

Regulatory Information

Permit No. Michigan Department of Environmental, Great Lakes and Energy (EGLE)
Air Quality Division (AQD) 75-22
Regulatory Citation 40 CFR 60, Subpart I

Source Information

<i>Source Name</i>	<i>Source ID</i>	<i>Target Parameters</i>
Asphalt Paving Materials Mixing Plant	SRN: P1209	PM, PM2.5, PM10, NOx, CO, VOC, Ni, H ₂ CO

Contact Information

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Alliance Technical Group, LLC (Alliance) has completed the source testing as described in this report. Results apply only to the source(s) tested and operating condition(s) for the specific test date(s) and time(s) identified within this report. All results are intended to be considered in their entirety, and Alliance is not responsible for use of less than the complete test report without written consent. This report shall not be reproduced in full or in part without written approval from the customer.

To the best of my knowledge and abilities, all information, facts and test data are correct. Data presented in this report has been checked for completeness and is accurate, error-free and legible. Onsite testing was conducted in accordance with approved internal Standard Operating Procedures. Any deviations or problems are detailed in the relevant sections in the test report.

This report is only considered valid once an authorized representative of Alliance has signed in the space provided below; any other version is considered draft. This document was prepared in portable document format (.pdf) and contains pages as identified in the bottom footer of this document.



Adam Robinson
Alliance Technical Group, LLC

8/18/2023

Date

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1.0 Introduction

Alliance Technical Group, LLC (Alliance) was retained by Asphalt Paving Inc. (Asphalt Paving) to conduct compliance testing at the Muskegon, Michigan facility. Portions of the facility are subject to provisions of the Michigan Department of Environmental, Great Lakes and Energy (EGLE) Air Quality Division (AQD) air permit and 40 CFR 60, Subpart I. Testing was conducted to determine the concentrations and mass emission rates of particulate matter (PM), particulate matter less than ten microns (PM10), particulate matter less than 2.5 microns (PM2.5), nitrogen oxides (NO_x), carbon monoxide (CO), total volatile organic compounds (VOC) reported as total hydrocarbons (THC), nickel (Ni), and formaldehyde (H₂CO) emitted from one (1) baghouse exhaust at the facility.

1.1 Facility Description

Asphalt Paving, Inc. (Asphalt Paving) installed a new Asphalt Paving Materials (APM) mixing plant (APM) on the site of 45 South Getty Street, Muskegon, Michigan. The Air Permit to Install for the 310-ton-per-hour counter-flow drum mix APM mixing plant was issued by EGLE in June 2022.

APM are produced by blending virgin aggregates, reclaimed asphalt pavement (RAP) and asphalt cement binder together in a rotating, inclined, direct-fired kiln, which is generally referred to as “the drum” in the asphalt paving industry. The virgin aggregates are introduced at the top end of the inclined drum and rely on gravity as they tumble down through the drum veiling through the exhaust gas produced by combusting natural gas with a heating value of approximately 1,037 BTUs per cubic foot. With the Astec Double Barrel APM mixing plant, the dried and heated aggregates drop out of the drum into an outer drum that wraps around the drying/heating drum. Asphalt cement binder is injected into the annular space between the drying/heating drum and the wrap-around drum where it is blended with the aggregates/RAP to uniformly coat them with asphalt binder.

Asphalt Paving uses RAP in the mixes they produce which can contain up to 50% RAP by weight, but routinely contain 20% to 25%. The percentages of RAP depends on the customer and the project. The advantage of RAP is that it reduces the demand for virgin aggregates and petroleum-based asphalt cement binder. When RAP mixes are being produced, the RAP is introduced into the same annular space as the asphalt cement binder, but closer to where the virgin aggregates are introduced. The virgin aggregates have been superheated in the drying & heating section and conductive heat transfer is relied upon between the virgin aggregates and the RAP to heat and dry the RAP materials prior to blending with the asphalt binder.

The process is controlled for particulate matter emissions with a fabric filter with an integrated knockout box. The fines collected by the fabric filter are returned to the mixing process and are introduced with the asphalt binder in the annular space between the direct-fired inner drum and the outer drum. Blue smoke arising from the heated asphalt binder is sucked back into the combustion zone of the inner drum.

The final product is transferred to a storage silo system. Asphalt Paving installed three storage silos for finished product. The storage system for APM is temporary storage. Materials are very rarely stored overnight, but when it happens, it typically only happens when laydown operations are cancelled due to an unexpected weather event and not resumed.

1.2 Project Team

Personnel involved in this project are identified in the following table.

Table 1-1: Project Team

Facility Personnel	Ryan Johnson
Regulatory Personnel	Regina Angellotti
Alliance Personnel	Samuel Hines Lucas Kovach Ryan Peluso

1.3 Site Specific Test Plan & Notification

Testing was conducted in accordance with the Site Specific Test Plan (SSTP) submitted to EGLE by Asphalt Paving.

2.0 Summary of Results

Alliance conducted compliance testing at the Asphalt Paving facility in Muskegon, Michigan on June 20-22, 2023. Testing consisted of determining the concentrations and mass emission rates of PM, PM10, PM2.5, NO_x, CO, VOC)reported as THC, Ni, and H₂CO emitted from one (1) baghouse exhaust at the facility.

Tables 2-1 and 2-2 provide a summary of the emission testing results with comparisons to the applicable 40 CFR 60, Subpart I and EGLE Permit limits. Any difference between the summary results listed in the following table and the detailed results contained in appendices is due to rounding for presentation.

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Table 2-1: Summary of Results – 6/20/23

Run Number	Run 1	Run 2	Run 3	Average
Date	6/20/23	6/20/23	6/20/23	--
Filterable Particulate Matter Data				
Concentration, grain/dscf	0.0018	0.0005	0.0008	0.0010
NSPS Limit, grain/dscf	--	--	--	0.04
Percent of Limit, %	--	--	--	3
Emission Rate, lb/hr	0.19	0.062	0.11	0.12
Emission Factor, lb/ton	9.5E-04	2.6E-04	4.2E-04	5.4E-04
Permit Limit, lb/ton	--	--	--	0.03
Percent of Limit, %	--	--	--	2
PM10/PM2.5 Data				
Filterable PM Emission Rate, lb/hr	0.19	0.062	0.11	0.12
Condensable PM Emission Rate, lb/hr	0.54	0.16	0.21	0.31
PM10/PM2.5 Emission Rate, lb/hr ¹	0.74	0.22	0.32	0.43
Emission Factor, lb/ton	3.6E-03	9.5E-04	1.2E-03	1.9E-03
Permit Limit, lb/ton	--	--	--	0.03
Percent of Limit, %	--	--	--	6
Nitrogen Oxides Data				
Emission Rate, lb/hr	2.12	2.19	2.48	2.27
Emission Factor, lb/ton	0.011	0.0093	0.0097	0.0099
Permit Limit, lb/ton	--	--	--	0.07
Percent of Limit, %	--	--	--	14
Carbon Monoxide Data				
Emission Rate, lb/hr	4.83	5.52	2.28	4.21
Emission Factor, lb/ton	2.4E-02	2.3E-02	8.9E-03	1.9E-02
Permit Limit, lb/ton	--	--	--	0.2
Percent of Limit, %	--	--	--	9
Total Hydrocarbons (as propane)				
Emission Rate, lb/hr	1.58	1.25	0.52	1.11
Emission Factor, lb/ton	7.9E-03	5.3E-03	2.0E-03	5.1E-03
Nickel Data				
Emission Rate, lb/hr	9.8E-04	7.1E-04	5.2E-04	7.4E-04
Emission Factor, lb/ton	4.9E-06	3.0E-06	2.0E-06	3.3E-06
Permit Limit, lb/ton	--	--	--	7.60E-05
Percent of Limit, %	--	--	--	4
Process Data				
Process Rate, ton/hr (PM, PM10, PM2.5)	203.0	235.5	261.3	233.3
Process Rate, ton/hr (Ni, NOx, CO, THC)	201.1	235.2	255.7	230.7

¹ PM10/PM2.5 is the summation of the filterable and condensable PM fractions.

Table 2-2: Summary of Results – 6/22/23

Run Number	Run 1	Run 2	Run 3	Average
Date	6/22/23	6/22/23	6/22/23	--
Carbon Monoxide Data				
Emission Rate, lb/hr	6.41	6.55	2.25	5.07
Emission Factor, lb/ton	0.027	0.031	0.010	0.023
Permit Limit, lb/ton	--	--	--	0.2
Percent of Limit, %	--	--	--	11
Total Hydrocarbons (as propane)				
Emission Rate, lb/hr	1.84	2.25	0.58	1.55
Emission Factor, lb/ton	7.7E-03	1.1E-02	2.6E-03	7.0E-03
Formaldehyde Data				
Emission Rate, lb/hr	0.72	0.69	0.43	0.61
Emission Factor, lb/ton	3.0E-03	3.2E-03	1.9E-03	2.7E-03
Permit Limit, lb/ton	--	--	--	5.40E-03
Percent of Limit, %	--	--	--	51
Process Data				
Process Rate, ton/hr (CO, THC, CHOH)	239.4	212.0	223.3	224.9

3.0 Testing Methodology

The emission testing program was conducted in accordance with the test methods listed in Table 3-1. Method descriptions are provided below while quality assurance/quality control data is provided in Appendix D.

Table 3-1: Source Testing Methodology

Parameter	U.S. EPA Reference Test Methods	Notes/Remarks
Volumetric Flow Rate	1 & 2	Full Velocity Traverses
Oxygen/Carbon Dioxide	3A	Instrumental Analysis
Moisture Content	4	Gravimetric Analysis
Particulate Matter	5 & 202	Isokinetic Sampling
Nitrogen Oxides	7E	Instrumental Analysis
Carbon Monoxide	10	Instrumental Analysis
Volatile Organic Compounds	25A	Instrumental Analysis
Formaldehyde	320	FTIR – Continuous Sampling
Nickel	29	Isokinetic Testing
Gas Dilution System Certification	205	--

3.1 U.S. EPA Reference Test Methods 1 and 2 – Volumetric Flow Rate

The sampling location and number of traverse (sampling) points was selected in accordance with U.S. EPA Reference Test Method 1. To determine the minimum number of traverse points, the upstream and downstream distances were equated into equivalent diameters and compared to Figure 1-1 in U.S. EPA Reference Test Method 1.

Full velocity traverses were conducted in accordance with U.S. EPA Reference Test Method 2 to determine the average stack gas velocity pressure, static pressure and temperature. The velocity and static pressure measurement system consists of a pitot tube and inclined manometer. The stack gas temperature was measured with a K-type thermocouple and pyrometer.

3.2 U.S. EPA Reference Test Method 3/3A – Oxygen/Carbon Dioxide

The oxygen (O₂) and carbon dioxide (CO₂) testing was conducted in accordance with U.S. EPA Reference Test Method 3A. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless steel probe, heated Teflon sample line(s), gas conditioning system and the identified gas analyzer. The gas conditioning system was a non-contact condenser used to remove moisture from the stack gas. The quality control measures are described in Section 3.11.

3.3 U.S. EPA Reference Test Method 4 – Moisture Content

The stack gas moisture content was determined in accordance with U.S. EPA Reference Test Method 4. The gas conditioning train consisted of a series of chilled impingers. Prior to testing, each impinger was filled with a known quantity of water or silica gel. Each impinger were analyzed gravimetrically before and after each test run on the same analytical balance to determine the amount of moisture condensed.

3.4 U.S. EPA Reference Test Method 5 and 202 – Total Particulate Matter

The total particulate matter (filterable and condensable PM) testing was conducted in accordance with U.S. EPA Reference Test Methods 5 and 202. The complete sampling system consisted of a stainless-steel nozzle, glass-lined probe, pre-weighed quartz filter, coil condenser, un-weighed Teflon filter, gas conditioning train, pump and calibrated dry gas meter. The gas conditioning train consisted of a coiled condenser and five (5) chilled impingers. The first, and second impingers were initially empty, the third contained 100 mL of de-ionized water, the fourth was empty, and the last impinger contained 200-300 grams of silica gel. The un-weighed 90 mm Teflon filter was placed between the second and third impingers. The probe liner heating system was maintained at a temperature of $248 \pm 25^\circ\text{F}$, and the impinger temperature was maintained at 68°F or less throughout testing. The temperature of the Teflon filter was maintained greater than 65°F but less than or equal to 85°F .

Following the completion of each test run, the sampling train was leak checked at a vacuum pressure greater than or equal to the highest vacuum pressure observed during the run. Condensate was collected in the first dry impinger, therefore the front-half of the sample train (the nozzle, probe, and heated pre-weighed filter) was removed in order to purge the back-half of the sample train (coil condenser, first and second impingers and CPM filter). A glass bubbler was inserted into the first impinger. If needed, de-ionized ultra-filtered (DIUF) water was added to the first impinger to raise the water level above the bubbler, then the coil condenser was replaced. Zero nitrogen was connected to the condenser, and a 60-minute purge at 14 liters per minute was conducted. After the completion of the nitrogen purge the impinger contents were measured for moisture gain.

The pre-weighed quartz filter was carefully removed and placed in container 1. The probe, nozzle and front half of the filter holder were rinsed three (3) times with acetone to remove any adhering particulate matter and these rinses were recovered in container 2. All containers were sealed, labeled and liquid levels marked for transport to the identified laboratory for filterable particulate matter analysis.

The contents of impingers 1 and 2 were recovered in container CPM Cont. #1. The back half of the filterable PM filter holder, the coil condenser, impingers 1 and 2 and all connecting glassware were rinsed with DIUF water and then rinsed with acetone, followed by hexane. The water rinses were added to container CPM Cont. #1 while the solvent rinses were recovered in container CPM Cont. #2. The Teflon filter was removed from the filter holder and placed in container CPM Cont. #3. The front half of the condensable PM filter holder was rinsed with DIUF water and then with acetone, followed by hexane. The water rinse was added to container CPM Cont. #1 while the solvent rinses were added to container CPM Cont. #2. All containers were sealed, labeled and liquid levels marked for transport to the identified laboratory for condensable particulate matter analysis.

3.5 U.S. EPA Reference Test Method 7E – Nitrogen Oxides

The nitrogen oxides (NO_x) testing was conducted in accordance with U.S. EPA Reference Test Method 7E. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless steel probe, heated Teflon sample line(s), gas conditioning system and the identified gas analyzer. The gas conditioning system was a non-contact condenser used to remove moisture from the stack gas. The quality control measures are described in Section 3.11.

3.6 U.S. EPA Reference Test Method 10 – Carbon Monoxide

The carbon monoxide (CO) testing was conducted in accordance with U.S. EPA Reference Test Method 10. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless steel probe, heated Teflon sample line(s), gas conditioning system and the identified gas analyzer. The gas conditioning system

was a non-contact condenser used to remove moisture from the stack gas. The quality control measures are described in Section 3.11.

3.7 U.S. EPA Reference Test Method 25A – Volatile Organic Compounds

The volatile organic compounds (VOC) testing was conducted in accordance with U.S. EPA Reference Test Method 25A. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless-steel probe, heated Teflon sample line(s) and the identified gas analyzer. The quality control measures are described in Section 3.12.

3.8 U.S. EPA Reference Test Method 29 – Metals

The metals testing was conducted in accordance with U.S. EPA Reference Test Method 29. The complete sampling system consisted of a glass nozzle, heated glass-lined probe, pre-cleaned quartz filter, gas conditioning system, pump and calibrated dry gas meter. The gas conditioning train consisted of four (4) chilled impingers. The first and second impingers contained 100 mL of HNO₃/H₂O₂, the third was empty and the fourth impinger contained 200-300 grams of silica gel. The probe liner and filter heating systems were maintained at a temperature of 120 ± 14°C (248 ± 25°F), and the impinger temperature was maintained at 20°C (68°F) or less throughout testing. Prior to testing, all glassware was cleaned and sealed in a controlled environment as outlined in the test method.

Following the completion of each test run, the sample train was leak checked at a vacuum pressure equal to or greater than the highest vacuum pressure observed during the run and the contents of the impingers were measured for moisture gain. The quartz filter was carefully removed and placed into container 1. The probe and nozzle were rinsed and brushed three (3) times with 0.1 N HNO₃ using a non-metallic brush and these rinses were placed in container 3. The front half of the filter holder was rinsed three (3) times with 0.1 N HNO₃ and these rinses were added to container 3. The contents of impingers 1, 2, and 3 were placed in container 4. Impingers 1, 2, and 3 along with the filter support, back half of the filter holder and all connecting glassware were triple-rinsed with 0.1 N HNO₃ and these rinses were added to container 4. All containers were sealed, labeled and liquid levels marked for transport to the identified laboratory for analysis.

3.9 U.S. EPA Reference Test Method 320 – Formaldehyde

The concentration of formaldehyde were determined in accordance with U.S. EPA Reference Test Method 320. Each source gas stream was extracted at a constant rate through a heated probe, heated filter and heated sample line and analyzed with a FTIR operated by a portable computer. The computer has FTIR spectra of calibration gases stored on the hard drive. These single component calibration spectra are used to analyze the measured sample spectra. The gas components to be measured were selected from the spectra library and incorporated into the analytical method. The signal amplitude, linearity, and signal to noise ratio were measured and recorded to document analyzer performance. A leak check was performed on the sample cell. The instrument path length was verified using ethylene as the Calibration Transfer Standard. Dynamic spiking was performed using a certified standard of the target compound or appropriate surrogate in nitrogen with sulfur hexafluoride blended as a tracer to calculate the dilution factor. All test spectra, interferograms, and analytical method information are recorded and stored with the calculated analytical results. The quality control measures are described in Section 3.13.

3.10 U.S. EPA Reference Test Method 205 – Gas Dilution System Certification

A calibration gas dilution system field check was conducted in accordance with U.S. EPA Reference Method 205. Multiple dilution rates and total gas flow rates were utilized to force the dilution system to perform two dilutions on each mass flow controller. The diluted calibration gases were sent directly to the analyzer, and the analyzer response

recorded in an electronic field data sheet. The analyzer response agreed within 2% of the actual diluted gas concentration. A second Protocol 1 calibration gas, with a cylinder concentration within 10% of one of the gas divider settings described above, was introduced directly to the analyzer, and the analyzer response recorded in an electronic field data sheet. The cylinder concentration and the analyzer response agreed within 2%. These steps were repeated three (3) times. Copies of the Method 205 data can be found in the Quality Assurance/Quality Control Appendix.

3.11 Quality Assurance/Quality Control – U.S. EPA Reference Test Methods 3A, 7E and 10

Cylinder calibration gases used met EPA Protocol 1 (+/- 2%) standards. Copies of all calibration gas certificates can be found in the Quality Assurance/Quality Control Appendix.

Low Level gas was introduced directly to the analyzer. After adjusting the analyzer to the Low-Level gas concentration and once the analyzer reading was stable, the analyzer value was recorded. This process was repeated for the High-Level gas. For the Calibration Error Test, Low, Mid, and High Level calibration gases were sequentially introduced directly to the analyzer. All values were within 2.0 percent of the Calibration Span or 0.5 ppmv/% absolute difference.

High or Mid Level gas (whichever was closer to the stack gas concentration) was introduced at the probe and the time required for the analyzer reading to reach 95 percent or 0.5 ppmv/% (whichever was less restrictive) of the gas concentration was recorded. The analyzer reading was observed until it reached a stable value, and this value was recorded. Next, Low Level gas was introduced at the probe and the time required for the analyzer reading to decrease to a value within 5.0 percent or 0.5 ppmv/% (whichever was less restrictive) was recorded. If the Low-Level gas was zero gas, the response was 0.5 ppmv/% or 5.0 percent of the upscale gas concentration (whichever was less restrictive). The analyzer reading was observed until it reached a stable value and this value was recorded. The measurement system response time and initial system bias were determined from these data. The System Bias was within 5.0 percent of the Calibration Span or 0.5 ppmv/% absolute difference.

High or Mid Level gas (whichever was closer to the stack gas concentration) was introduced at the probe. After the analyzer response was stable, the value was recorded. Next, Low Level gas was introduced at the probe, and the analyzer value recorded once it reached a stable response. The System Bias was within 5.0 percent of the Calibration Span or 0.5 ppmv/% absolute difference or the data was invalidated and the Calibration Error Test and System Bias were repeated.

Drift between pre- and post-run System Bias was within 3 percent of the Calibration Span or 0.5 ppmv/% absolute difference. If the drift exceeded 3 percent or 0.5 ppmv/%, the Calibration Error Test and System Bias were repeated.

To determine the number of sampling points, a gas stratification check was conducted prior to initiating testing. The pollutant concentrations were measured at three points (16.7, 50.0 and 83.3 percent of the measurement line). Each traverse point was sampled for a minimum of twice the system response time.

If the pollutant concentration at each traverse point did not differ more than 5 percent or 0.5 ppmv/0.3% (whichever was less restrictive) of the average pollutant concentration, then single point sampling was conducted during the test runs. If the pollutant concentration did not meet these specifications but differed less than 10 percent or 1.0 ppmv/0.5% from the average concentration, then three (3) point sampling was conducted (stacks less than 7.8 feet in diameter - 16.7, 50.0 and 83.3 percent of the measurement line; stacks greater than 7.8 feet in diameter – 0.4, 1.0,

and 2.0 meters from the stack wall). If the pollutant concentration differed by more than 10 percent or 1.0 ppmv/0.5% from the average concentration, then sampling was conducted at a minimum of twelve (12) traverse points. Copies of stratification check data can be found in the Quality Assurance/Quality Control Appendix.

An NO₂ – NO converter check was performed on the analyzer prior to initiating testing or at the completion of testing. An approximately 50 ppm nitrogen dioxide cylinder gas was introduced directly to the NO_x analyzer and the instrument response was recorded in an electronic data sheet. The instrument response was within +/- 10 percent of the cylinder concentration.

A Data Acquisition System with battery backup was used to record the instrument response in one (1) minute averages. The data was continuously stored as a *.CSV file in Excel format on the hard drive of a computer. At the completion of testing, the data was also saved to the Alliance server. All data was reviewed by the Field Team Leader before leaving the facility. Once arriving at Alliance's office, all written and electronic data was relinquished to the report coordinator and then a final review was performed by the Project Manager.

3.12 Quality Assurance/Quality Control – U.S. EPA Reference Test Method 25A

Cylinder calibration gases used met EPA Protocol 1 (+/- 2%) standards. Copies of all calibration gas certificates can be found in the Quality Assurance/Quality Control Appendix.

Within two (2) hours prior to testing, zero gas was introduced through the sampling system to the analyzer. After adjusting the analyzer to the Zero gas concentration and once the analyzer reading was stable, the analyzer value was recorded. This process was repeated for the High-Level gas, and the time required for the analyzer reading to reach 95 percent of the gas concentration was recorded to determine the response time. Next, Low and Mid-Level gases were introduced through the sampling system to the analyzer, and the response was recorded when it was stable. All values were less than +/- 5 percent of the calibration gas concentrations.

Mid Level gas was introduced through the sampling system. After the analyzer response was stable, the value was recorded. Next, Zero gas was introduced through the sampling system, and the analyzer value recorded once it reached a stable response. The Analyzer Drift was less than +/- 3 percent of the span value.

A Data Acquisition System with battery backup was used to record the instrument response in one (1) minute averages. The data was continuously stored as a *.CSV file in Excel format on the hard drive of a computer. At the completion of testing, the data was also saved to the Alliance server. All data was reviewed by the Field Team Leader before leaving the facility. Once arriving at Alliance's office, all written and electronic data was relinquished to the report coordinator and then a final review was performed by the Project Manager.

3.13 Quality Assurance/Quality Control – U.S. EPA Reference Method 320

EPA Protocol 1 Calibration Gases – Cylinder calibration gases used met EPA Protocol 1 (+/- 2%) standards. Copies of all calibration gas certificates can be found in the Quality Assurance/Quality Control Appendix.

After providing ample time for the FTIR to reach the desired temperature and to stabilize, zero gas (nitrogen) was introduced directly to the instrument sample port. While flowing nitrogen the signal amplitude was recorded, a

background spectra was taken, a linearity check was performed and recorded, the peak to peak noise and the root mean square in the spectral region of interest was measured and a screenshot was recorded.

Following the zero gas checks, room air was pulled through the sample chamber and the line width and resolution was verified to be at 1879 cm⁻¹, the peak position was entered and the FWHH was recorded (screenshot). Following these checks, another background spectra was recorded and the calibration transfer standard (CTS) was introduced directly to the instrument sample port. The CTS instrument recovery was recorded and the instrument mechanical response time was measured.

Next, stack gas was introduced to the FTIR through the sampling system and several scans were taken until a stable reading was achieved. The native concentration of our target spiking analyte (formaldehyde) was recorded. Spike gas was introduced to the sampling system at a constant flow rate $\leq 10\%$ of the total sample flow rate and a corresponding dilution ratio was calculated along with a system response time. Matrix spike recovery spectra were recorded and were within the $\pm 30\%$ of the calculated value of the spike concentration that the method requires.

The matrix spike recovery was conducted once at the beginning of the testing and the CTS recovery procedures were repeated following each test run. The corresponding values were recorded.

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