SOURCE TEST REPORT
PACKED BED SCRUBBERS
METHANOL EMISSION RATE TESTING
CYTEC INDUSTRIES, INC.
KALAMAZOO, MICHIGAN

Prepared For:

Cytec Industries, Inc.
Packed Bed Scrubbers 631-203 and 631-204
3115 Miller Road
Kalamazoo, MI 49001

For Submittal To:

United States Environmental Protection Agency

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STAC STACK TESTING ACCREDITATION COUNCIL

ACCREDITED TO ASTM D7036 ONLY CERT #3925.01

MONTROSE AIR QUALITY SERVICES

EXECUTIVE SUMMARY

To comply with Administrative Consent Order No. EPA-5-19-113(a)-MI-01, Cytec Industries, Inc. (Cytec) retained Montrose Air Quality Services, LLC (Montrose) to conduct a methanol (MeOH) emission rate and removal efficiency test program on two packed bed scrubbers at the Cytec facility in Kalamazoo, Michigan. The purpose of this document is to present the test report for this emissions test program.

As required by paragraph 17 of the U.S. EPA Administrative Consent Order (ACO) dated April 25, 2019 (see Appendix A), the emissions test program included measurement of the methanol emission rates and removal efficiencies of two packed bed scrubbers (Equipment ID 631-203 and 631-204) as specified in the ACO. The packed bed scrubbers control emissions from the KM Polymers process.

Testing of the 631-203 packed bed scrubber inlet and outlet consisted of triplicate 60-minute test runs completed on September 24, 2019 with a 3-hour average scrubber water flowrate of approximately 2.9 gallons per minute. Testing of the 631-204 packed bed scrubber inlet and outlet consisted of triplicate 60-minute test runs completed on September 25, 2019 with a 3-hour average scrubber water flowrate of approximately 2.9 gallons per minute. The results of the packed bed scrubber emissions test program are summarized by Tables E-1 and E-2.

Table E-1
631-203 Packed Bed Scrubber System Test Results

Test Run	Average Inlet Methanol Emission Rate (lbs/hr)	Average Outlet Methanol Emission Rate (lbs/hr)	Methanol Removal Efficiency (%)
1	< 6.29	< 0.00003	99.9996
2	< 6.55	< 0.00003	99.9996
3	< 6.79	< 0.00003	99.9996
Averages	< 6.54	< 0.00003	99.9996

Table E-2
631-204 Packed Bed Scrubber System Test Results

Test Run	Average Inlet Methanol Emission Rate (lbs/hr)	Average Outlet Methanol Emission Rate (lbs/hr)	Methanol Removal Efficiency (%)
1	< 8.02	< 0.00013	99.9984
2	< 8.04	< 0.00027	99.9967
3	< 7.92	< 0.00012	99.9985
Averages	< 8.00	< 0.00003	99.9979

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A. Introduction

To comply with Administrative Consent Order No. EPA-5-19-113(a)-MI-01, Cytec Industries, Inc. (Cytec) retained Montrose Air Quality Services, LLC (Montrose) to conduct a methanol (MeOH) emission rate and removal efficiency test program on two packed bed scrubbers at the Cytec facility in Kalamazoo, Michigan. The purpose of this document is to present the test report for this emissions test program.

As required by paragraph 17 of the U.S. EPA Administrative Consent Order (ACO) dated April 25, 2019 (see Appendix A), the emissions test program included measurement of the methanol emission rates and removal efficiencies of two packed bed scrubbers (Equipment ID 631-203 and 631-204) as specified in the ACO. The packed bed scrubbers control emissions from the KM Polymers process.

A.i Emissions Test Results

Testing of the 631-203 packed bed scrubber inlet and outlet consisted of triplicate 60-minute test runs completed on September 24, 2019 with a 3-hour average scrubber water flowrate of approximately 2.9 gallons per minute. Testing of the 631-204 packed bed scrubber inlet and outlet consisted of triplicate 60-minute test runs completed on September 25, 2019 with a 3-hour average scrubber water flowrate of approximately 2.9 gallons per minute. The results of the packed bed scrubber emissions test program are summarized by Tables 1 and 2.

Table 1
631-203 Packed Bed Scrubber System Test Results

Test Run	Average Inlet Methanol Emission Rate (lbs/hr)	Average Outlet Methanol Emission Rate (lbs/hr)	Methanol Removal Efficiency (%)
1	< 6.29	< 0.00003	99.9996
2	< 6.55	< 0.00003	99.9996
3	< 6.79	< 0.00003	99.9996
Averages	< 6.54	< 0.00003	99.9996

Table 2
631-204 Packed Bed Scrubber System Test Results

Test Run	Average Inlet Methanol Emission Rate (lbs/hr)	Average Outlet Methanol Emission Rate (lbs/hr)	Methanol Removal Efficiency (%)
1	< 8.02	< 0.00013	99.9984
2	< 8.04	< 0.00027	99.9967
3	< 7.92	< 0.00012	99.9985
Averages	< 8.00	< 0.00003	99.9979

A.ii Process and Control Equipment Data Related to Calculating Emission Rates

During the testing period, the following process and control equipment data relevant for the calculation of emissions rates was monitored:

- Scrubber inlet water flowrate
- Leacher in service times
- Current Pass
- Relative timing of pass (i.e. xx lbs of solvent into 1st pass)
- Timing of Nitrogen bubbling and duration
- Nitrogen Flow during bubbling

This data is included in Appendix D.i.

A.iii Test Errors Discussion

No errors were observed during the emissions test program.

A.iv Deviations from Reference Test Methods

Testing was conducted using Methods 1, 2, 3, and 320, with specific deviations as set forth in the approved test protocol. There were no deviations from the approved test protocol during the testing. Specific test methodology is described more fully in Sections C.iii and C.iv.

A.v Production Data

As approved in the test protocol, the 631-203 and 631-204 3-hour average scrubber water flowrates were approximately 2.9 gallons per minute for the stack test and are representative of normal operating conditions. The rate did not vary significantly from the set point over the course of the testing. Production data recorded during the emissions test program is provided in Appendix D.v.

B. Facility Operations

Sections B.i through B.iii provide a description of facility operations.

B.i Process Description

MeOH emissions routed through the packed bed scrubbers are associated with only the leaching, washing and solvent recovery portions of the KM Polymers process. The leaching and washing portions of the process involve passing varying quantities and mixtures ratios of water, MeOH, acetone through the KM Polymer product as well as distillation and recovery of the MeOH and acetone portions of the liquid. This portion of the process is completed over an extended time period with the solvent recovery

distillation process recovering approximately 11,500 gallons of solvent per batch over the course of approximately 45 hours.

B.ii Emissions Control Operating Parameters

Water flow meters are installed to control water flow to each of the two packed bed scrubbers. Testing of the 631-203 packed bed scrubber inlet and outlet consisted of triplicate 60-minute test runs completed on September 24, 2019 with a 3-hour average scrubber water flowrate of approximately 2.9 gallons per minute. Testing of the 631-204 packed bed scrubber inlet and outlet consisted of triplicate 60-minute test runs completed on September 25, 2019 with a 3-hour average scrubber water flowrate of approximately 2.9 gallons per minute. A digital output from each water flow meter is tied into the DCS process control system, providing data acquisition on continuous basis. Data recorded during the emissions test program is provided in Appendix D.v.

B.iii Facility Operating Parameters

Process and control equipment data monitored and recorded during the emissions test program includes:

- Scrubber inlet water flowrate
- Leacher in service times
- Current Pass
- Relative timing of pass (i.e. xx lbs of solvent into 1st pass)
- Timing of Nitrogen bubbling and duration
- Nitrogen Flow during bubbling

Process operating conditions for each test run are summarized in Appendix D.i.

C. Sampling and Analytical Procedures

Sections C.i through C.v summarize the emissions test program Sampling and Analytical Procedures.

C.i Sampling Ports

Both packed bed scrubbers have one inlet sampling location and one outlet sampling location as follows:

(1) The inlet to the each scrubber is a 3-inch diameter, Schedule 10S pipe with an inside diameter of 3.26 inches.
(2) The outlet from each scrubber is a 2-inch diameter, Schedule 10S pipe with an inside diameter of 2.157 inches.

The scrubber sampling locations are illustrated by Figures 1, 2, 3, and 4.

C.ii Sampling Point Description

Exhaust gas velocity was measured at the center of each pipe.

C.iii Sampling Procedure Description

Sampling and analysis procedures followed the requirements codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A) and 40 CFR 63, Appendix A:

- Method 1 - *"Sample and Velocity Traverses for Stationary Sources"* will be used to determine the sampling locations.
- Method 2 - *"Determination of Stack Gas Velocity and Volumetric Flowrate"* will be used to measure exhaust gas velocity.
- Method 3 - *"Gas Analysis for the Determination of Dry Molecular Weight (Fyrite Analysis)"* will be used to determine exhaust gas oxygen content.
- Method 320 - *"Measurement of Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infared Spectroscopy"* will be used to measure exhaust gas MeOH concentrations at the two packed bed scrubbers. Method 320 will also be used to measure exhaust gas carbon dioxide and moisture content at each sampling location.

Both packed bed scrubbers have one inlet sampling location and one outlet sampling location as follows:

(1) The inlet to the each scrubber is a 3-inch diameter, Schedule 10S pipe with an inside diameter of 3.26 inches.
(2) The outlet from each scrubber is a 2-inch diameter, Schedule 10S pipe with an inside diameter of 2.157 inches.

The scrubber sampling locations are illustrated by Figures 1, 2, 3, and 4.

C.iv Method Deviations

With respect to the methods listed above, the following method variations were requested and approved for each sampling location:

- Because the exhaust gas flowrates are variable and because the sampling locations are only 2.157 or 3.26 inches in diameter, exhaust gas flowrate was measured using stationary pitot tubes fixed in position at the center of the pipes. Figures 1, 2, 3, and 4 illustrate the location of the velocity pressure sampling location and the Method 320 sampling location.

- Because of the configuration of the stack test ports, Montrose used a small S-type pitot tube rather than a standard pitot tube.

- Velocity pressure were measured using differential pressure transmitters with a range of 0 to 0.25 inch of water and the velocity pressure will be datalogged at one second intervals. The specified accuracy of the differential pressure transmitter is +/- 0.00125 inches of water.

- Because all flowrates were extremely low, all velocity pressures less than 0.01 inches of water were considered to be 0.01 inches of water for the purpose of emission rate calculations.

- Because the exhaust flowrate and gas characteristics were variable, prior to the first test run and after the last test run, the sampling locations were checked for cyclonic flow at the center of the duct.

- Prior to and after each test run, pitot tube leak checks were conducted.

- The accuracy of the differential pressure transmitters were verified at Montrose's office in Royal Oak, Michigan before the test program. Tubing was teed to a manometer and the manometer readings checked against the high and low pressure sides of the transmitters. Each transmitter side was checked at four levels (zero, low, mid, and high) three times with values recorded on calibration data sheets.

- The static pressure was measured once before the beginning of the emissions test program and once at the end of the emissions test program.

- Exhaust gas temperatures were measured and recorded at fifteen minute intervals during each test run.

- Exhaust gas moisture content was measured by Fourier Transform Infrared Spectroscopy (FTIR) as was used to analyze for exhaust gas MeOH concentrations.

- Bag grab samples were collected at the exhaust from the FTIR unit and analyzed for O_2 content using a Fyrite analyzer. Exhaust gas molecular weight was determined from the measured O_2 content as well as concentration data for other compounds as measured by the FTIR used to analyze for exhaust gas MeOH concentrations.

- FTIR data was recorded at a maximum interval of 15 seconds during the emissions test program.

Because of the high methanol concentrations, the Method 320 MeOH analyte spikes were performed in ambient air as opposed to the sample stream. This approach confirmed the FTIR/sampling system to accurately deliver and quantify a known concentration of MeOH.

C.v Analytical Procedures

The emissions test program did not include collected samples. Analytical procedures for the on-site Method 320 analyses is included in the Prism Analytical Technologies report included in Appendix D.iii.

D Appendices

Sections D.i through D.vii provide identification of Appendices for the corresponding information.

D.i Results and Example Calculations

Detailed test results are summarized by Tables 3, 4, 5, and 6 in Appendix D.i. Example calculations are also provided in Appendix D.i.

D.ii Raw Field Data

Raw field data are provided in Appendix D.ii.

D.iii Laboratory Report

The Method 320 FTIR report from Prism Analytical Technologies is included in Appendix D.iii.

D.iv Calibration

Equipment calibration documents for the Method 320 FTIR analysis are included in the Prism Analytical Technologies report included in Appendix D.iii. Exhaust gas flowrate equipment calibration documents are included in Appendix D.iv.

D.v Process and Control Equipment Data

Raw process and control equipment data is provided in Appendix D.v.

D.vi Test Log

The test log is summarized by the field notes and data sheets included in Appendix D.ii.

D.vii Project Personnel

Project personnel are summarized by Table 7 in Appendix D.vii.

D.viii Related Correspondence

Correspondence related to the emissions test program is provided in Appendix D.viii.

Table 3
Methanol Emission Test Results
Packed Bed Water Scrubber 203
Cytec Industries, Inc.
Kalamazoo, Michigan

Test Date	Test Run	Test Run Time	Process Step	Process Step Start Time	Process Step End Time	Water Scrubber Water Flowrate (gal/min)	Scrubber Inlet Methanol Emission Rate (lbs/hr)	Scrubber Outlet Methanol Emission Rate (lbs/hr)	Overall Methanol Removal Efficiency (%)
September 24, 2019	1	9:18 - 10:18	N2 Bubbling	9:53:20	9:56:10	2.8	< 6.29	< 0.00003	99.9996
	2	10:30 - 11:30	N2 Bubbling	10:46:17	10:50:08	3.0	< 6.55	< 0.00003	99.9996
	3	11:38 - 12:38	N2 Bubbling	11:51:45	11:54:54	2.8	< 6.79	< 0.00003	99.9996
					3-Test Averages:	2.9	< 6.54	< 0.00003	99.9996

Table 4
Methanol Emission Test Results
Packed Bed Water Scrubber 204
Cytec Industries, Inc.
Kalamazoo, Michigan

Test Date	Test Run	Test Run Time	Process Step	Process Step Start Time	Process Step End Time	Water Scrubber Water Flowrate (gal/min)	Scrubber Inlet Methanol Emission Rate (lbs/hr)	Scrubber Outlet Methanol Emission Rate (lbs/hr)	Overall Methanol Removal Efficiency (%)
September 25, 2019	1	8:22 - 9:22	N2 Bubbling	8:32:30	8:34:41	2.9	< 8.02	< 0.00013	99.9984
	2	9:37 - 10:37	N2 Bubbling	9:27:01	9:29:16	2.9	< 8.04	< 0.00027	99.9967
	3	10:45 - 11:45	N2 Bubbling	11:25:46	11:27:48	2.9	< 7.92	< 0.00012	99.9985
					3-Test Averages:	2.9	< 8.00	< 0.00017	99.9979

Table 5
Scrubber 203 Detailed Emission Test Results
Sampling Date: 9/24/19

				Inlet Data									Outlet Data								
Scrubber ID	Test Run	Test Date	Test Time	Average Velocity Pressure (in. H_2O)	Average Temperature (^oF)	Static Pressure (in. Hg)	O_2 Conc. (%)	CO_2 Conc. (%)	H_2O Conc. (%)	Methanol Conc. (%)	Average Exhaust Gas Flowrate (scfm)	Methanol Emission Rate (lbs/hr)	Average Velocity Pressure (in. H_2O)	Average Temperature (^oF)	Static Pressure (in. Hg)	O_2 Conc. (%)	CO_2 Conc. (%)	H_2O Conc. (%)	Methanol Conc. (ppmv)	Average Exhaust Gas Flowrate (scfm)	Methanol Emission Rate (lbs/hr)
	1		9:18 - 10:18	< 0.01	79	29.54	9.5	< 1.0	< 1.0	6.56	< 19.3	< 6.29	< 0.01	65	29.32	20.9	0.31	1.89	< 0.5	< 10.8	< 0.00003
203	2	9/24/2019	10:30 - 11:30	< 0.01	81	29.54	9.0	< 1.0	< 1.0	6.84	< 19.2	< 6.55	< 0.01	67	29.32	20.9	0.35	2.00	< 0.5	< 10.7	< 0.00003
	3		11:38 - 12:38	< 0.01	83	29.54	9.0	< 1.0	< 1.0	7.11	< 19.2	< 6.79	< 0.01	69	29.32	20.9	0.31	1.98	< 0.5	< 10.7	< 0.00003
			Averages:	< 0.01	81	29.54	9.2	< 1.0	< 1.0	6.84	< 19.2	< 6.54	< 0.01	67	29.32	20.9	0.32	1.96	< 0.5	< 10.7	< 0.00003

Inlet Pipe Inside Diameter (in.):	3.26
Outlet Pipe Inside Diameter (in.):	2.157

Notes:
(1) Barometric pressure, corrected to sea level, on the day of testing was 30.12 in. Hg. Elevation of the sampling location was approximately 804', so the actual barometric pressure was (30.12 - (804 x (0.1/100)) = 29.32 in. Hg.
The static pressure at the inlet sampling location was 3.0 in. H_2O and the static pressure at the outlet sampling location was 0.0 in. H_2O.

Table 6
Scrubber 204 Detailed Emission Test Results
Sampling Date: 9/25/19

				Inlet Data									Outlet Data								
Scrubber ID	Test Run	Test Date	Test Time	Average Velocity Pressure (in. H_2O)	Average Temperature (^oF)	Static Pressure (in. Hg)	O_2 Conc. (%)	CO_2 Conc. (%)	H_2O Conc. (%)	Methanol Conc. (%)	Average Exhaust Gas Flowrate (scfm)	Methanol Emission Rate (lbs/hr)	Average Velocity Pressure (in. H_2O)	Average Temperature (^oF)	Static Pressure (in. Hg)	O_2 Conc. (%)	CO_2 Conc. (%)	H_2O Conc. (%)	Methanol Conc. (ppmv)	Average Exhaust Gas Flowrate (scfm)	Methanol Emission Rate (lbs/hr)
	1		8:22 - 9:22	< 0.01	68	29.20	12.0	< 1.0	< 1.0	8.35	< 19.3	< 8.02	< 0.01	69	29.00	20.9	0.06	1.52	2.5	< 10.6	< 0.00013
204	2	9/25/2019	9:37 - 10:37	< 0.01	68	29.20	12.0	< 1.0	< 1.0	8.38	< 19.3	< 8.04	< 0.01	73	29.00	20.9	0.05	1.48	5.1	< 10.5	< 0.00027
	3		10:45 - 11:45	< 0.01	70	29.20	12.0	< 1.0	< 1.0	8.26	< 19.3	< 7.92	< 0.01	79	29.00	20.9	0.10	1.49	2.2	< 10.4	< 0.00012
			Averages:	< 0.01	69	29.20	12.0	< 1.0	< 1.0	8.33	< 19.3	< 8.00	< 0.01	74	29.00	20.9	0.07	1.49	3.3	< 10.5	< 0.00017

Inlet Pipe Inside Diameter (in.):	3.26
Outlet Pipe Inside Diameter (in.):	2.157

Notes:
(1) Barometric pressure, corrected to sea level, on the day of testing was 29.80 in. Hg. Elevation of the sampling location was approximately 804', so the actual barometric pressure was (29.80 - (804 x (0.1/100)) = 29.00 in. Hg.
The static pressure at the inlet sampling location was 2.8 in. H_2O and the static pressure at the outlet sampling location was 0.0 in. H_2O.

Table 7
Test Personnel

Name and Title	Affiliation	Telephone
Mr. Jeff Shina Sr. Process Engineer	Cytec Industries, Inc. 3115 Miller Road Kalamazoo, Michigan 49001	(269) 349-6677
Mr. Randal J. Tysar District Manager	Montrose Air Quality Services 4949 Fernlee Avenue Royal Oak, Michigan 48073	(248) 548-8070
Mr. David Kopenen Field Technician	Montrose Air Quality Services 4949 Fernlee Avenue Royal Oak, Michigan 48073	(248) 548-8070
Ms. Lindsey Wells Chemist/FTIR Specialist	Prism Analytical Technologies 2625 Denison Mt. Pleasant, Michigan 48858	(989) 772-5088

FIGURES

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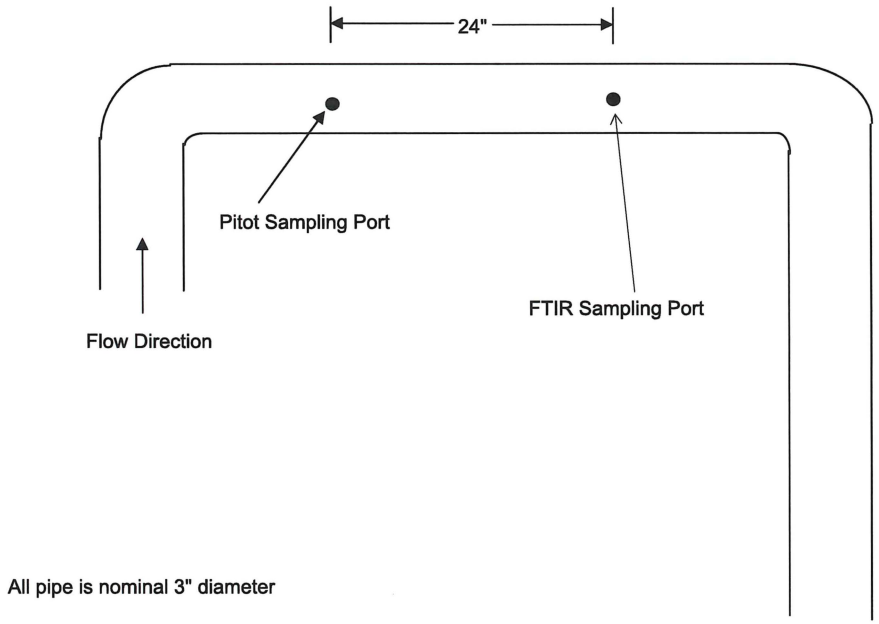

DRAWING IS NOT TO SCALE

Figure 1

Site: **Scrubber 631-203 Inlet Sampling Location** **Cytec Industries, Inc.** **Kalamazoo, Michigan**	**Sampling Dates:** **Sept. 24 and 25, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, Michigan**

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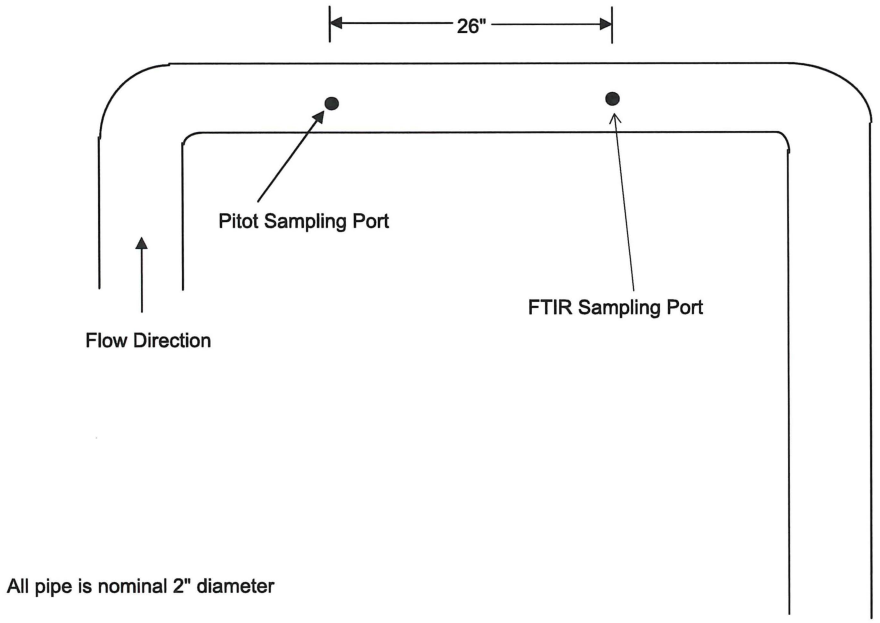

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Figure 2

Site: **Scrubber 631-203 Outlet Sampling Location** **Cytec Industries, Inc.** **Kalamazoo, Michigan**	**Sampling Dates:** **Sept. 24 and 25, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, Michigan**

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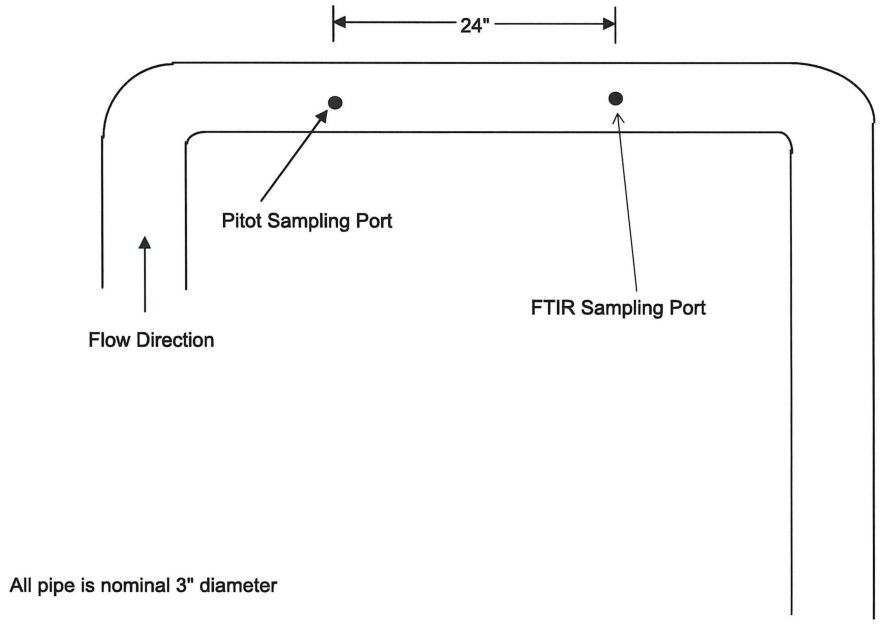

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Figure 3

Site: **Scrubber 631-204 Inlet Sampling Location** **Cytec Industries, Inc.** **Kalamazoo, Michigan**	**Sampling Dates:** **Sept. 24 and 25, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, Michigan**

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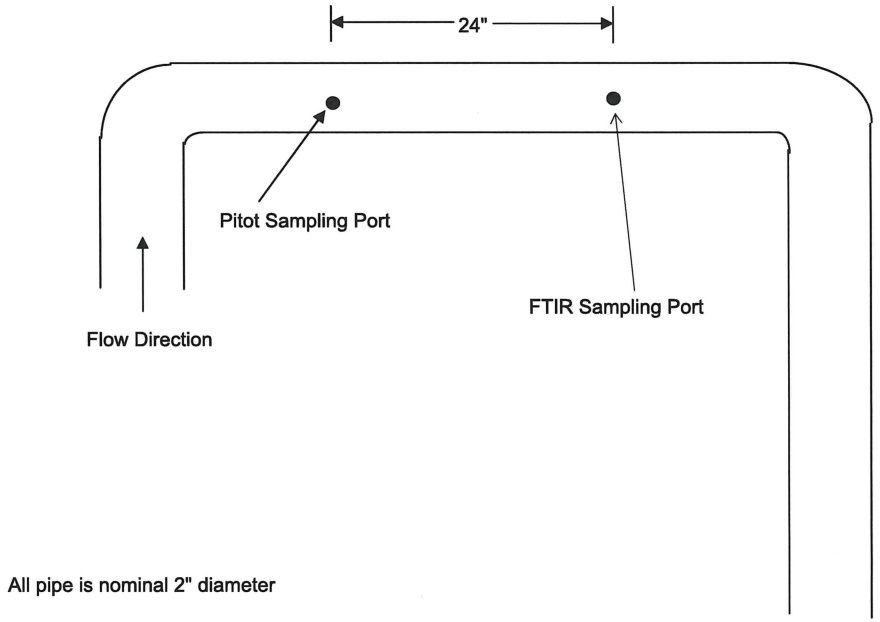

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Figure 4

Site: **Scrubber 631-204 Outlet Sampling Location** **Cytec Industries, Inc.** **Kalamazoo, Michigan**	**Sampling Dates:** **Sept. 24 and 25, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, Michigan**