0.045	0.037	0.043	-
VOCs (as propane) Emission Rate	VOC	lb VOC/gal	0.0013	0.0012	0.0007	0.0010	0.16

TABLE 4: D-Wing (4.03) Controlled Emission Results

FCA US,LLC- Chrysler Technology Center

Facility: Chrysler Technology Center
City: Auburn Hills, MI
Source: D-Wing 4.03
Date: 10/08/2021

Parameter	Symbol	Units	Test #1	Test #2	Test #3	Average	Limits
VOCs (as propane) Concentration	VOC	ppmvd	3.1	1.9	1.3	2.1	-
Oxygen Concentration	O_2	$\%_{dry}$	7.8	8.5	9.4	8.6	-
VOCs (as propane) Emission Rate	VOC	lbs/hr	0.068	0.041	0.029	0.046	-
VOCs (as propane) Emission Rate	VOC	lb VOC/gal	0.0009	0.0006	0.0005	0.0007	0.16

TABLE 5: EU-CELL-B10 Flow Measurements

FCA US,LLC- Chrysler Technology Center

Facility: Chrysler Technology Center
City: Auburn Hills, MI
Source: EU-CELL-B10
Date: 09/08/2021

Parameter	Units	Run 1	Run 2	Run 3	Average
Stack Gas Temperature	°F	92.6	94.7	106.8	98.0
Velocity	ft/sec	65.9	65.3	65.2	65.4
Actual Flowrate	cfm	2,377	2,355	2,351	2,361
Dry Reference Flowrate	dscfm	2,161	2,134	2,085	2,127
Speed	rpm	800	1,600	2,100	-
Fuel use	gal/hr	0.683	2.113	3.142	-

TABLE 6: EU-CELL-B11 Uncontrolled Flow Measurements

FCA US,LLC- Chrysler Technology Center

Facility: Chrysler Technology Center
City: Auburn Hills, MI
Source: EU-CELL-B11
Date: 09/08/2021

Parameter	Units	Run 1	Run 2	Run 3	Average
Stack Gas Temperature	°F	83.0	90.3	100.0	91.1
Velocity	ft/sec	62.2	62.8	62.7	62.6
Actual Flowrate	cfm	2,245	2,267	2,261	2,258
Dry Reference Flowrate	dscfm	2,078	2,070	2,029	2,059
Speed	rpm	600	1,000	2,100	-
Fuel use	gal/hr	0.503	1.346	2.465	-

TABLE 7: C-Wing (4.01) Controlled Flow Measurements

FCA US,LLC- Chrysler Technology Center

Facility: Chrysler Technology Center
City: Auburn Hills, MI
Source: C-Wing 4.01
Date: 11/08/2021

Parameter	Units	Run 1	Run 2	Run 3	Average
Stack Gas Temperature	°F	1338.9	1311.3	1299.1	1316.4
Velocity	ft/sec	80.7	83.1	84.1	82.6
Actual Flowrate	cfm	13,971	14,387	14,553	14,304
Dry Reference Flowrate	dscfm	3,486	3,646	3,714	3,615
Fuel use	gal/hr	37.8	38.9	52.9	-

TABLE 8: D-Wing (4.03) Controlled Flow Measurements

FCA US,LLC- Chrysler Technology Center

Facility: Chrysler Technology Center
City: Auburn Hills, MI
Source: D-Wing 4.03
Date: 10/08/2021

Parameter	Units	Run 1	Run 2	Run 3	Average
Stack Gas Temperature	°F	1368.9	1374.7	1378.1	1373.9
Velocity	ft/sec	75.8	75.8	75.8	75.8
Actual Flowrate	cfm	13,116	13,130	13,119	13,122
Dry Reference Flowrate	dscfm	3,210	3,204	3,195	3,203
Fuel use	gal/hr	72.4	68.5	55.8	-