



## 1 INTRODUCTION

RWDI AIR Inc. (RWDI) was retained by FCA US LLC (FCA) to complete air emissions testing on January 5<sup>th</sup> and 6<sup>th</sup>, 2021, at their Chrysler Technology Center (CTC) on the simulation test cell EU-CELL-E19 (Cell E19) located at 800 Chrysler Drive, Auburn Hills, MI 48326-3757.

The air pollutant emissions rate verification testing was carried out pursuant to the requirements of a Permit to Install (PTI 155-18). Flexible Group (FG-CNTRLDCELLS) special condition V.2 requires verification testing for the parameters of nitrogen oxides (NOx), carbon monoxide (CO), volatile organic compounds (VOCs), and particulate matter (PM<sub>10</sub>/PM<sub>2.5</sub>) (filterable plus condensable). Testing was completed within 180 days of trial operation of the simulation testing at the CTC,

Testing was successfully completed on dynamometer test cell E19 during simulation testing (also referred to as "V2V" testing) operating at a representative capacity.

Testing of emissions was conducted by Mr. Alec Smith, Mr. Juan Vargas, Mr. Mason Sakshaug and Mr. Brad Bergeron of RWDI. Mr. Thomas Caltrider, Mr. Stuart Weiss, and Mr. Robert Sherako were on-site to monitor the process operation and witness the testing on behalf of FCA US LLC. Mr. Mark Dziadosz and Mr. Adam Bognar from the State of Michigan Department of Environment, Great Lakes and Energy (EGLE) were also present during the testing.

## 2 PROCESS 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). In accordance with the PTI, the source testing program was focused on the simulation test cells, which include: EU-CELL-C12 (2 test stands), EU-CELL-C14 (2 test stands), EU-CELL-E02 (1 test stand), EU-CELL-E04 (1 test stand), EU-CELL-E06 (1 test stand), EU-CELL-E08 (1 test stand), EU-CELL-E17 (1 test stand), EU-CELL-E19 (1 test stand) and EU-CELL-E20 (1 test stand). At the time of the test, only EU-CELL-E17 and EU-CELL-E19 were operational. Since EU-CELL-E17 and EU-CELL-E19 are identical, only EU-CELL-E19 was tested in order to confirm emissions from a representative cell for the simulation testing.



## 3 SAMPLING LOCATIONS AND METHODS

### 3.1 Sampling Location

The exhaust stack for the simulation testing on E-Wing Cells has a diameter of 12 inches at the point of discharge, and an inside diameter of 28.5 inches at the testing port location. The exhaust duct has two sets of sampling ports, 90 degrees apart. The sampling ports were 6 inches in diameter and located approximately 8 duct diameters upstream and more than 2 duct diameters downstream of any flow disturbances.

As discussed in the previously submitted source testing plan, RWDI tested for Total Particulate Matter (PM/PM<sub>10</sub>/PM<sub>2.5</sub>) using Reference Method 5 and Method 202 (Dry Impinger Method). All particulate matter collected was assumed to be equivalent to PM<sub>10</sub> and PM<sub>2.5</sub>.

### 3.2 Test Methods

#### 3.2.1 Velocity, Temperature and Volumetric Flow Rate Determination

The exhaust velocities and flow rates were determined following U.S. EPA Method 2, "Determination of Stack Gas Velocity and Volumetric 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 U.S. EPA Method 2. Temperature measurements were made simultaneously with the velocity measurements and were conducted using a chromel-alumel type "k" thermocouple in conjunction with a calibrated digital temperature indicator.

The dry molecular weight of the stack gas was determined following calculations outlined in U.S. EPA Method 3, "Gas Analysis for the Determination of Dry Molecular Weight". The stack was assumed to be at ambient conditions for the determination of the dry molecular weight. Stack moisture content was determined through direct condensation and according to U.S. EPA Method 4, "Determination of Moisture Content of Stack Gases".

#### 3.2.2 Determination of Total Particulate Matter (US EPA Method 5 and 202)

Sampling for total particulate matter was performed in accordance with a modified version of U.S. EPA Method 5, "Determination of Particulate Matter Emissions from Stationary Sources". Sampling was conducted using a calibrated Environmental Supply C-5000 Source Sampling System. Triplicate sampling runs were conducted.

Sampling was conducted isokinetically using the required number of traverse points across the stack diameter. The sample was drawn through a quartz nozzle, quartz lined sample probe and quartz fibre filter, all maintained at 250 °F ± 25 °F, to capture total particulate matter. The sample was then introduced into the impinger train where it passed through two empty impingers, a secondary filter which was maintained at a temperature between 68 °F and 85 °F. Lastly, the gas stream was drawn through one water impinger and one impinger containing silica gel. A total of 12 points (six (6) per traverse) were used.

Upon completion of the test, the sampling train was recovered, as in the procedures detailed in the reference method, and the samples were packaged for transport to ALS in Burlington, Ontario for analysis.



### **3.2.3 Sampling for Nitrogen Oxides, Carbon Monoxide, Oxygen and Carbon Dioxide**

Oxygen (O<sub>2</sub>), carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO) and nitrogen oxides (NO<sub>x</sub>) concentrations were determined utilizing RWDI's continuous emissions monitoring (CEM) system.

Prior to testing, a 3-point analyzer calibration error check was conducted using USEPA protocol gases. The calibration error check was performed by introducing zero, mid and high-level calibration gases directly into the analyzer. The calibration error check was performed to confirm that the analyzer response is within  $\pm 2\%$  of the certified calibration gas introduced. Prior to each test run, a system-bias test was performed where known concentrations of calibration gases were introduced at the probe tip to measure if the analyzers response was within  $\pm 5\%$  of the introduced calibration gas concentrations. At the conclusion of each test run a system-bias check was performed to evaluate the percent drift from pre and post-test system bias checks. The system bias checks were used to confirm that the analyzer did not drift greater than  $\pm 3\%$  throughout a test run.

Zero and upscale calibration checks were conducted both before and after each test run in order to quantify measurement system calibration drift and sampling system bias. Upscale is either the mid- or high-range gas, whichever most closely approximates the flue gas level. During these checks, the calibration gases were introduced into the sampling system at the probe outlet so that the calibration gases be analyzed in the same manner as the flue gas samples.

A gas sample was continuously extracted from the stack and delivered to a series of gas analyzers, which measure the pollutant or diluent concentrations in the gas. The analyzers were calibrated on-site using EPA Protocol No. 1 certified calibration mixtures. The probe tip was equipped with a sintered stainless-steel filter for particulate removal. The end of the probe was connected to a heated Teflon sample line, which delivers the sample gases from the stack to the CEM system. The heated sample line was designed to maintain the gas temperature above 250°F in order to prevent condensation of stack gas moisture within the line.

Before entering the analyzers, the gas sample passed directly into a refrigerated condenser, which cools the gas to approximately 35°F to remove the stack gas moisture. After passing through the condenser, the dry gas then enters a Teflon-head diaphragm pump and a flow control panel, which delivered the gas in series to the CO, O<sub>2</sub>, CO<sub>2</sub>, and NO<sub>x</sub> analyzers (as applicable). Each of these analyzers measured the respective gas concentrations on a dry volumetric basis.

### **3.2.4 Sampling for Total Hydrocarbons**

VOC testing was performed on the exhaust of Cell 19 (outlet). The measurements were taken continuously following the USEPA Method 25A on the outlet using a total hydrocarbon (THC) analyzer. Stratification checks for oxygen were also completed on the selected Cell exhaust at three locations prior to testing. The Source Test consisted of three, up to 240-minute tests.

Regular performance checks on the CEM was carried out by zero and span calibration checks using USEPA Protocol calibration gases. These checks verified the ongoing precision of the monitor with time by introducing pollutant-free (zero) air followed by known calibration gas (span) into the monitor. The response of the monitor to pollutant-free air and the corresponding sensitivity to the span gases were reviewed frequently as an ongoing indication of analyzer performance.



Prior to testing, a 4-point analyzer calibration error check was conducted using USEPA protocol gases. The calibration error check were performed by introducing zero, low, mid and high-level calibration gases directly into the analyzer. The calibration error check was performed to confirm that the analyzer response is within  $\pm 5\%$  of the certified calibration gas introduced. Prior to each test run, a system-bias test was performed where known concentrations of calibration gases were introduced at the probe tip to measure if the analyzers response is within  $\pm 5\%$  of the introduced calibration gas concentrations. At the conclusion of each test run a system-bias check was performed to evaluate the percent drift from pre- and post-test system bias checks. The system bias checks was used to confirm that the analyzer did not drift greater than  $\pm 3\%$  throughout a test run.

Zero and upscale calibration checks were conducted both before and after each test run in order to quantify measurement system calibration drift and sampling system bias. Upscale is either the mid- or high-range gas, whichever most closely approximates the flue gas level. During these checks, the calibration gases were introduced into the sampling system at the probe outlet so that the calibration gases was analyzed in the same manner as the flue gas samples.

A gas sample was continuously extracted from the stack and delivered to a series of gas analyzers, which measure the pollutant or diluent concentrations in the gas. The analyzers were calibrated on-site using EPA Protocol No. 1 certified calibration mixtures. The probe tip was equipped with a sintered stainless-steel filter for particulate removal. The end of the probe was connected to a heated Teflon sample line, which delivers the sample gases from the stack to the CEM system. The heated sample line was designed to maintain the gas temperature above 250°F in order to prevent condensation of stack gas moisture within the line.

### 3.3 Quality Assurance/ Quality Control Measures

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, equipment calibrations for all measured parameters, completion of Chain of Custody forms when submitting laboratory samples, and submission of field blank samples to the laboratories. **Table 2** of the Tables Section presents a sample log and summarizes the sampling times, sample ID's, and filter ID's.

All samplers were bench tested and calibrated in RWDI's office prior to field deployment. For each sample collected with a Method 5 sampling train, both pre- and post- leak checks were conducted by plugging the inlet and drawing a vacuum of equal to or greater than the vacuum recorded during the test. Dry gas meter reading leakage rates greater than 4 percent of the average sampling rate or  $0.00057 \text{ m}^3/\text{min}$  (0.02 cfm), whichever is less, were considered unacceptable. Similar leak check procedures for pitot tube and pressure lines were also conducted. 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. Leak checks for each test were documented on the field data sheets presented in the applicable appendices for each sample parameter.



## 4 RESULTS

The average emission results for this study are presented in the 'Tables' section of this report. Detailed information for each test run can be found in the appendices. Below is a table identifying each parameter, the corresponding table and appendices where results can be found.

**Table 4.0:** Summary of Data References

Parameter	Table	Appendix
Total Particulate Matter (PM, PM <sub>10</sub> , PM <sub>2.5</sub> )	4	B
NOx, CO, O <sub>2</sub> , CO <sub>2</sub> , VOCs	5	C
Emission Rate Summary	6	N/A

All sampling field notes are provided in **Appendix D**. All laboratory results are included in **Appendix E**. All calibration information for the equipment used for this study is included in **Appendix F**.

### 4.1 Discussion of Results

Sampling was completed between January 5<sup>th</sup> and 6<sup>th</sup>, 2021 and no issues occurred during the sampling process. A summary of the results can be found in the tables section of this report and the more detailed calculations can be found in **Appendices B, C, and H**. Total particulate matter (TPM) was measured (U.S. EPA Method 5/202). The results have been summarized below in **Table 4.1**.

All concentrations were corrected to reference conditions of 68°F, and 29.92 in. Hg. Operating conditions during the sampling were monitored by FCA personnel. All equipment was operated under representative operating conditions. A summary of the process data during each of the testing events is provided in **Appendix G**.

Contact was maintained between the operator and the sampling team. A member of the RWDI sampling team contacted the operator before each test, to ensure that the process was at representative maximum operating conditions.

**Table 4.1.:** Sampling Results Summary

Parameter	Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)	Emission Rate (lbs/gallon)
NOx	-	0.31	0.1789
CO	-	0.15	0.0839
VOC (as propane)	-	0.029	0.0167
TPM (Filterable + Condensable) <sup>[1][2]</sup>	0.0004	0.0071	-

**Notes:**

[1] Sampling followed U.S. EPA Method 5/202; average of three tests, Total PM was assumed to be equivalent to PM<sub>10</sub> and PM<sub>2.5</sub> results

[2] Concentration values are expressed at 29.92 in.Hg, and 68 °F. All values are blank corrected



## 5 CONCLUSIONS

Testing was successfully completed on January 5<sup>th</sup> and 6<sup>th</sup>, 2021. All parameters were tested in accordance with referenced methodologies.

**Table 1: Summary of Sampling Parameters and Methodology**

Source Location	No. of Tests per Stack	Sampling Parameter	Sampling Method
<b>E-Wing Cell 19 Exhaust</b>	3	Volumetric Flow Rate	U.S. EPA <sup>[1]</sup> Methods 1-4
	3	Particulate Matter	U.S. EPA <sup>[1]</sup> Method 5
	3	Condensable Particulate Matter	U.S. EPA <sup>[1]</sup> Method 202
	3	Oxygen/Carbon Dioxide	U.S. EPA <sup>[1]</sup> Method 3A
	3	Oxides Of Nitrogen	U.S. EPA <sup>[1]</sup> Method 7E
	3	Carbon Monoxide	U.S. EPA <sup>[1]</sup> Method 10
	3	Total Hydrocarbon	U.S. EPA <sup>[1]</sup> Method 25A

**Notes:**

[1] U.S. EPA - United States Environmental Protection Agency





**Table 2: TPM Sampling Times and Sample Log**  
**CTC**

Source and Test #	Sampling Date	Start Time	End Time	Filter ID / Trap ID	Lab Sample ID
Blank	6-Jan-21	--	--	--	L2547101-MB
<b>Cell 19</b>					
Test #1	5-Jan-21	8:12 AM	12:28 PM	QZ8216	L2547101-1/2/3
Test #2	5-Jan-21	1:43 PM	5:58 PM	QZ8214	L2547101-4/5/6
Test #3	6-Jan-21	7:23 AM	11:33 AM	QZ8215	L2547101-7/8/9



**Table 3: Sampling Summary**  
CTC

Stack Gas Parameter	Testing Date	Cell 19 Exhaust M5/202			Average
		Test #1	Test #2	Test #3	
		Jan/05	Jan/05	Jan/06	
Stack Temperature	°F	87	87	82	85
Volume	ft <sup>3</sup>	182.08	189.79	174.79	182.22
Moisture	%	1.0%	1.2%	0.6%	0.9%
Velocity	ft/s	7.74	7.99	7.20	7.65
Actual Flow Rate	cf/min	2,059	2,124	1,915	2,032
Referenced Flow Rate <sup>[1]</sup>	dscf/min	1,974	2,034	1,877	1,961
Sampling Isokinetic Rate	%	97	99	98	98

**Notes:**

[1] Referenced flow rate expressed as dry at 101.3 kPa, 68 °F, and Actual Oxygen  
Detailed sampling results including individual test results can be found in Appendix B



**Table 4a: Cell 19 Exhaust - TPM Non Corrected**

Source	Parameter <sup>[1]</sup>	Test 1		Test 2		Test 3		Average	
		Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)	Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)	Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)	Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)
Cell 19	Filterable Particulate Matter	0.0002	0.0040	0.0002	0.0035	0.0002	0.0034	0.0002	0.0037
	Total Particulate Matter	0.0006	0.0099	0.0007	0.0115	0.0005	0.0088	0.0006	0.0101

**Table 4b: Cell 19 Exhaust - TPM Blank Corrected**

Source	Parameter <sup>[1]</sup>	Test 1		Test 2		Test 3		Average	
		Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)	Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)	Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)	Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)
Cell 19	Filterable Particulate Matter	0.0002	0.0039	0.0002	0.0034	0.0002	0.0033	0.0002	0.0035
	Total Particulate Matter	0.0004	0.0069	0.0005	0.0085	0.0004	0.0059	0.0004	0.0071

**Notes:**

[1] Sampling followed U.S. EPA Method 5/202; average of three tests,

[2] Concentration values are expressed at 29.92 in.Hg, and 68 °F,



**Table 5: Cell 19 Exhaust - NOx, CO, & VOCs**

Parameter <sup>(1)</sup>	Test 1			Test 2			Test 3			Average		
	Concentration (ppm <sub>d</sub> )	Emission Rate (lbs/hr)	Emission Rate (lbs/gallon)	Concentration <sup>(2)</sup> (ppm <sub>d</sub> )	Emission Rate (lbs/hr)	Emission Rate (lbs/gallon)	Concentration <sup>(2)</sup> (ppm <sub>d</sub> )	Emission Rate (lbs/hr)	Emission Rate (lbs/gallon)	Concentration <sup>(2)</sup> (ppm <sub>d</sub> )	Emission Rate (lbs/hr)	Emission Rate (lbs/gallon)
NOx	24.1	0.34	0.1987	27.4	0.40	0.2216	15.0	0.20	0.1165	22.2	0.31	0.1789
CO	15.0	0.13	0.0754	19.7	0.18	0.0974	16.7	0.14	0.0790	17.2	0.15	0.0839
VOC	2.16	0.029	0.0171	2.28	0.032	0.0177	2.06	0.027	0.0153	2.17	0.029	0.0167

**Notes:**

<sup>(1)</sup>"d" indicated based on dry conditions





**Table 6: Cell 19 Emission Rate Summary**

Parameter	Concentration <sup>[2]</sup> (gr/dscf)	Emission Rate (lbs/hr)	Emission Rate (lbs/gallon)
NOx	-	0.31	0.1789
CO	-	0.15	0.0839
VOC (as propane)	-	0.029	0.0167
TPM (Filterable + Condensable) <sup>[1]</sup> <sub>[2]</sub>	0.0004	0.0071	-

**Notes:**

[1] Sampling followed U.S. EPA Method 5/202; average of three tests, Total PM was assumed to be equivalent to PM10 and PM2.5 results

[2] Concentration values are expressed at 29.92 in.Hg, and 68 °F. All values are blank corrected

