Regulatory Information

Permit No. Michigan Department of Environmental, Great Lakes and Energy (EGLE) Air Quality Division (AQD) MI-ROP-B2103-2014d

Source Information

Source Name	*Target Parameters*
Dryer Train (A & B) Dryer/RTO Stack	PM, PM2.5, PM10, NOx, CO
Dryer Train (A & B) Recycle Bin Stack	PM

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.

1/11/2024

Kenji Kinoshita
Project Manager
Alliance Technical Group, LLC

Date

RESPONSIBLE OFFICIAL CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attached documents and, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant civil and criminal penalties, including the possibility of fine or imprisonment or both, for submitting false, inaccurate or incomplete information.

1.16.24

Steven Miller
Detroit Biosolids Drying Facility

Date

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APPENDICES

1.0 Introduction

Alliance Technical Group, LLC (Alliance) was retained by Synagro Technologies, Inc. on behalf of Great Lakes Water Authority (GLWA) to conduct compliance testing at the Detroit Biosolids Drying Facility (DBDF). Portions of the facility are subject to provisions of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division (AQD) Renewable Operating Permit (ROP). Testing was conducted to determine the concentrations and mass emission rates of particulate matter (PM), particulate matter less than ten microns (PM_{10}), particulate matter less than 2.5 microns ($PM_{2.5}$), nitrogen oxides (NO_x) and carbon monoxide (CO) from the exhaust of two (2) Dryer Trains (A&B) Dryer/RTO Stack. Testing was also conducted to determine the concentrations and mass emission rates of PM from two (2) Dryer Trains (A&B) Recycle Bin Stack.

1.1 Facility Description

The facility has four dryer trains (designated as EUDryerTrainA, EUDryerTrainB, EUDryerTrainC, and EUDryerTrainD). The biosolids dryer trains consist of a triple-pass rotary natural gas-fired dryer equipped with a low-NO_x burner and exhaust recirculation, a cyclone product collector, a vibrating screener, a recycle bin, and a crusher. Emissions from the dryer train's cyclone exhaust through a three-stage impingement tray scrubber followed by a regenerative thermal oxidizer (RTO) followed by a packed tower liquid counterflow scrubber. Emissions from the recycle bin are controlled with a fabric filter collector. Each of the four dryer trains exhausts through two stacks (two stacks per train).

The equipment used to prepare the feed to the dryer trains consists of eight sludge grinders (two per dryer train), eight electrically powered dewatering centrifuges (two per dryer train), a cake bin and an enclosed pug mill from each dryer train, and conveyors to transfer materials. The facility also has a hot water heater, an air handling unit, and make-up air units for the building, all-natural gas fired.

1.2 Project Team

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

Table 1-1: Project Team

Regulatory Personnel	Stephen Weis - EGLE
Alliance Personnel	Lucas Kovach Ryne Cooper Dennis Haynes

1.3 Site Specific Test Plan & Notification

Testing was conducted in accordance with the Site-Specific Test Plan (SSTP) submitted to EGLE by GWLA on September 18, 2023.

1.4 Test Program Notes

No technical difficulties or protocol deviations were encountered during this test program.

2.0 Summary of Results

Alliance conducted compliance testing at the DBDF facility in Detroit, MI on December 12-13, 2023. Testing was conducted to determine the concentrations and mass emission rates of PM, PM_{10}, $PM_{2.5}$, NO_x and CO from the exhausts of one (1) Dryer Train (A&B) Dryer/RTO Stack. Testing was also conducted to determine the concentrations and mass emission rates of PM from one (1) Dryer Train (A&B) Recycle Bin Stack.

Tables 2-1 through 2-4 provide a summary of the emission testing results with comparisons to the applicable EGLE permit limits. Any difference between the summary results listed in the following tables and the detailed results contained in appendices is due to rounding for presentation.

Table 2-1: Summary of Results – Dryer Train (A) Dryer/RTO Stack

Emissions Data				
Run Number	**Run 1**	**Run 2**	**Run 3**	**Average**
Date	**12/12/23**	**12/12/23**	**12/12/23**	**--**
Carbon Monoxide Data				
Concentration, ppmvd	17.2	19.0	20.1	18.8
Emission Rate, lb/hr	0.33	0.38	0.40	0.37
Permit Limit, lb/hr	--	--	--	3.67
Percent of Limit, %	--	--	--	**10**
Nitrogen Oxides Data				
Concentration, ppmvd	19.2	18.6	18.2	18.7
Emission Rate, lb/hr	0.60	0.62	0.60	0.60
Permit Limit, lb/hr	--	--	--	3.95
Percent of Limit, %	--	--	--	**15**
Filterable Particulate Matter Data				
Concentration, grain/dscf	0.0011	0.0010	0.0013	0.0011
Emission Rate, lb/hr	0.042	0.039	0.052	0.044
Permit Limit, lb/hr	--	--	--	1.22
Percent of Limit, %	--	--	--	**4**
Condensable Particulate Matter Data				
Concentration, grain/dscf	0.0035	0.0020	0.0039	0.0031
Emission Rate, lb/hr	0.13	0.079	0.15	0.12
Total Particulate Matter Data				
Concentration, grain/dscf	0.0046	0.0030	0.0052	0.0043
Emission Rate, lb/hr	0.17	0.12	0.21	0.17
$PM_{2.5}$ Permit Limit, lb/hr	--	--	--	1.14
Percent of Limit, %	--	--	--	**14**
PM_{10} Permit Limit, lb/hr	--	--	--	1.63
Percent of Limit, %	--	--	--	**10**

Table 2-2: Summary of Results – Dryer Train (B) Dryer/RTO Stack

Emissions Data				
Run Number	**Run 1**	**Run 2**	**Run 3**	**Average**
Date	**12/13/23**	**12/13/23**	**12/13/23**	**--**
Carbon Monoxide Data				
Concentration, ppmvd	13.2	14.4	14.8	14.1
Emission Rate, lb/hr	0.26	0.28	0.29	0.27
Permit Limit, lb/hr	--	--	--	3.67
Percent of Limit, %	--	--	--	**7**
Nitrogen Oxides Data				
Concentration, ppmvd	19.5	20.7	20.9	20.4
Emission Rate, lb/hr	0.64	0.65	0.67	0.65
Permit Limit, lb/hr	--	--	--	3.95
Percent of Limit, %	--	--	--	**17**
Filterable Particulate Matter Data				
Concentration, grain/dscf	0.0012	0.0042	0.0014	0.0023
Emission Rate, lb/hr	0.047	0.16	0.052	0.086
Permit Limit, lb/hr	--	--	--	1.22
Percent of Limit, %	--	--	--	**7**
Condensable Particulate Matter Data				
Concentration, grain/dscf	0.0055	0.0078	0.0048	0.0060
Emission Rate, lb/hr	0.21	0.30	0.18	0.23
Total Particulate Matter Data				
Concentration, grain/dscf	0.0067	0.012	0.0061	0.0083
Emission Rate, lb/hr	0.26	0.45	0.23	0.32
$PM_{2.5}$ Permit Limit, lb/hr	--	--	--	1.14
Percent of Limit, %	--	--	--	**28**
PM_{10} Permit Limit, lb/hr	--	--	--	1.63
Percent of Limit, %	--	--	--	**19**

Table 2-3: Summary of Results – Dryer Train (A) Recycle Bin Stack

Emissions Data				
Run Number	**Run 1**	**Run 2**	**Run 3**	**Average**
Date	**12/12/23**	**12/12/23**	**12/12/23**	**--**
Filterable Particulate Matter Data				
Emission Rate, lb/hr	7.6E-03	6.0E-03	1.9E-02	1.1E-02
Concentration, grain/dscf	8.8E-04	9.8E-04	3.1E-03	1.6E-03
Condensable Particulate Matter Data				
Emission Rate, lb/hr	6.6E-03	6.7E-04	4.2E-03	3.8E-03
Concentration, grain/dscf	7.7E-04	1.1E-04	6.9E-04	5.2E-04
Total Particulate Matter Data				
Emission Rate, lb/hr	1.4E-02	6.7E-03	2.3E-02	1.5E-02
Concentration, grain/dscf	1.7E-03	1.1E-03	3.7E-03	2.2E-03
Permit Limit, grain/dscf	--	--	--	0.005
Percent of Limit, %	--	--	--	**43**

Table 2-4: Summary of Results – Dryer Train (B) Recycle Bin Stack

Emissions Data				
Run Number	**Run 1**	**Run 2**	**Run 3**	**Average**
Date	**12/13/23**	**12/13/23**	**12/13/23**	**--**
Filterable Particulate Matter Data				
Emission Rate, lb/hr	9.1E-03	9.9E-03	6.8E-03	8.6E-03
Concentration, grain/dscf	1.2E-03	1.5E-03	9.0E-04	1.2E-03
Condensable Particulate Matter Data				
Emission Rate, lb/hr	3.8E-03	2.5E-03	7.2E-03	4.5E-03
Concentration, grain/dscf	5.1E-04	3.7E-04	9.5E-04	6.1E-04
Total Particulate Matter Data				
Emission Rate, lb/hr	1.3E-02	1.2E-02	1.4E-02	1.3E-02
Concentration, grain/dscf	1.7E-03	1.8E-03	1.9E-03	1.8E-03
Permit Limit, grain/dscf	--	--	--	0.005
Percent of Limit, %	--	--	--	**36**

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
Oxygen/Carbon Dioxide	3/3A	Integrated Bag / Instrumental Analysis
Moisture Content	4	Gravimetric Analysis
Nitrogen Oxides	7E	Instrumental Analysis
Carbon Monoxide	10	Instrumental Analysis
Particulate Matter	5 & 202	Isokinetic Sampling
Gas Dilution System Certification	205	--

3.1 U.S. EPA Reference Test Methods 1 and 2 – Sampling/Traverse Points and Volumetric Flow Rate

The sampling location and number of traverse (sampling) points were 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 and Figure 1-2 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 consisted of a pitot tube and inclined manometer. The stack gas temperature was measured with a K-type thermocouple and pyrometer.

Stack gas velocity pressure and temperature readings were recorded during each test run. The data collected was utilized to calculate the volumetric flow rate in accordance with U.S. EPA Reference Test Method 2.

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

The oxygen (O_2) and carbon dioxide (CO_2) testing were 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 3.9.

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

During the PM testing of the Recycle Bin Stacks, the oxygen (O_2) and carbon dioxide (CO_2) testing was conducted in accordance with U.S. EPA Reference Test Method 3/3A. One (1) integrated Tedlar bag sample was collected during each test run. The bag samples were analyzed on site with a gas analyzer. The remaining stack gas

constituent was assumed to be nitrogen for the stack gas molecular weight determination. The quality control measures are described in Section 3.10.

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

The stack gas moisture content (BWS) 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 was analyzed gravimetrically before and after each test run on the same balance to determine the amount of moisture condensed.

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

The nitrogen oxides (NOx) 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 3.9.

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 gas. The quality control measures are described in Section 3.9.

3.7 U.S. EPA Reference Test Methods 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 glass 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 four (4) chilled impingers. The first, and second impingers were initially empty, the third contained 100 mL of de-ionized water 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 ±25°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. The nitrogen purge was omitted due to minimal condensate collected in the dry impingers. After the leak check 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.

3.8 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.

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

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.

Direct Calibration & Calibration Error Test

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.

System Bias and Response Time

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.

Post Test System Bias Checks

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.

Post Test Drift Checks
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.

Stratification Check
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.

NO_x Converter Check
An NO_2 – NO converter check was performed on the analyzer prior to initiating testing. An approximately 50 ppm nitrogen dioxide cylinder gas was introduced directly to the NOx analyzer and the instrument response was recorded in an electronic data sheet. The instrument response was within +/- 10 percent of the cylinder concentration.

Data Collection
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.

3.10 Quality Assurance/Quality Control – U.S. EPA Reference Test Method 3/3A

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.

Direct Calibration & Calibration Error Test
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% absolute difference.

Data Collection

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.

Alliance TECHNICAL GROUP

Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Run No. /Method Run 1 / Method 3A

O_2 - Outlet Concentration (C_{O_2}), % dry

$$C_{O_2} = (C_{obs} - C_0) \times \left(\frac{C_{MA}}{(C_M - C_0)} \right)$$

where,

C_{obs}	11.5	= average analyzer value during test, % dry
C_o	0.0	= average of pretest & posttest zero responses, % dry
C_{MA}	10.0	= actual concentration of calibration gas, % dry
C_M	10.0	= average of pretest & posttest calibration responses, % dry
C_{O_2}	11.5	= O_2 Concentration, % dry

Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Run No. /Method Run 1 / Method 3A

CO_2 - Outlet Concentration (C_{CO_2}), % dry

$$C_{CO_2} = (C_{obs} - C_0) \times \left(\frac{C_{MA}}{(C_M - C_0)}\right)$$

where,

C_{obs}	5.5	= average analyzer value during test, % dry
C_0	0.0	= average of pretest & posttest zero responses, % dry
C_{MA}	8.0	= actual concentration of calibration gas, % dry
C_M	8.0	= average of pretest & posttest calibration responses, % dry
C_{CO_2}	5.4	= CO_2 Concentration, % dry

Location: SDetroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Run No. /Method Run 1 / Method 10

CO - Outlet Concentration (C_{CO}), ppmvd

$$C_{CO} = (C_{obs} - C_0) \times \left(\frac{C_{MA}}{(C_M - C_0)}\right)$$

where,

C_{obs}	17.3	= average analyzer value during test, ppmvd
C_o	0.0	= average of pretest & posttest zero responses, ppmvd
C_{MA}	15.0	= actual concentration of calibration gas, ppmvd
C_M	15.1	= average of pretest & posttest calibration responses, ppmvd
C_{CO}	17.2	= CO Concentration, ppmvd

CO - Outlet Emission Rate (ER_{CO}), lb/hr

$$ER_{CO} = \frac{C_{CO} \times MW \times Qs \times 60 \frac{min}{hr} \times 28.32 \frac{L}{ft^3}}{24.04 \frac{L}{g-mole} \times 1.0E06 \times 453.592 \frac{g}{lb}}$$

where,

C_{CO}	17.2	= CO - Outlet Concentration, ppmvd
MW	28.01	= CO molecular weight, g/g-mole
Qs	4,326	= stack gas volumetric flow rate at standard conditions, dscfm
ER_{CO}	0.33	= lb/hr

Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Run No. /Method Run 1 / Method 7E

NOx - Outlet Concentration (C_{NOx}), ppmvd

$$C_{NOx} = (C_{obs} - C_0) \times \left(\frac{C_{MA}}{(C_M - C_0)} \right)$$

where,

C_{obs}	18.7	= average analyzer value during test, ppmvd
C_o	0.0	= average of pretest & posttest zero responses, ppmvd
C_{MA}	20.5	= actual concentration of calibration gas, ppmvd
C_M	20.0	= average of pretest & posttest calibration responses, ppmvd
C_{NOx}	19.2	= NOx Concentration, ppmvd

NOx - Outlet Emission Rate (ER_{NOx}), lb/hr

$$ER_{NOx} = \frac{C_{NOx} \times MW \times Qs \times 60 \frac{min}{hr} \times 28.32 \frac{L}{ft^3}}{24.04 \frac{L}{g-mole} \times 1.0E06 \times 453.592 \frac{g}{lb}}$$

where,

C_{NOx}	19.2	= NOx - Outlet Concentration, ppmvd
MW	46.0055	= NOx molecular weight, g/g-mole
Qs	4,326	= stack gas volumetric flow rate at standard conditions, dscfm
ER_{NOx}	0.60	= lb/hr

Alliance TECHNICAL GROUP

Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Run No.: 1
Parameter: PM, CPM

Meter Pressure (Pm), in. Hg

$$Pm = Pb + \frac{\Delta H}{13.6}$$

where,

Pb	29.51	= barometric pressure, in. Hg
ΔH	1.725	= pressure differential of orifice, in H_2O
Pm	29.64	= in. Hg

Absolute Stack Gas Pressure (Ps), in. Hg

$$Ps = Pb + \frac{Pg}{13.6}$$

where,

Pb	29.51	= barometric pressure, in. Hg
Pg	-0.07	= static pressure, in. H_2O
Ps	29.50	= in. Hg

Standard Meter Volume (Vmstd), dscf

$$Vmstd = \frac{17.636 \times Y \times Vm \times Pm}{Tm}$$

where,

Y	1.022	= meter correction factor
Vm	82.982	= meter volume, cf
Pm	29.64	= absolute meter pressure, in. Hg
Tm	499.3	= absolute meter temperature, °R
Vmstd	88.771	= dscf

Standard Wet Volume (Vwstd), scf

$$Vwstd = 0.04716 \times Vlc$$

where,

Vlc	265.3	= weight of H_2O collected, g
Vwstd	12.512	= scf

Moisture Fraction (BWSsat), dimensionless (theoretical at saturated conditions)

$$BWSsat = \frac{10^{6.37-\left(\frac{2,827}{Ts+365}\right)}}{Ps}$$

where,

Ts	125.0	= stack temperature, °F
Ps	29.50	= absolute stack gas pressure, in. Hg
BWSsat	0.133	= dimensionless

Moisture Fraction (BWS), dimensionless (measured)

$$BWS = \frac{Vwstd}{(Vwstd + Vmstd)}$$

where,

Vwstd	12.512	= standard wet volume, scf
Vmstd	88.771	= standard meter volume, dscf
BWS	0.124	= dimensionless

Moisture Fraction (BWS), dimensionless

$$BWS = BWSmsd \text{ unless } BWSsat < BWSmsd$$

where,

BWSsat	0.133	= moisture fraction (theoretical at saturated conditions)
BWSmsd	0.124	= moisture fraction (measured)
BWS	0.124	

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Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Run No.: 1
Parameter: PM, CPM

Molecular Weight (DRY) (Md), lb/lb-mole

$$Md = (0.44 \times \%CO_2) + (0.32 \times \%O2) + (0.28\,(100 - \%CO_2 - \%O2))$$

where,

CO_2	5.6	= carbon dioxide concentration, %
O_2	11.2	= oxygen concentration, %
Md	29.35	= lb/lb mol

Molecular Weight (WET) (Ms), lb/lb-mole

$$Ms = Md\,(1 - BWS) + 18.015\,(BWS)$$

where,

Md	29.35	= molecular weight (DRY), lb/lb mol
BWS	0.124	= moisture fraction, dimensionless
Ms	27.95	= lb/lb mol

Average Velocity (Vs), ft/sec

$$Vs = 85.49 \times Cp \times (\Delta P^{1/2})\,avg \times \sqrt{\frac{Ts}{Ps \times Ms}}$$

where,

Cp	0.840	= pitot tube coefficient
$\Delta P^{1/2}$	0.333	= velocity head of stack gas, $(in.\ H_2O)^{1/2}$
Ts	584.7	= absolute stack temperature, °R
Ps	29.50	= absolute stack gas pressure, in. Hg
Ms	27.95	= molecular weight of stack gas, lb/lb mol
Vs	20.2	= ft/sec

Average Stack Gas Flow at Stack Conditions (Qa), acfm

$$Qa = 60 \times Vs \times As$$

where,

Vs	20.2	= stack gas velocity, ft/sec
As	4.59	= cross-sectional area of stack, ft^2
Qa	5,546	= acfm

Average Stack Gas Flow at Standard Conditions (Qs), dscfm

$$Qs = 17.636 \times Qa \times (1 - BWS) \times \frac{Ps}{Ts}$$

where,

Qa	5,546	= average stack gas flow at stack conditions, acfm
BWS	0.124	= moisture fraction, dimensionless
Ps	29.50	= absolute stack gas pressure, in. Hg
Ts	584.7	= absolute stack temperature, °R
Qs	4,326	= dscfm

Dry Gas Meter Calibration Check (Yqa), dimensionless

$$Yqa = \frac{Y - \left(\frac{\Theta}{Vm}\sqrt{\frac{0.0319 \times Tm \times 29}{\Delta H@ \times \left(Pb + \frac{\Delta\,Havg.}{13.6}\right) \times Md}}\sqrt{\Delta H}\,avg.\right)}{Y} \times 100$$

where,

Y	1.022	= meter correction factor, dimensionless
Θ	120	= run time, min.
Vm	82.982	= total meter volume, dcf
Tm	499.3	= absolute meter temperature, °R
ΔH@	1.816	= orifice meter calibration coefficient, in. H_2O
Pb	29.51	= barometric pressure, in. Hg
ΔH avg	1.725	= average pressure differential of orifice, in H_2O
Md	29.35	= molecular weight (DRY), lb/lb mol
$(\Delta H)^{1/2}$	1.306	= average squareroot pressure differential of orifice, $(in.\ H2O)^{1/2}$
Yqa	0.0	= percent

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Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Run No.: 1
Parameter: PM, CPM

Volume of Nozzle (Vn), ft^3

$$Vn = \frac{Ts}{Ps}\left(0.002669 \times Vlc + \frac{Vm \times Pm \times Y}{Tm}\right)$$

where,

Ts	584.7	= absolute stack temperature, °R
Ps	29.50	= absolute stack gas pressure, in. Hg
Vlc	265.3	= volume of H_2O collected, ml
Vm	82.982	= meter volume, cf
Pm	29.64	= absolute meter pressure, in. Hg
Y	1.022	= meter correction factor, unitless
Tm	499.3	= absolute meter temperature, °R
Vn	113.776	= volume of nozzle, ft^3

Isokinetic Sampling Rate (I), %

$$I = \left(\frac{Vn}{\theta \times 60 \times An \times Vs}\right) \times 100$$

where,

Vn	113.776	= nozzle volume, ft3
θ	120.0	= run time, minutes
An	0.00078	= area of nozzle, ft^2
Vs	20.2	= average velocity, ft/sec
I	100.6	= %

Filterable PM Concentration (C_s), grain/dscf

$$C_s = \frac{M_n \times 0.0154}{Vmstd}$$

where,

Mn	6.5	= filterable PM mass, mg
Vmstd	88.771	= standard meter volume, dscf
C_s	0.0011	= grain/dscf

Filterable PM Emission Rate (PMR), lb/hr

$$PMR = \frac{C_s \times Qs \times 60}{7.0E+03}$$

where,

C_s	0.0011	= filterable PM concentration, grain/dscf
Qs	4,326	= average stack gas flow at standard conditions, dscfm
PMR	0.042	= lb/hr

Condensable PM Concentration (C_{CPM}), grain/dscf

$$C_{CPM} = \frac{M_{CPM} \times 0.0154}{Vmstd}$$

where,

M_{CPM}	20.0	= condensable PM mass, mg
Vmstd	88.771	= standard meter volume, dscf
C_{CPM}	0.0035	= grain/dscf

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Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Run No.: 1
Parameter: PM, CPM

Condensable PM Emission Rate (ER_{CPM}), lb/hr

$$ER_{CPM} = \frac{C_{CPM} \times Qs \times 60\frac{min}{hr}}{7.0E+03}$$

where,

C_{CPM}	0.0035	= condensable PM concentration, grain/dscf
Qs	4,326	= average stack gas flow at standard conditions, dscfm
ER_{CPM}	0.13	= lb/hr

Total PM Concentration (C_{TPM}), grain/dscf

$$C_{TPM} = C_S + C_{CPM}$$

where,

C_s	0.0011	= filterable PM concentration, grain/dscf
C_{CPM}	0.0035	= condensable PM concentration, grain/dscf
C_{TPM}	0.0046	= grain/dscf

Total PM Emission Rate (ER_{TPM}), lb/hr

$$ER_{TPM} = PMR + ER_{CPM}$$

where,

PMR	0.04	= filterable PM emission rate, lb/hr
ER_{CPM}	0.13	= condensable PM emission rate, lb/hr
ER_{TPM}	0.17	= lb/hr

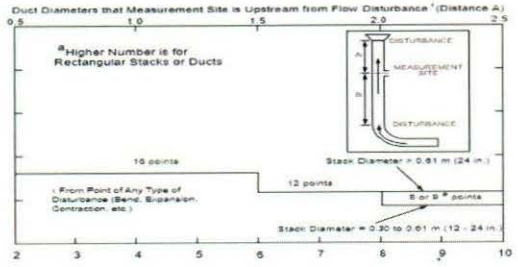
Method 1 Data

Strat Check Pts.

Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Date: 12/12/23

Stack Parameters

Duct Orientation:	Vertical	
Duct Design:	Circular	
Distance from Far Wall to Outside of Port:	33.25	in
Nipple Length:	4.25	in
Depth of Duct:	29.00	in
Cross Sectional Area of Duct:	4.59	ft^2
No. of Test Ports:	2	
Number of Readings per Point:	1	
Distance A:	75.0	ft
Distance A Duct Diameters:	31.0	(must be ≥ 0.5)
Distance B:	55.0	ft
Distance B Duct Diameters:	22.8	(must be ≥ 2)
Actual Number of Traverse Points:	3	
Measurer (Initial and Date):	AK 12/11/23	
Reviewer (Initial and Date):	DH 12/11/23	



CIRCULAR DUCT

LOCATION OF TRAVERSE POINTS

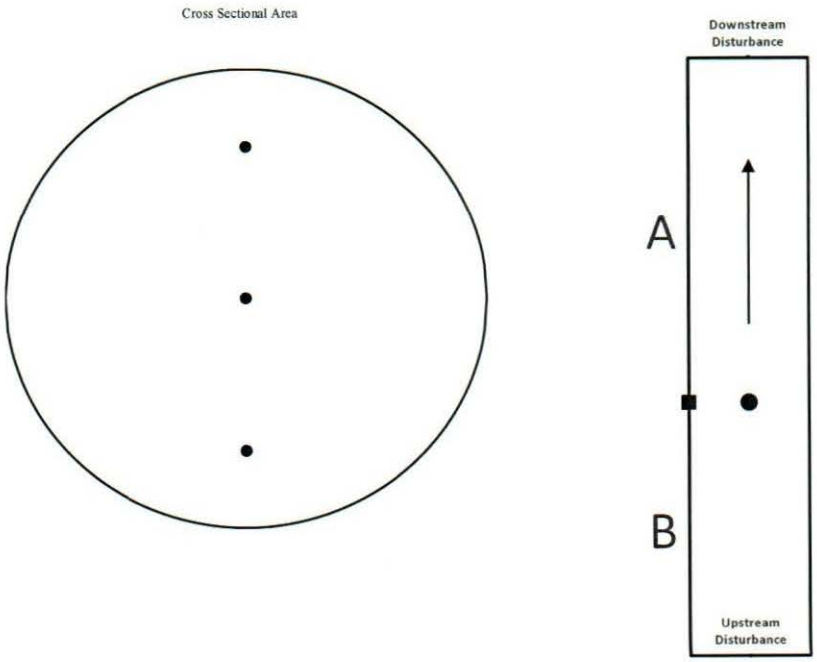
Number of traverse points on a diameter

	2	3	4	5	6	7	8	9	10	11	12
1	14.6	16.7	6.7	--	4.4	--	3.2	--	2.6	--	2.1
2	85.4	50.0	25.0	--	14.6	--	10.5	--	8.2	--	6.7
3	--	83.3	75.0	--	29.6	--	19.4	--	14.6	--	11.8
4	--	--	93.3	--	70.4	--	32.3	--	22.6	--	17.7
5	--	--	--	--	85.4	--	67.7	--	34.2	--	25.0
6	--	--	--	--	95.6	--	80.6	--	65.8	--	35.6
7	--	--	--	--	--	--	89.5	--	77.4	--	64.4
8	--	--	--	--	--	--	96.8	--	85.4	--	75.0
9	--	--	--	--	--	--	--	--	91.8	--	82.3
10	--	--	--	--	--	--	--	--	97.4	--	88.2
11	--	--	--	--	--	--	--	--	--	--	93.3
12	--	--	--	--	--	--	--	--	--	--	97.9

**Percent of stack diameter from inside wall to traverse point.*

Traverse Point	% of Diameter	Distance from inside wall	Distance from outside of port
1	16.7	4.84	9.09
2	50.0	14.50	18.75
3	83.3	24.16	28.41
4	--	--	--
5	--	--	--
6	--	--	--
7	--	--	--
8	--	--	--
9	--	--	--
10	--	--	--
11	--	--	--
12	--	--	--

Stack Diagram
A = 75 ft.
B = 55 ft.
Depth of Duct = 29 in.



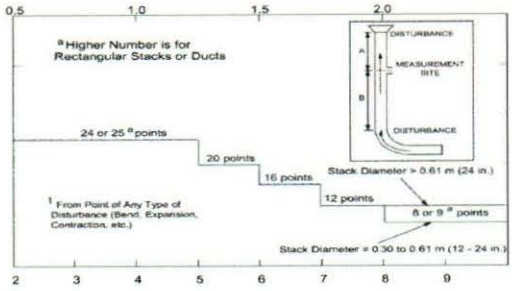
Method 1 Data

PM Sampling Pts

Location: Detroit Biosolids Drying Facility
Source: Dryer Train (A) Dryer/RTO Stack
Project No.: AST-2023-3723
Date: 12/11/23

Stack Parameters

Duct Orientation:	Vertical	
Duct Design:	Circular	
Distance from Far Wall to Outside of Port:	33.25	in
Nipple Length:	4.25	in
Depth of Duct:	29.00	in
Cross Sectional Area of Duct:	4.59	ft^2
No. of Test Ports:	2	
Distance A:	75.0	ft
Distance A Duct Diameters:	31.0	(must be ≥ 0.5)
Distance B:	55.0	ft
Distance B Duct Diameters:	22.8	(must be ≥ 2)
Minimum Number of Traverse Points:	12	
Actual Number of Traverse Points:	12	
Number of Readings per Point:	1	
Measurer (Initial and Date):	RC	
Reviewer (Initial and Date):	RC	



CIRCULAR DUCT

LOCATION OF TRAVERSE POINTS

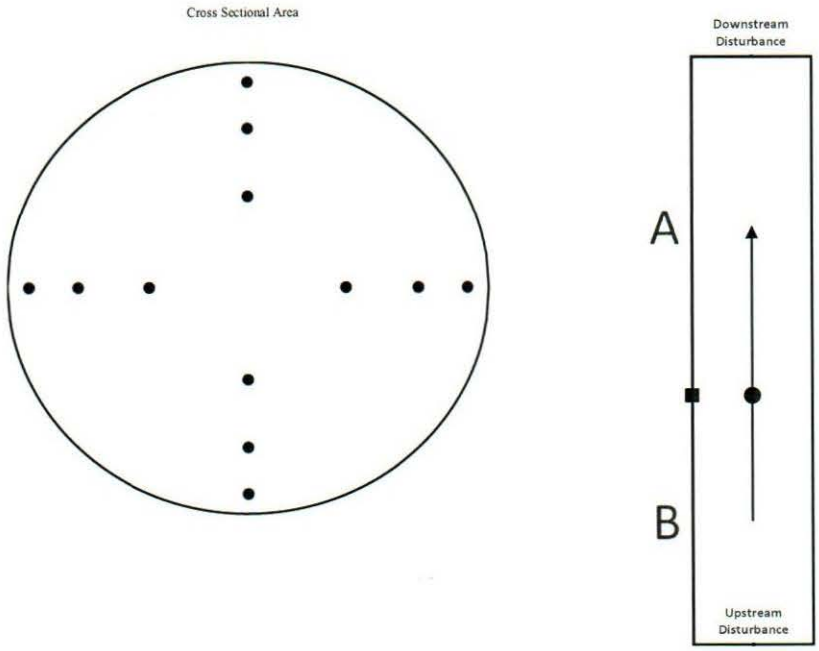
Number of traverse points on a diameter

	2	3	4	5	6	7	8	9	10	11	12
1	14.6	--	6.7	--	4.4	--	3.2	--	2.6	--	2.1
2	85.4	--	25.0	--	14.6	--	10.5	--	8.2	--	6.7
3	--	--	75.0	--	29.6	--	19.4	--	14.6	--	11.8
4	--	--	93.3	--	70.4	--	32.3	--	22.6	--	17.7
5	--	--	--	--	85.4	--	67.7	--	34.2	--	25.0
6	--	--	--	--	95.6	--	80.6	--	65.8	--	35.6
7	--	--	--	--	--	--	89.5	--	77.4	--	64.4
8	--	--	--	--	--	--	96.8	--	85.4	--	75.0
9	--	--	--	--	--	--	--	--	91.8	--	82.3
10	--	--	--	--	--	--	--	--	97.4	--	88.2
11	--	--	--	--	--	--	--	--	--	--	93.3
12	--	--	--	--	--	--	--	--	--	--	97.9

[a] Percent of stack diameter from inside wall to traverse point.

Traverse Point	% of Diameter	Distance from inside wall	Distance from outside of port
1	4.4	1.28	5 1/2
2	14.6	4.23	8 1/2
3	29.6	8.58	12 13/16
4	70.4	20.42	24 11/16
5	85.4	24.77	29
6	95.6	27.72	32
7	--	--	--
8	--	--	--
9	--	--	--
10	--	--	--
11	--	--	--
12	--	--	--

Stack Diagram
A = 75 ft.
B = 55 ft.
Depth of Duct = 29 in.



Cyclonic Flow Check

Location Detroit Biosolids Drying Facility
Source Dryer Train (A) Dryer/RTO Stack
Project No. AST-2023-3723
Date 12/11/23

Sample Point	Angle (ΔP=0)
1	3
2	5
3	2
4	1
5	3
6	5
7	4
8	2
9	1
10	3
11	5
12	4
Average	3

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Location Detroit Biosolids Drying Facility
Source Dryer Train (A) Dryer/RTO Stack
Project No. AST-2023-3723

Run Number		Run 1	Run 2	Run 3	Average
Date		12/12/23	12/12/23	12/12/23	--
Start Time		7:55	12:40	15:25	--
Stop Time		8:55	13:40	16:25	--
Input Data - Outlet					
Moisture Fraction, dimensionless	BWS	0.124	0.152	0.142	0.139
Volumetric Flow Rate (M1-4), dscfm	Qs	4,326	4,625	4,597	4,516
Calculated Data - Outlet					
O_2 Concentration, % dry	C_{O_2}	11.5	10.7	10.5	10.9
CO_2 Concentration, % dry	C_{CO_2}	5.45	6.15	6.06	5.89
CO Concentration, ppmvd	C_{CO}	17.2	19.0	20.1	18.8
CO Emission Rate, lb/hr	ER_{CO}	0.33	0.38	0.40	0.37
NOx Concentration, ppmvd	C_{NOx}	19.2	18.6	18.2	18.7
NOx Emission Rate, lb/hr	ER_{NOx}	0.60	0.62	0.60	0.60

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Emission Calculations

Location Detroit Biosolids Drying Facility
Source Dryer Train (A) Dryer/RTO Stack
Project No. AST-2023-3723
Parameter PM, CPM

Run Number		Run 1	Run 2	Run 3	Average
Date		12/12/23	12/12/23	12/12/23	--
Start Time		7:55	12:40	15:25	--
Stop Time		10:06	14:47	17:31	--
Run Time, min	(θ)	120.0	120.0	120.0	120.0
INPUT DATA					
Barometric Pressure, in. Hg	(Pb)	29.51	29.51	29.51	29.51
Meter Correction Factor	(Y)	1.022	1.022	1.022	1.022
Orifice Calibration Value	(ΔH @)	1.816	1.816	1.816	1.816
Meter Volume, ft^3	(Vm)	82.982	93.401	91.345	89.243
Meter Temperature, °F	(Tm)	39.7	47.2	52.1	46.3
Meter Temperature, °R	(Tm)	499.3	506.8	511.8	506.0
Meter Orifice Pressure, in. WC	(ΔH)	1.725	2.075	2.100	1.967
Volume H_2O Collected, mL	(Vlc)	265.3	414.3	334.0	337.9
Nozzle Diameter, in	(Dn)	0.378	0.378	0.378	0.378
Area of Nozzle, ft^2	(An)	0.0008	0.0008	0.0008	0.0008
Filterable PM Mass, mg	(Mn)	6.5	6.3	8.2	7.0
Condensable PM Mass, mg	(M_{CPM})	20.0	12.8	24.2	19.0
ISOKINETIC DATA					
Standard Meter Volume, ft^3	(Vmstd)	88.771	98.524	95.436	94.244
Standard Water Volume, ft^3	(Vwstd)	12.512	19.538	15.751	15.934
Moisture Fraction Measured	(BWSmsd)	0.124	0.165	0.142	0.144
Moisture Fraction @ Saturation	(BWSsat)	0.133	0.152	0.154	0.146
Moisture Fraction	(BWS)	0.124	0.152	0.142	0.139
Meter Pressure, in Hg	(Pm)	29.64	29.66	29.66	29.65
Volume at Nozzle, ft^3	(Vn)	113.776	133.727	126.040	124.51
Isokinetic Sampling Rate, (%)	(I)	100.6	104.5	101.8	102.3
DGM Calibration Check Value, (+/- 5%)	(Y_{qa})	0.0	1.6	-1.4	0.1
EMISSION CALCULATIONS					
Filterable PM Concentration, grain/dscf	(C_s)	0.0011	0.0010	0.0013	0.0011
Filterable PM Emission Rate, lb/hr	(PMR)	0.042	0.039	0.052	0.044
Condensable PM Concentration, grain/dscf	(C_{CPM})	0.0035	0.0020	0.0039	0.0031
Condensable PM Emission Rate, lb/hr	(ER_{CPM})	0.13	0.079	0.15	0.12
Total PM Concentration, grain/dscf	(C_{TPM})	0.0046	0.0030	0.0052	0.0043
Total PM Emission Rate, lb/hr	(ER_{TPM})	0.17	0.12	0.21	0.17

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Location Detroit Biosolids Drying Facility
Source Dryer Train (A) Dryer/RTO Stack
Project No. AST-2023-3723

Run Number		Run 1	Run 2	Run 3	Average
Date		12/12/23	12/12/23	12/12/23	--
Start Time		7:55	12:40	15:25	--
Stop Time		10:06	14:47	17:31	--
Calculated Data - Outlet					
O_2 Concentration, % dry	C_{O_2}	11.2	10.5	10.3	10.7
CO_2 Concentration, % dry	C_{CO_2}	5.6	6.2	6.2	6.0