APEX COMPANIES, LLC

Air Emissions Test Report
RTO VOC Destruction Efficiency Testing
Pratt & Whitney AutoAir, Inc.
Holt, Michigan

PREPARED FOR:
Pratt & Whitney AutoAir, Inc.
1781 Holloway Drive
Holt, Michigan 48842

State Registration No. P0774

Apex Project No. 22008390

January 24, 2023

Apex Companies, LLC
46555 Humboldt Drive, Suite 103
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Executive Summary

Pratt & Whitney AutoAir, Inc. (PWAA) retained Apex Companies, LLC (Apex) to evaluate volatile organic compound (VOC) destruction efficiency from one regenerative thermal oxidizer (RTO) at the PWAA facility in Holt, Michigan. The source is regulated by Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit to Install (PTI) No. 204-16A, effective January 26, 2018.

The testing followed United States Environmental Protection Agency (USEPA) Reference Methods 1 through 4, 25A, and 205.

Detailed results are presented in Table 1 after the Tables Tab of this report. The following table summarizes the results of the testing conducted on December 15, 2022.

RTO Emissions Results

Parameter	Unit	Average Result	Permit Limit
Inlet NMVOC	lb/hr	10.85	-
Outlet NMVOC	lb/hr	0.12	-
NMVOC DE	-	98.9%	≥98%

NMVOC: non-methane volatile organic compound
DE: destruction efficiency
lb/hr: pound per hour

1.0 **Introduction**

1.1 Summary of Test Program

Pratt & Whitney AutoAir, Inc. (PWAA) retained Apex Companies, LLC (Apex) to evaluate volatile organic compound (VOC) destruction efficiency from one regenerative thermal oxidizer (RTO) at the PWAA facility in Holt, Michigan. The source is regulated by Michigan Department of Environment, Great Lakes, and Energy (EGLE) Permit to Install (PTI) No. 204-16A, effective January 26, 2018.

The testing followed United States Environmental Protection Agency (USEPA) Reference Methods 1 through 4, 25A, and 205.

Table 1-1 lists the emission source tested, parameters, and test date.

Table 1-1
Source Tested, Parameters, and Test Date

Source	Test Parameter	Test Date
RTO	Volatile organic compounds (VOC) Methane	December 15, 2022

1.2 Key Personnel

The key personnel involved in this test program are listed in Table 1-2. Mr. David Kawasaki, with Apex, led the emission testing program. Ms. Michele Strickland, with PWAA, provided process coordination and recorded operating parameters. Ms. Lindsey Wells, with EGLE, witnessed the testing and verified production parameters were recorded.

Table 1-2
Key Contact Information

Client	Apex
Christina Robedeau, ASP, CSP Site EHS Manager **Pratt & Whitney AutoAir, Inc.** 1781 Holloway Drive Holt, Michigan 48842 Phone: 706.905.1727 christina.robedeau@prattwhitney.com	David Kawasaki, QSTI Senior Engineer **Apex Companies, LLC** 46555 Humboldt Drive, Suite 103 Novi, Michigan 48377 Phone: 248.590.5134 david.kawasaki@apexcos.com
EGLE	
Lindsey Wells Environmental Quality Analyst **EGLE Air Quality Division** Constitution Hall, 2nd Floor, South 525 West Allegan Street Lansing, Michigan 48909 Phone: 517.282.2345 wellsl8@michigan.gov	Matthew Karl Environmental Quality Analyst **EGLE Air Quality Division** Constitution Hall, 2nd Floor, South 525 West Allegan Street Lansing, Michigan 48909 Phone: 517.282.2126 karlm@michigan.gov

2.0 Source and Sampling Locations

2.1 Process Description

The PWAA facility in Holt, Michigan has an erosion coat line (EU-EROSIONCOAT) consisting of an electric, infrared radiated oven curing zone, two natural gas fired curing zones, one electric convection oven, clean-up operations, and six paint booths: a Primer booth, Chemlok booth, and four Chemglaze booths. Each booth includes a robot equipped with a high-volume low-pressure (HVLP) applicator. Emissions are vented to an RTO.

The Chemlok booth was not operational during testing.

2.2 Control Equipment Description

One RTO controls emissions from the erosion coat line (EU-EROSIONCOAT). The RTO must meet a minimum VOC destruction efficiency of 98%, a minimum temperature of 1,500°F, and a minimum retention time of 0.5 seconds.

Operating parameters were measured and recorded by PWAA personnel during testing. Table 2-1 summarizes the operating conditions during testing of the RTO. Additional operating parameter data are included in Appendix E.

Table 2-1
Summary of RTO Operating Data

Run	Chamber Temperature (°F)
1	1,548
2	1,548
3	1,548
Average	**1,548**

2.3 Flue Gas Sampling Locations

2.3.1 RTO Inlet Sampling Location

Two sampling ports oriented at 90° to one another are located in a straight section of a 48 inch-internal-diameter duct. The sampling ports are located:

- Approximately 3 feet (0.75 duct diameters) from the nearest downstream disturbance.
- Approximately 15 feet (3.75 duct diameters) from the nearest upstream disturbance.

The sampling ports are accessible via aerial lift. A photograph of the RTO inlet sampling location is presented in Figure 2-1. Figure 1 in the Appendix depicts the RTO inlet sampling ports and traverse point locations.

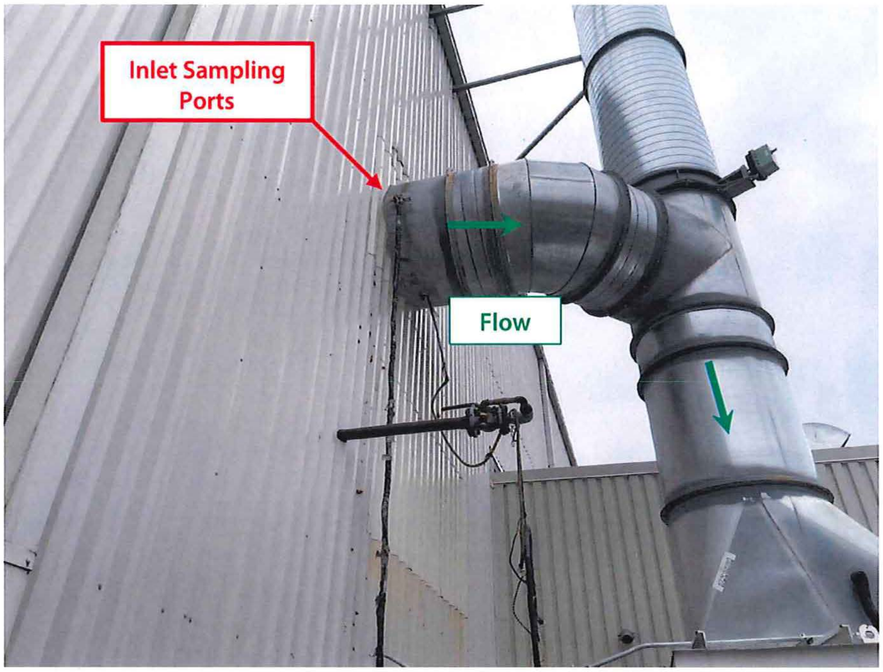


Figure 2-1. RTO Inlet Sampling Location

2.3.2 RTO Outlet Sampling Location

Two sampling ports oriented at 90° to one another are located in a straight section of a 40 inch-internal-diameter duct. The sampling ports are located:

- Approximately 9 feet (2.7 duct diameters) from the nearest downstream disturbance.
- Approximately 13.3 feet (4.0 duct diameters) from the nearest upstream disturbance.

The sampling ports are accessible via aerial lift. A photograph of the RTO outlet sampling location is presented in Figure 2-2. Figure 2 in the Appendix depicts the RTO outlet sampling ports and traverse point locations.

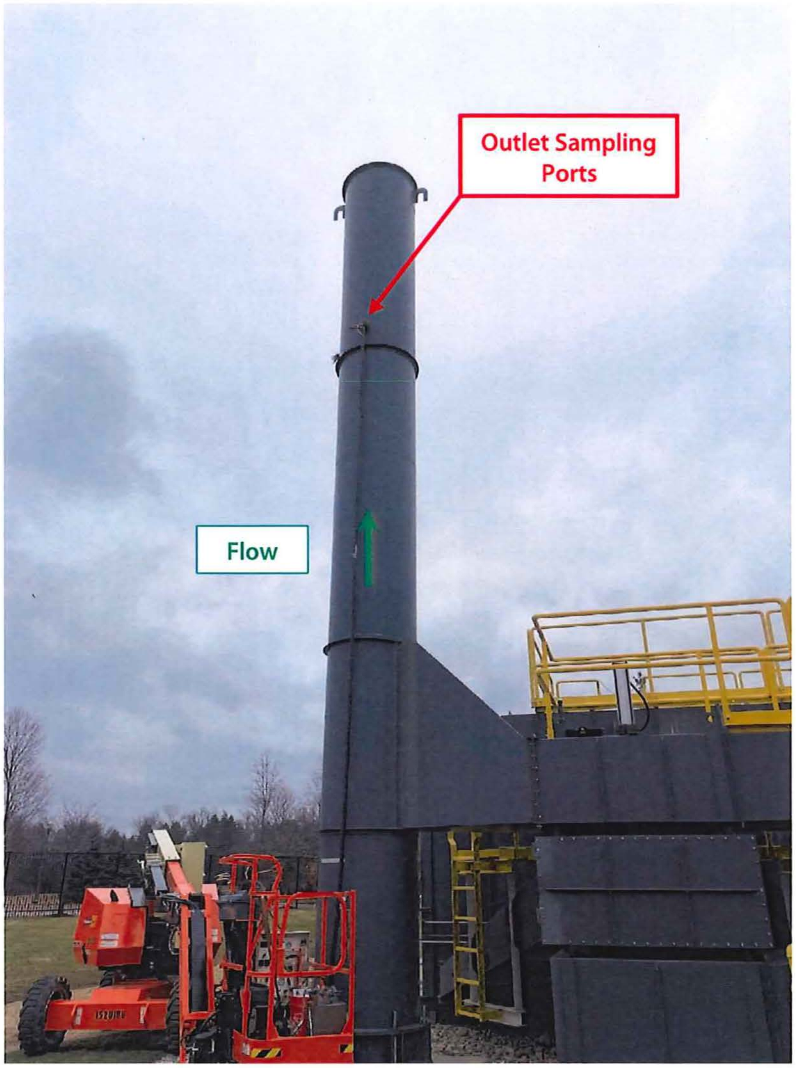


Figure 2-2. RTO Outlet Sampling Location

2.4 Process Sampling Locations

Process sampling was not required during this test program. A process sample is a sample that is analyzed for operational parameters, such as calorific value of a fuel (e.g., natural gas, coal), organic compound content (e.g., paint coatings), or composition (e.g., polymers).

3.0 Summary and Discussion of Results

3.1 Objectives and Test Matrix

The objective of the air emission testing was to evaluate VOC destruction efficiency from one RTO, as regulated by EGLE PTI No. 204-16A, effective January 26, 2018.

Table 3-1 summarizes the sampling and analytical matrix.

Table 3-1
Sampling and Analytical Matrix

Sampling Location	Sample/Type of Pollutant	Sample Method	Date (2022)	Run	Start Time	End Time
RTO Inlet and Outlet	Flowrate, molecular weight, moisture content, VOC, methane	USEPA 1-4, 25A, 205	Dec. 15	1	0757	0857
				2	1210	1310
				3	1536	1636

3.2 Field Test Changes and Issues

Communication between PWAA, Apex, and EGLE allowed the testing to be completed as proposed in the July 13, 2022, Intent-to-Test Plan.

3.3 Summary of Results

The results of testing are presented in Table 3-2. Detailed results are presented in Appendix Table 1 after the Tables Tab of this report. Graphs are presented after the Graphs Tab of this report. Sample calculations are presented in Appendix B.

Table 3-2
RTO Emissions Results

Parameter	Unit	Run 1	Run 2	Run 3	Average Result	Permit Limit
Inlet Total VOC	lb/hr	12.10	12.02	8.91	**11.01**	-
Inlet Methane	lb/hr	0.19	0.16	0.15	**0.16**	-
Inlet NMVOC	lb/hr	11.91	11.87	8.76	**10.85**	-
Outlet Total VOC	lb/hr	0.14	0.13	0.09	**0.12**	-
Outlet Methane	lb/hr	0	0	0	**0**	-
Outlet NMVOC	lb/hr	0.14	0.13	0.09	**0.12**	-
NMVOC DE	-	98.8%	98.9%	98.9%	**98.9%**	**≥98%**

VOC: volatile organic compound
NMVOC: non-methane volatile organic compound
DE: destruction efficiency
lb/hr: pound per hour

4.0 Sampling and Analytical Procedures

Apex measured emissions in accordance with USEPA sampling methods. Table 4-1 presents the emissions test parameters and sampling methods.

Table 4-1
Emission Testing Methods

Parameter	RTO Inlet	RTO Outlet	USEPA Reference	
			Method	Title
Sampling ports and traverse points	•	•	1	Sample and Velocity Traverses for Stationary Sources
Velocity and flowrate	•	•	2	Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
Molecular weight	•	•	3	Gas Analysis for the Determination of Dry Molecular Weight
Moisture content	•	•	4	Determination of Moisture Content in Stack Gases
Volatile organic compounds (VOCs), methane	•	•	25A	Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer
Gas dilution	•	•	205	Verification of Gas Dilution Systems for Field Instrument Calibrations

4.1 Emission Test Methods

4.1.1 Volumetric Flowrate (USEPA Methods 1 and 2)

USEPA Method 1, "Sample and Velocity Traverses for Stationary Sources," was used to evaluate the sampling locations and the number of traverse points for sampling and the measurement of velocity profiles. Figures 1 and 2 in the Appendix depict the source locations and traverse points.

USEPA Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)," was used to measure flue gas velocity and calculate volumetric flowrates. S-type Pitot tubes and thermocouple assemblies, calibrated in accordance with Method 2, Section 10.0, were used during testing. Because the dimensions of the Pitot tubes met the requirements outlined in Method 2, Section 10.1, and are within the specified limits, the baseline Pitot tube coefficient of 0.84 (dimensionless) was assigned. The digital manometer and thermometer are calibrated using calibration standards that are traceable to National Institute of Standards and Technology (NIST). Pitot tube inspection sheets are included in Appendix A.

Cyclonic Flow Check. Apex evaluated whether cyclonic flow was present at the sampling locations. Cyclonic flow is defined as a flow condition with an average null angle greater than 20°. The direction of flow can be determined by aligning the Pitot tube to obtain zero (null) velocity head reading—the direction would be parallel to the Pitot tube face openings or perpendicular to the null position. By measuring the angle of the Pitot tube face openings in relation to the stack walls when a null angle is obtained, the direction of flow is measured. If the absolute average of the flow direction angles is greater than 20°, the flue gas is considered to be cyclonic at that sampling location and an alternative location should be selected.

The average of the measured traverse point flue gas velocity null angles were less than 20° at the sampling locations. The measurements indicate the absence of cyclonic flow.

Field data sheets are included in Appendix C. Computer-generated field data sheets are included in Appendix D.

4.1.2 Molecular Weight (USEPA Method 3)

USEPA Method 3, "Gas Analysis for the Determination of Dry Molecular Weight," was used to determine the molecular weight of the flue gas. Flue gas was extracted from the stack through a probe and directed into a Fyrite® gas analyzer. The concentrations of carbon dioxide (CO_2) and oxygen (O_2) were measured by chemical absorption to within ±0.5%. The average CO_2 and O_2 results of the grab samples were used to calculate molecular weight.

4.1.3 Moisture Content (USEPA Method 4)

USEPA Method 4, "Determination of Moisture Content in Stack Gases" was used to determine the moisture content of the flue gas. Refer to Figure 4-1 for a drawing of the USEPA Method 4 sampling train.

Apex's modular USEPA Method 4 stack sampling system consists of:

- A stainless steel probe.
- Tygon® umbilical line connecting the probe to the impingers.
- A set of four impingers with the configuration shown in Table 4-2.
- A sampling line.
- An Environmental Supply® control case equipped with a pump, dry-gas meter, and calibrated orifice.

Table 4-2
USEPA Method 4 Impinger Configuration

Impinger Order (Upstream to Downstream)	Impinger Type	Impinger Contents	Contents
1	Modified	Water	~100 grams
2	Greenburg Smith	Water	~100 grams
3	Modified	Empty	0 grams
4	Modified	Silica desiccant	~300 grams

Prior to initiating a test run, the sampling train was leak-checked by capping the probe tip and applying a vacuum of approximately 5 inches of mercury to the sampling train. The dry-gas meter was monitored for approximately 1 minute to verify the sample train leak rate was less than 0.02 cfm. The sample probe was then inserted into the sampling port near the centroid of the stack in preparation of sampling. Flue gas was extracted at a constant rate from the stack, with moisture removed from the sample stream by the chilled impingers.

At the conclusion of the test run, a post-test leak check was conducted and the impinger train was carefully disassembled. The weight of liquid or silica gel in each impinger was measured with a scale capable of measuring to the nearest 0.5 gram. The weight of water collected within the impingers and volume of flue gas sampled were used to calculate the percent moisture content. One moisture content sample was collected during each test run.

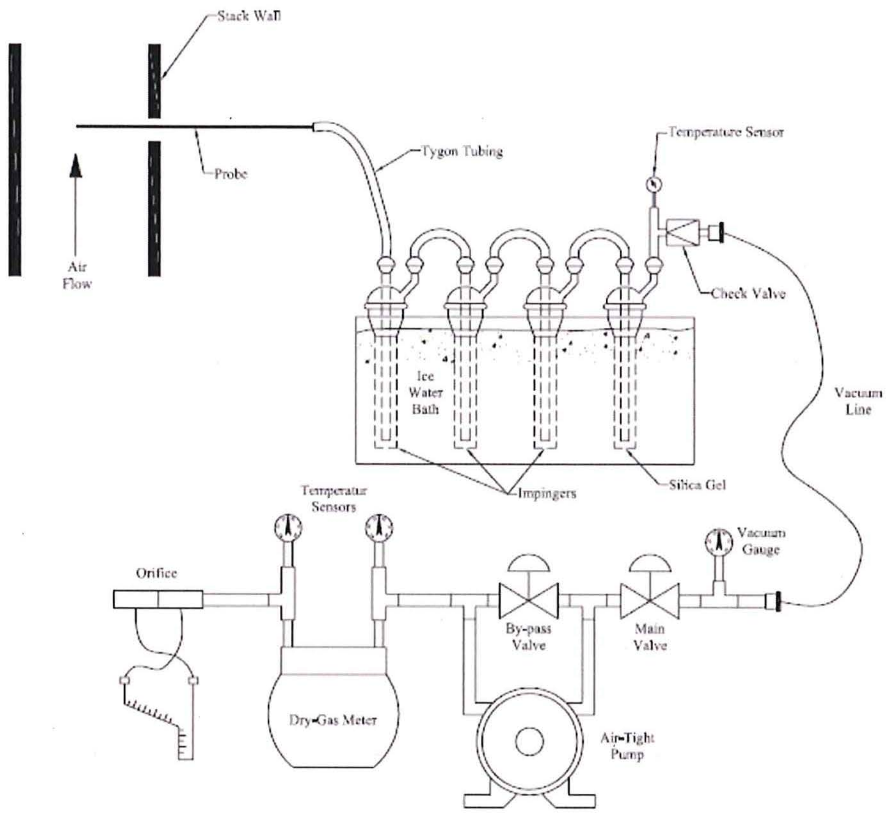
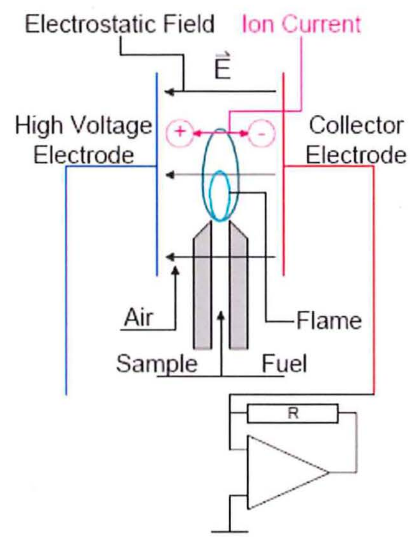


Figure 4-1. USEPA Method 4 Sampling Train

4.1.4 Volatile Organic Compounds (USEPA Method 25A)

USEPA Method 25A, "Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer," was used to measure VOC concentrations in the flue gas. Samples were collected through a stainless-steel probe and heated sample line into an analyzer.



A flame ionization detector (FID) determines the average hydrocarbon concentration in part per million by volume (ppmv) of VOC as the calibration gas (i.e., propane). The FID is fueled by 100% hydrogen, which generates a flame with a negligible number of ions. Flue gas is introduced into the FID and enters the flame chamber. The combustion of flue gas generates electrically charged ions. The analyzer applies a polarizing voltage between two electrodes around the flame, producing an electrostatic field. Negatively charged ions, anions, migrate to a collector electrode, while positive charged ions, cations, migrate to a high-voltage electrode. The current between the electrodes is directly proportional to the hydrocarbon concentration in the sample. The flame chamber is depicted at right.

Using the voltage analog signal, measured by the FID, the concentration of VOCs was recorded by a data acquisition system (DAS). The average concentration of VOCs is reported as the calibration gas (i.e., propane) in equivalent units.

Before testing, the analyzer was calibrated by introducing a zero-calibration range gas (<1% of span value) and high-calibration range gas (80-90% span value) to the tip of the sampling probe. The span value was set to 1.5 to 2.5 times the expected concentration (e.g., 0-100 ppmv). Next, a low-calibration range gas (25-35% of span value) and mid-calibration range gas (45-55% of span value) were introduced. The analyzers are considered to be calibrated when the analyzer response is ±5% of the calibration gas value.

At the conclusion of a test run, a calibration drift test was performed by introducing the zero- and mid-calibration gas to the tip of the sampling probe. The test run data was considered valid if the calibration drift test demonstrated the analyzers are responding within 3% of the calibration span from pre-test to post-test calibrations.

Figure 4-2 depicts the USEPA Method 25A sampling train.

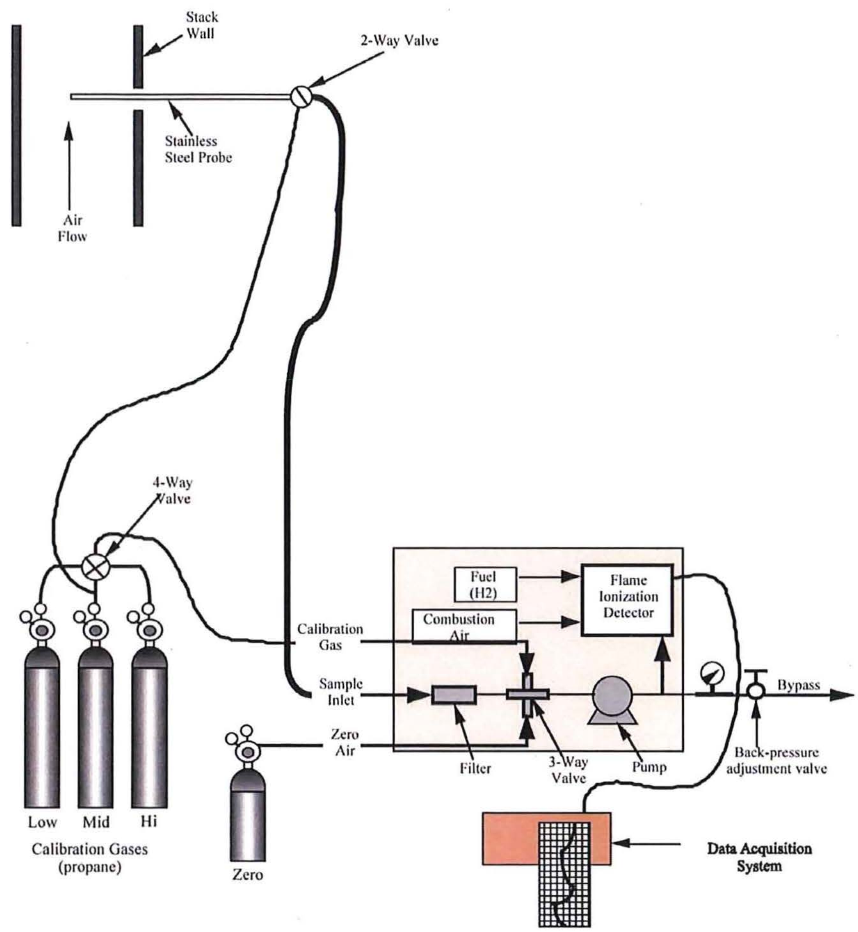


Figure 4-2. USEPA Method 25A Sampling Train

4.1.5 Gas Dilution (USEPA Method 205)

USEPA Method 205, "Verification of Gas Dilution Systems for Field Instrument Calibrations," was used to introduce known values of calibration gases into the analyzers. The gas dilution system consists of calibrated orifices or mass flow controllers and dilutes a high-level calibration gas to within ±2% of predicted values. The gas divider is capable of diluting gases at set increments and was evaluated for accuracy in the field in accordance with USEPA Method 205.

Prior to testing, the gas divider dilutions were measured to evaluate that they were within ±2% of predicted values. Two sets of three dilutions of the high-level calibration gas were performed. In addition, a certified mid-level calibration gas was introduced into an analyzer; this calibration gas concentration was within ± 10% of a gas divider dilution concentration.

4.2 Process Data

PWAA recorded process data during testing. EGLE personnel verified the requested operating and process data were recorded. Process data are included in Appendix E.

5.0 Quality Assurance and Quality Control

5.1 QA/QC Procedures

Equipment used in this emissions test program passed Quality Assurance (QA) and Quality Control (QC) procedures. Refer to Appendix A for equipment calibrations. Before testing, the sampling equipment was cleaned, inspected, and calibrated according to procedures outlined in the applicable USEPA sampling method and USEPA's "Quality Assurance Handbook for Air Pollution Measurement Systems: Volume III, Stationary Source-Specific Methods."

5.2 QA/QC Audits

Onsite QA/QC procedures (i.e., Pitot tube inspections, leak check, calibrations) were performed in accordance with the respective USEPA sampling methods. Equipment inspection and calibration measurements are presented in Appendix A.

Offsite QA audits include dry-gas meter and thermocouple calibrations.

5.2.1 Audit Sample Results QA/QC

QA audit samples were not proposed during this test program. Currently, audit samples for the parameters to be measured are not available from the USEPA Stationary Source Audit Program.

5.2.2 Sampling Train QA/QC

The sampling trains described in Section 4.1 were audited for measurement accuracy and data reliability. Table 5-1 summarizes the QA/QC audits conducted on each sampling train.

Table 5-1
USEPA Method 4 Sampling Train QA/QC

Parameter	Run 1	Run 2	Run 3	Method Requirement	Comment
RTO Inlet					
Sampling train post-test leak check	0 ft^3 for 1 min at 4 in Hg	0.004 ft^3 for 1 min at 5 in Hg	0.002 ft^3 for 1 min at 5 in Hg	<0.020 ft^3 for 1 minute at a vacuum ≥ recorded during test	Valid
Sampling vacuum (in Hg)	1	1	1		
RTO Outlet					
Sampling train post-test leak check	0 ft^3 for 1 min at 5 in Hg	0 ft^3 for 1 min at 5 in Hg	0 ft^3 for 1 min at 5 in Hg	<0.020 ft^3 for 1 minute at a vacuum ≥ recorded during test	Valid
Sampling vacuum (in Hg)	1	1	1		

5.2.3 Instrument Analyzer QA/QC

The instrument analyzer sampling trains described in Section 4.1 were audited for measurement accuracy and data reliability. The analyzers passed the applicable calibration criteria. Table 5-2 summarizes the gas cylinders used during this test program. Analyzer calibration, bias, and drift data are included in Appendix A.

Table 5-2
Calibration Gas Cylinder Information

Parameter	Gas Vendor	Cylinder Serial Number	Cylinder Value	Expiration Date
Air	Airgas	CC469317	--	07/17/2027
Propane	Airgas	ALM-014745	1,113 ppm	03/02/2028
Propane	Airgas	CC469693	85.46 ppm	05/09/2026
Methane	Airgas	CC19255	80.40 ppm	04/28/2023

5.2.4 Dry-Gas Meter QA/QC

Table 5-3 summarizes the dry-gas meter calibration checks in comparison to the acceptable USEPA tolerance. Complete dry-gas meter calibrations are included in Appendix A.

Table 5-3
Dry-Gas Meter Calibration QA/QC

Dry-Gas Meter	Pre-test DGM Calibration Factor	Post-test DGM Calibration Factor	Difference Between Pre- and Post-test Calibrations	Acceptable Tolerance	Comment
1	1.003 (10/26/2022)	0.998 (12/20/2022)	0.005	±0.05	Valid
X	1.021 (07/07/2022)	0.991 (12/20/2022)	0.030	±0.05	Valid

5.2.5 Thermocouple QA/QC

Temperature measurements using thermocouples and digital pyrometers were compared to a reference temperature prior to testing to evaluate accuracy of the equipment. The thermocouples and pyrometers measured temperature within ±1.5% of the reference temperatures and were within USEPA acceptance criteria. Thermocouple calibration sheets are included in Appendix A.

5.3 Data Reduction and Validation

The emissions testing Project Manager and/or the QA/QC Officer validated computer spreadsheets. The computer spreadsheets were used to ensure that field calculations were accurate. Random inspection of the field data sheets were conducted to verify data have been recorded appropriately. At the completion of a test, the raw field data were entered into computer spreadsheets to provide applicable onsite emissions calculations. The computer data were checked against the raw field sheets for accuracy during review of the report.

5.4 QA/QC Problems

Equipment audits and QA/QC procedures demonstrate sample collection accuracy and compliance for the test runs.

6.0 Limitations

The information and opinions rendered in this report are exclusively for use by Pratt & Whitney AutoAir, Inc.. Apex Companies, LLC will not distribute or publish this report without consent of Pratt & Whitney AutoAir, Inc., 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. Apex Companies, LLC 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.

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Tables

Table 1

RTO VOC Emissions Results

Pratt & Whitney AutoAir, Inc.

Holt, Michigan

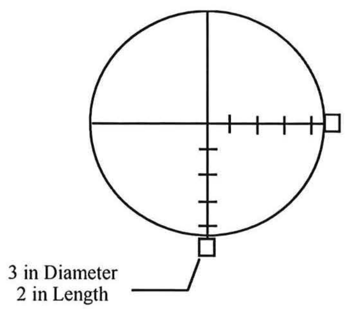
Apex Project No. 22008390

Sampling Date: December 15, 2022

Parameter	Unit	Run 1	Run 2	Run 3	Average
Start Time		0757-0857	1210-1310	1536-1636	
Duration	min	60	60	60	60
RTO Chamber Temperature	°F	1,548	1,548	1,548	1,548
Volumetric Flowrate	scfm	24,611	24,307	23,761	24,226
Total VOC Concentration	ppmvw, as propane	71.7	72.1	54.7	66.2
Total VOC Mass Emission Rate	lb/hr, as propane	12.10	12.02	8.91	11.01
Methane Concentration	ppmvw, as methane	2.7	2.2	2.1	2.3
Methane Concentration	ppmvw, as propane	1.1	0.9	0.9	1.0
Methane Mass Emission Rate	lb/hr, as propane	0.19	0.16	0.15	0.16
Nonmethane Concentration	ppmvw, as propane	70.6	71.2	53.8	65.2
Nonmethane VOC Mass Emission Rate	lb/hr, as propane	11.91	11.87	8.76	10.85
Volumetric Flowrate	scfm	27,019	26,208	26,672	26,633
Total VOC Concentration	ppmvw, as propane	0.8	0.7	0.5	0.7
Total VOC Mass Emission Rate	lb/hr, as propane	0.14	0.13	0.09	0.12
Methane Concentration	ppmvw, as methane	*0*	*0*	*0*	*0*
Methane Concentration	ppmvw, as propane	*0*	*0*	*0*	*0*
Methane Mass Emission Rate	lb/hr, as propane	*0*	*0*	*0*	*0*
Nonmethane Concentration	ppmvw, as propane	0.8	0.7	0.5	0.7
Nonmethane VOC Mass Emission Rate	lb/hr, as propane	0.14	0.13	0.09	0.12
Nonmethane VOC Destruction Efficiency		**98.8%**	**98.9%**	**98.9%**	**98.9%**

Italicized results were less than the detection limit of the analyzer
lb/hr: pound per hour
scfm: wet standard cubic foot per minute
ppmvw: part per million by volume, wet basis

Figures



Traverse Point	Distance From Stack Wall (inch)
1	1.5
2	5.0
3	9.3
4	15.5
5	32.5
6	38.7
7	43.0
8	46.5

Source	Distance From Ports to Nearest Upstream Bend/ Disturbance	Distance From Ports to Nearest Downstream Bend/ Disturbance
RTO Inlet	15 feet (3.75 diameters)	3 feet (0.75 diameter)

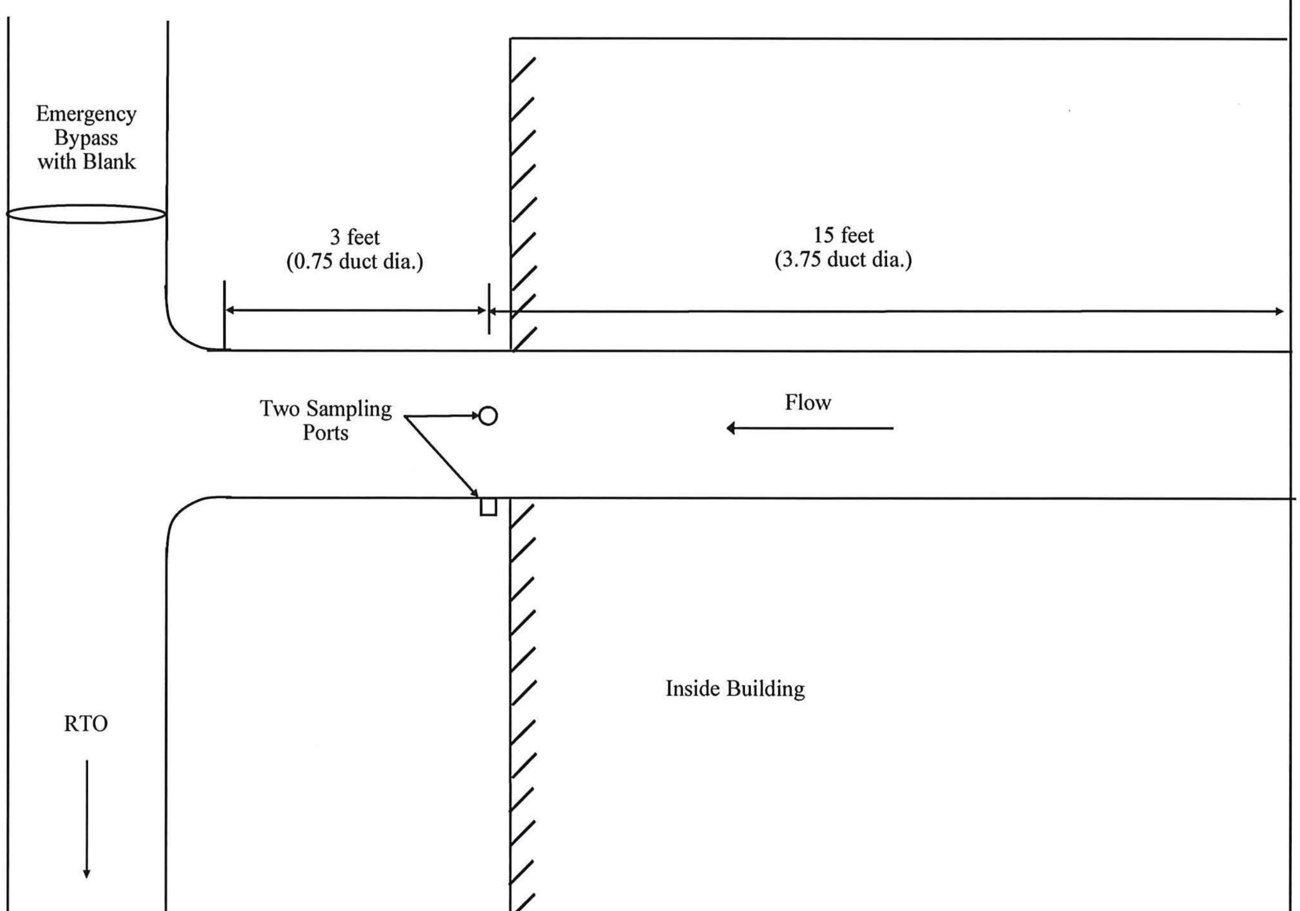


Figure 1
RTO Inlet Sampling Ports and Traverse Point Locations

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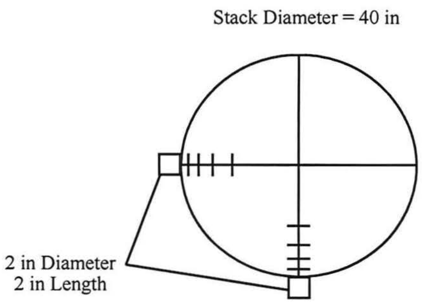

Traverse Point	Distance from Wall (in)
1	1.3
2	4.2
3	7.8
4	12.9
5	27.1
6	32.2
7	35.8
8	38.7

Source	Distance from Ports to Nearest Upstream Bend/Disturbance	Distance from Ports to Nearest Downstream Bend/Disturbance
RTO Outlet	13.3 feet (4.0 diameters)	9 feet (2.7 diameters)

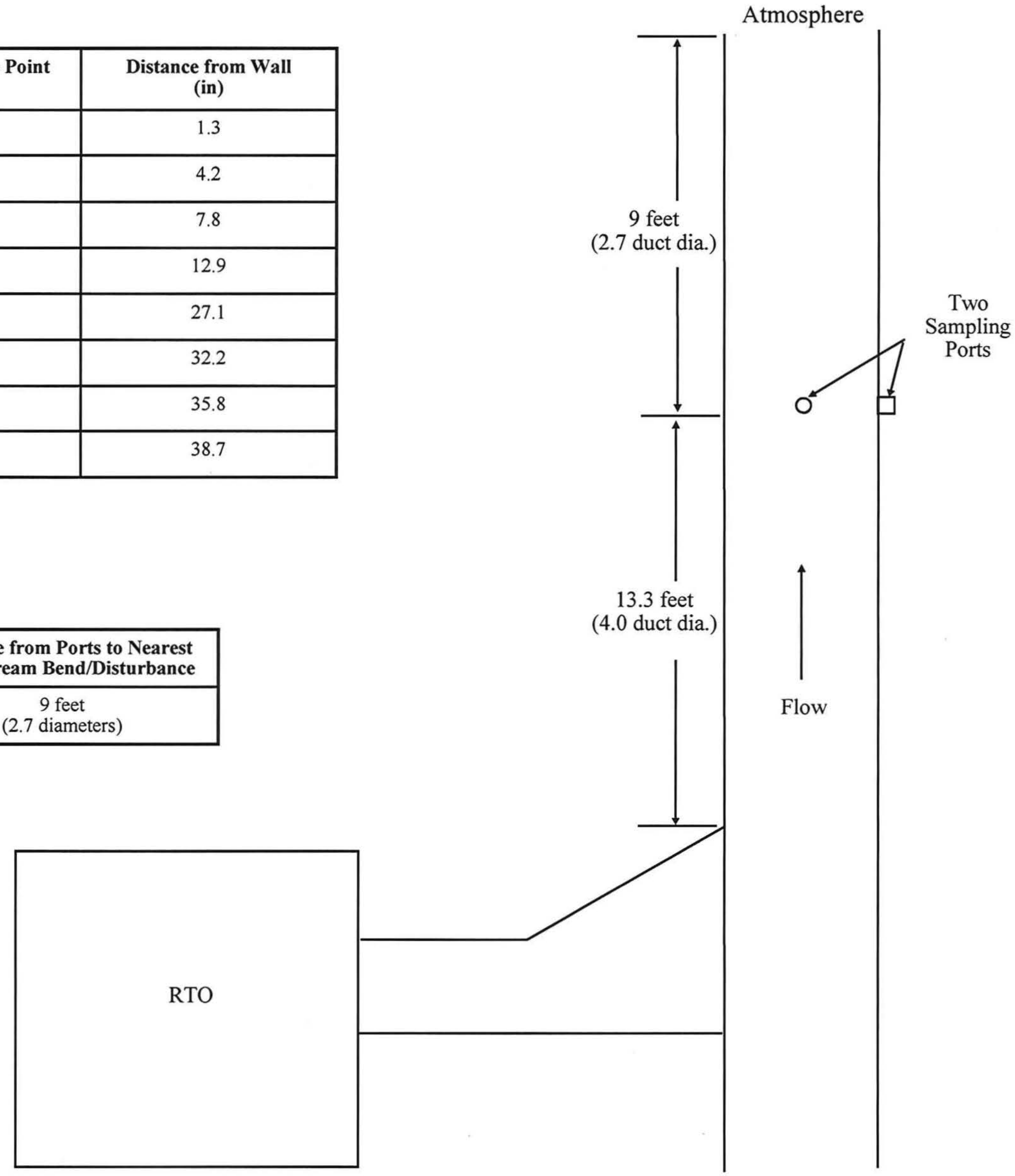

Figure 2
RTO Outlet Sampling Ports and Traverse Point Locations

Pratt & Whitney AutoAir, Inc.
1781 Holloway Drive
Holt, Michigan 48842

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