OATS Project 1803A

BREMBO, NORTH AMERICA
HOMER, MICHIGAN

Automobile Brake System Components Foundry Particulate Emissions Field Test Report

Michigan Department of Environmental Quality, Air Quality Division
Permit To Install No. PTI 199-14A

Revised October 1, 2018 to:

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We certify that we have examined the information submitted in this report and believe the results presented are true, accurate, and complete.

Daniel Klassen
President

Joseph Ward
Project Manager

1.0 INTRODUCTION

Optimal Air Testing Services, Inc. (Optimal) was contracted by Brembo North America (Brembo) to complete air emissions performance testing at their foundry in Homer, Michigan. The foundry is covered by Part 40 of the Code of Federal Regulations, Part 63 (40 CFR 63), Subpart EEEEE National Emission Standards for Hazardous Air Pollutants from Iron and Steel Foundries (Iron and Steel Foundry MACT). The measured emissions from the high-performance automobile brake system components foundry are compared below to allowable limits set forth by the Michigan Department of Environmental Quality (MDEQ) Permit To Install No. PTI 199-14A Renewable Operating Permit MI-ROP-N6226-2015.

As shown below in Table 1, 2 and 3, Optimal measured air emissions from:

- Four Electric Induction Furnaces and Pouring Station (MeltPour) Baghouse Stack
- Cooling House Regenerative Thermal Oxidizer (RTO) Baghouse Stack
- Shakeout and Sand System Baghouse Stack

Particulate emissions testing was completed on April 25, 26 and 27, 2018. Samples were collected while Brembo operated the processes associated with each baghouse at the capacity levels expected to occur during normal operations. Operating parameters and production were monitored by Brembo personnel and submitted to Optimal for inclusion into the emissions report.

The Regenerative Thermal Oxidizer (RTO) test program followed procedures prescribed in Title 40 of the Code of Federal Regulations, Part 60 (40CFR60), Appendix A, Methods 1, 2, 3, 4 and 5 to measure total suspended particulate (TSP) matter and 40CFR51, Methods 202 to measure condensable particulate matter. Method 201A was not used because sampling within the allowable isokinetic criteria of ±20 percent could not be performed due to the large velocity deviations within the stack. Therefore, the assumption must be made that large particulates were collected in the baghouse and the collected particulate is less than 2.5 microns in diameter (PM_{10} and $PM_{2.5}$). Results shown below are the average of three 120-minute tests (runs). Measured parameters and results for each run are shown in Table 4.

Table 1: RTO Baghouse Particulate Emissions, April 25 and 26, 2018

Particulate Results	Average Emissions
Filterable Particulate Concentration (TSP)	0.0006 gr/dscf
Filterable Particulate Emission Rate (TSP)	0.37 lb/hr
Condensable Inorganic PM Concentration	0.0005 gr/dscf
Condensable Inorganic PM Emission Rate	0.29 lb/hr
Condensable Organic PM Concentration	0.0003 gr/dscf
Condensable Organic PM Emission Rate	0.19 lb/hr
Total $PM_{10/2.5}$ Concentration	0.0014 gr/dscf
Total $PM_{10/2.5}$ Emission Rate	0.85 lb/hr

The MeltPour and Shakeout & Sand System particulate matter test program followed procedures prescribed in 40CFR51, Methods 201A and 202. Method 201A utilizes an in-stack cyclone to separate large particulate from particulate matter less than 10 microns in diameter (PM_{10}) and a second cyclone to separate particulate less than 2.5 microns in diameter ($PM_{2.5}$). Method 202 measures particulate that passes through the cyclones and heated filter and condenses after the sample gas is cooled.

PM_{10} results shown below in Tables 2 and 3 include the sum of particulate matter that collected downstream of the first cyclone (PM_{10} fraction, $PM_{2.5}$ matter plus the condensable matter). $PM_{2.5}$ results include the sum of particulate matter that collected downstream of the second cyclone ($PM_{2.5}$ matter plus the condensable matter). Test parameters and results for particulate that was collected in each fraction of the sample train for each run is detailed in Tables 5 and 6. Results are based on the average of three runs approximately 120-minutes in duration.

Table 2: Shakeout & Sand System Baghouse Particulate Emissions, April 26 and 27, 2018

Particulate Results	Average Emissions
Filterable PM Concentration	0.0096 gr/dscf
Filterable PM Emission Rate	12.31 lb/hr
$PM_{2.5}$ Concentration (includes condensable PM)	0.0090 gr/dscf
$PM_{2.5}$ Emission Rate	11.48 lb/hr
PM_{10} Concentration (includes above $PM_{2.5}$)	0.0108 gr/dscf
PM_{10} Emission Rate	13.73 lb/hr

Table 3: MeltPour Baghouse Particulate Emissions, April 26 and 27, 2018

Particulate Results	Average Emissions
Filterable PM Concentration	0.0024 gr/dscf
Filterable PM Emission Rate	1.72 lb/hr
$PM_{2.5}$ Concentration (includes condensable PM)	0.0026 gr/dscf
$PM_{2.5}$ Emission Rate	1.86 lb/hr
PM_{10} Concentration (includes above $PM_{2.5}$)	0.0034 gr/dscf
PM_{10} Emission Rate	2.43 lb/hr

Coordinating the field portion of the test program were:

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Description of Installation

Brembo North America, Inc. manufactures high performance automobile brake system components at it's facility located in Homer MI.

Brembo is a grey iron foundry to cast and manufacture said brake system components.

The facility is currently classified as a new foundry that is part of a major source of hazardous emissions and is subject to the provisions of the National Emissions Standards for Hazardous Air Pollutants from Iron and Steel Foundries (40 CFR Part 63 Subpart EEEEE, Iron and Steel Foundry MACT)..

2.0 SUMMARY OF RESULTS

Table 4: RTO Test Parameters and Emissions, April 25 and 26, 2018

	Date Start Time	4/25/18 12:47	4/25/18 15:38	4/26/18 8:27	
	Stop Time	14:52	17:43	10:30	
Test Parameters	**Units**	**Run 1**	**Run 2**	**Run 3**	**Avg.**
P_{bar} (Barometric Pressure, absolute)	Inches Hg	28.75	28.75	28.92	
Y (Dry Gas Meter Calibration Factor)	unitless	1.0005	1.0005	1.0005	
C_p (Pitot tube Coefficient)	unitless	0.84	0.84	0.84	
D_n (Diameter of Nozzle)	Inches	0.240	0.240	0.240	
θ (Total Sampling Time of Test)	Minutes	120	120	120	
ΔH (Orifice Pressure Drop)	Inches H_2O	1.87	1.82	1.84	
V_m (Dry Gas Sampled - as measured)	ft^3 (dry)	95.264	97.234	95.234	
T_m (Gas Meter Temperature, avg.)	Degree F	73	67	61	
V_{lc} (Condensate and silica gel)	g	31.4	25.3	21.4	
Location/Process Parameters					
A_s (Cross-sectional Area of Stack)	ft^2	30.94	30.94	30.94	30.94
P_g (Static Pressure of Stack Gas)	Inches H_2O	-0.38	-0.42	-0.46	-0.42
T_s (Temperature of Stack Gas)	Degree F	193	186	196	192
$\sqrt{\Delta p}$ (Sq. root of velocity head of gas)	$\sqrt{}$ In. H_2O	0.7714	0.8100	0.8213	0.8009
CO_2 (Carbon Dioxide)	%	0.5	0.4	0.5	0.5
O_2 (Oxygen)	%	21.00	21.10	21.20	21.10
Calculations					
V_{mstd} (Gas Sampled, standard (std) cond.)	ft^3	91.199	94.036	93.689	92.975
V_{wstd} (Water Vapor in Gas Sampled, std)	ft^3	1.48	1.19	1.01	1.23
B_{ws} (Water Vapor in Gas, by Vol.)	%	1.60	1.25	1.07	1.31
M_d (Molecular Weight of Dry Stack Gas)	lb/lb-mole	28.92	28.91	28.93	28.92
M_s (Molecular Weight of Wet Stack Gas)	lb/lb-mole	28.75	28.77	28.81	28.78
P_s (Pressure of Stack Gas, Absolute)	In. Hg	28.72	28.72	28.89	28.78
Iso (Percent of Isokinetic Sampling)	%	107.22	104.38	102.95	104.9
Flow Results					
V_s (Average Stack Gas Velocity)	ft/m (fpm)	2,956	3,085	3,142	3,061
Q_a (Actual Volumetric Flow Rate)	ft^3/m (dscfm)	91,450	95,440	97,200	94,697
Q_{std} (Dry Volumetric Flow Rate, std.)	ft^3/m (cfm)	69,810	73,940	74,690	72,813
Particulate Results					
Mass of Filterable PM Collected	mg/sample	5.73	1.63	3.38	
Filterable PM Conc. - std.	gr/dscf	0.0010	0.0003	0.0006	0.0006
Filterable PM Emission Rate	lb/hr	0.58	0.17	0.36	0.37
Mass of Inorganic Condensables	mg/sample	3.6	2.8	2.0	
Inorganic Concentrations - std.	gr/dscf	0.0006	0.0005	0.0003	0.0005
Inorganic Emission Rate	lb/hr	0.36	0.29	0.21	0.29
Mass of Organic Condensables	mg/sample	1.7	2.7	1.1	
Organic Concentrations - std.	gr/dscf	0.0003	0.0004	0.0002	0.0003
Organic Emission Rate	lb/hr	0.17	0.28	0.12	0.19
Total PM Concentrations - std.	**gr/dscf**	**0.0019**	**0.0012**	**0.0011**	**0.0014**
Total PM Emission Rate	**lb/hr**	**1.12**	**0.74**	**0.68**	**0.85**

Table 5: Sand and Shakeout System Test Parameters and Emissions, April 26 and 27, 2018

	Date Start Time	4/26/18 15:13	4/26/18 19:04	4/27/18 11:05	
	Stop Time	17:18	21:06	13:06	
Test Parameters	**Units**	**Run 1**	**Run 2**	**Run 3**	**Avg.**
P_{bar} (Barometric Pressure, absolute)	Inches Hg	28.80	28.80	28.67	
Y (Dry Gas Meter Calibration Factor)	unitless	1.0096	1.0096	1.0096	
C_p (Pitot tube Coefficient)	unitless	0.84	0.84	0.84	
D_n (Diameter of Nozzle)	Inches	0.149	0.149	0.149	
θ (Total Sampling Time of Test)	Minutes	121.25	118.75	118.75	
V_m (Dry Gas Sampled - as measured)	ft^3 (dry)	45.41	44.330	44.09	
T_m (Gas Meter Temperature, avg.)	Degree F	71	77	71	
V_{lc} (Condensate and silica gel)	g	60.2	52.5	58.4	
Location/Process Parameters					
A_s (Cross-sectional Area of Stack)	ft^2	49.61	49.61	49.61	49.61
P_g (Static Pressure of Stack Gas)	Inches H_2O	-0.55	-0.60	-0.57	-0.57
T_s (Temperature of Stack Gas)	Degree F	120	122	122	121
√Δp (Sq. root of velocity head of gas)	√ In. H_2O	1.0090	1.0097	0.9671	0.9953
CO_2 (Carbon Dioxide)	%	0.1	0.1	0.1	0.1
O_2 (Oxygen)	%	20.8	20.6	20.9	20.8
V_{mstd} (Gas Sampled, standard (std) cond.)	ft^3	43.91	42.43	42.46	42.93
V_{wstd} (Water Vapor in Gas Sampled, std)	ft^3	2.83	2.47	2.75	2.68
B_{ws} (Water Vapor in Gas, by Vol.)	%	6.06	5.50	6.08	5.88
M_d (Molecular Weight of Dry Stack Gas)	lb/lb-mole	28.848	28.84	28.85	28.85
M_s (Molecular Weight of Wet Stack Gas)	lb/lb-mole	28.19	28.24	28.19	28.21
P_s (Pressure of Stack Gas, Absolute)	In. Hg	28.76	28.76	28.63	28.71
Iso (Percent of Isokinetic Sampling)	%	99.0	97.3	102.4	99.6
V_s (Average Stack Gas Velocity)	ft/m (fpm)	3,678	3,683	3,538	3,633
Q_a (Actual Volumetric Flow Rate)	ft^3/m (dscfm)	182,490	182,730	175,530	180,250
Q_{std} (Dry Volumetric Flow Rate, std.)	ft^3/m (cfm)	149,860	150,480	143,084	147,808
Filterable $PM_{2.5}$ Emissions					
D50 (dia. w/50% penetration probability)	µm	2.415	2.49	2.46	2.45
m_n (Front $^1/_2$ $PM_{2.5}$ Mass)	mg/sample	31.10	22.81	12.17	
$PM_{2.5}$ Filterable Concentrations - std.	gr/dscf	0.01093	0.0083	0.0044	0.0079
$PM_{2.5}$ Filterable Emission Rate	lb/hr	14.038	10.701	5.425	10.055
Condensable ($PM_{2.5}$) Emissions					
Organic m_n (Back $^1/_2$ Mass)	mg/sample	3.1	0.7	1.1	
Condensable Organic Concentrations - std.	gr/dscf	0.0011	0.0003	0.0004	0.0006
Condensable Organic Emission Rate	lb/hr	1.399	0.328	0.490	0.739
Inorganic m_n (Back 1/2 Mass)	mg/sample	1.0	1.3	2.2	
Condensable Inorganic Concentrations - std.	gr/dscf	0.0004	0.0005	0.0008	0.0005
Condensable Inorganic Emission Rate	lb/hr	0.451	0.610	0.981	0.681
$PM_{2.5}$ Particulate Results (Includes Condensable Matter)					
$PM_{2.5}$ Concentrations - std.	gr/dscf	0.0124	0.0090	0.0056	0.0090
$PM_{2.5}$ Total Particulate Emission Rate	lb/hr	15.889	11.639	6.896	11.475
PM_{10} with larger diameter than 2.5 microns					
D50 (dia. w/50% penetration probability)	µm	10.814	10.98	10.89	10.89
m_n (Front $^1/_2$ $PM_{2.5}$ Mass)	mg/sample	5.78	6.58	2.39	
PM_{10} Conc.rger than 2.5 microns	gr/dscf	0.00203	0.0024	0.0009	0.0018
PM_{10} Emissions greater than 2.5 microns	lb/hr	2.608	3.086	1.066	2.253
PM_{10} Results					
PM_{10} Concentrations - std.	gr/dscf	0.0144	0.0114	0.0065	0.0108
PM_{10} Emission Rate	lb/hr	18.497	14.725	7.962	13.728
Filterable PM Results					
Filterable PM Concentrations - std.	gr/dscf	0.0130	0.0107	0.0053	0.0096
Filterable PM Emission Rate	lb/hr	16.646	13.787	6.491	12.308

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Table 6: MeltPour Test Parameters and Emissions, April 26 and 27, 2018

	Date Start Time	4/26/18 18:22	4/27/18 9:56	4/27/18 11:05	
	Stop Time	20:27	12:02	13:09	
Test Parameters	**Units**	**Run 1**	**Run 2**	**Run 3**	**Avg.**
P_{bar} (Barometric Pressure, absolute)	Inches Hg	28.80	28.67	28.67	
Y (Dry Gas Meter Calibration Factor)	unitless	1.0186	1.0186	1.0186	
C_p (Pitot tube Coefficient)	unitless	0.84	0.84	0.84	
D_n (Diameter of Nozzle)	Inches	0.149	0.149	0.149	
θ (Total Sampling Time of Test)	Minutes	121.50	121.75	121.00	
V_m (Dry Gas Sampled - as measured)	ft^3 (dry)	47.3872	47.783	49.0074	
T_m (Gas Meter Temperature, avg.)	Degree F	73	72	78	
V_{lc} (Condensate and silica gel)	g	20.3	10.1	12.0	
Location/Process Parameters					
A_s (Cross-sectional Area of Stack)	ft^2	28.67	28.67	28.67	28.67
P_g (Static Pressure of Stack Gas)	Inches H_2O	-0.30	-0.25	-0.27	-0.27
T_s (Temperature of Stack Gas)	Degree F	126	124	127	126
$\sqrt{\Delta p}$ (Sq. root of velocity head of gas)	$\sqrt{}$ In. H_2O	0.9397	0.9472	0.9494	0.9454
CO_2 (Carbon Dioxide)	%	0.2	0.2	0.2	0.2
O_2 (Oxygen)	%	20.8	20.8	20.8	20.8
V_{mstd} (Gas Sampled, standard (std) cond.)	ft^3	46.07	46.38	46.96	46.47
V_{wstd} (Water Vapor in Gas Sampled, std)	ft^3	0.96	0.48	0.56	0.67
B_{ws} (Water Vapor in Gas, by Vol.)	%	2.03	1.01	1.19	1.41
M_d (Molecular Weight of Dry Stack Gas)	lb/lb-mole	28.864	28.86	28.86	28.86
M_s (Molecular Weight of Wet Stack Gas)	lb/lb-mole	28.64	28.75	28.73	28.71
P_s (Pressure of Stack Gas, Absolute)	In. Hg	28.78	28.65	28.65	28.69
Iso (Percent of Isokinetic Sampling)	%	108.1	106.9	109.1	108.0
V_s (Average Stack Gas Velocity)	ft/m (fpm)	3,413	3,436	3,455	3,435
Q_a (Actual Volumetric Flow Rate)	ft^3/m (dscfm)	97,850	98,510	99,060	98,473
Q_{std} (Dry Volumetric Flow Rate, std.)	ft^3/m (cfm)	83,080	84,390	84,215	83,895
Filterable $PM_{2.5}$ Emissions					
D50 (dia. w/50% penetration probability)	µm	2.487	2.50	2.45	2.48
m_n (Front $^1/_2$ $PM_{2.5}$ Mass)	mg/sample	5.16	4.47	4.76	
$PM_{2.5}$ Filterable Concentrations - std.	gr/dscf	0.00173	0.0015	0.0016	0.0016
$PM_{2.5}$ Filterable Emission Rate	lb/hr	1.232	1.077	1.128	1.145
Condensable ($PM_{2.5}$) Emissions					
Organic m_n (Back $^1/_2$ Mass)	mg/sample	1.8	1.7	2.0	
Condensable Organic Concentrations - std.	gr/dscf	0.0006	0.0006	0.0007	0.0006
Condensable Organic Emission Rate	lb/hr	0.429	0.409	0.474	0.438
Inorganic m_n (Back 1/2 Mass)	mg/sample	1.2	1.9	0.3	
Condensable Inorganic Concentrations - std.	gr/dscf	0.0004	0.0006	0.0001	0.0004
Condensable Inorganic Emission Rate	lb/hr	0.286	0.457	0.071	0.272
$PM_{2.5}$ Particulate Results (Includes Condensable Matter)					
$PM_{2.5}$ Concentrations - std.	gr/dscf	0.0027	0.0027	0.0023	0.0026
$PM_{2.5}$ Total Particulate Emission Rate	lb/hr	1.947	1.943	1.674	1.855
PM_{10} with larger diameter than 2.5 microns					
D50 (dia. w/50% penetration probability)	µm	10.909	10.96	10.80	10.89
m_n (Front $^1/_2$ $PM_{2.5}$ Mass)	mg/sample	4.33	1.23	1.64	
PM_{10} Conc.rger than 2.5 microns	gr/dscf	0.00145	0.0004	0.0005	0.0008
PM_{10} Emissions greater than 2.5 microns	lb/hr	1.032	0.296	0.389	0.573
PM_{10} Results					
PM_{10} Concentrations - std.	gr/dscf	0.0042	0.0031	0.0029	0.0034
PM_{10} Emission Rate	lb/hr	2.980	2.240	2.064	2.428
Filterable PM Results					
Filterable PM Concentrations - std.	gr/dscf	0.0032	0.0019	0.0021	0.0024
Filterable PM Emission Rate	lb/hr	2.265	1.373	1.518	1.719

3.0 SUMMARY OF SAMPLING METHODS

Optimal performed the following U.S. Environmental Protection Agency (EPA) test methods to meet the requirements of the specified work. These methods may be referenced in Title 40 of the Code of Federal Regulations, Parts 51 and 60. The methods are titled as follows:

- Method 1 "Sample and Velocity Traverses for Stationary Sources;"
- Method 2 "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube);"
- Method 3 "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources;"
- Method 4 "Determination of Moisture Content in Stack Gases;"
- Method 5 "Determination of Particulate Matter Emissions from Stationary Sources;" (TSP)
- Method 201A "Determination of PM_{10} and $PM_{2.5}$ Emissions from Stationary Sources;" (Constant Rate Procedure)
- Method 202 "Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources;"

4.0 METHODOLOGY AND PROCEDURES

Optimal collected source data and samples of exhaust gas from the three stacks to measure particulate emissions. Particulate emissions were based on the average of three runs following test methods listed in Title 40 of the Code of Federal Regulations, Part 51 (40CFR51) and Part 60 (40CFR60).

Brief descriptions of the sampling methods are shown below.

4.1 Stack Gas Velocity and Volumetric Flow Rate.

40 CFR 60 Method 1 was used to determine sample points for traverses measuring velocity head and temperature. Method 2 procedures were followed to calculate stack gas velocity during each run. Velocity and temperature sampling points were based on upstream and downstream distances from flow disturbances and the stack diameter. Physical dimensions were measured on-site.

Table 7 Stack Dimensions and Traverse Points

Emissions Source Baghouse Stack	RTO	Shakeout & Sand System	MeltPour
Stack Configuration (Vertical)	Circular	Circular	Circular
Test Location	Stack	Stack	Stack
Measured Inside Dimensions	75 5/16 inches	95 3/8 inches	72.5 inches
Port Length	4 5/16 inch	4 1/4 inch	4 1/2 inch
Distance from ports upstream to disturbance (B)	4.8 Diameters	~ 6.3 Diameters*	~ 7.4 Diameters*
Distance from ports downstream to disturbance	2.4 Diameters	~ 3.8 Diameters	~3.6 Diameters
No. of Ports	2	2	2
Velocity/temp./Particulate traverse points	24 (12 per	12 (6 per port)	12 (6 per port)
Point #1	1 9/16"	4 3/16"	3 13/16"
Point #2	5 1/16"	13 15/16"	10 9/16"
Point #3	8 7/8"	28 1/4"	21 7/16"
Point #4	13 5/16"	67 1/8"	51 1/16"
Point #5	18 13/16"	81 7/16"	61 15/16"
Point #6	26 13/16"	91 3/16"	69 5/16"
Point #7	48 1/2"		
Point #8	56 1/2"		
Point #9	62.0		
Point #10	66 7/16"		
Point #11	70 1/4"		
Point #12	73 3/4"		

*Estimated Measurement

The velocity and temperature sampling apparatus consisted of S-type stainless steel pitot tubes and a thermocouple to measure gas temperature. Pitots were calibrated at the Optimal laboratory prior to job mobilization. The velocity apparatus was leak checked before and after each run.

4.2 Oxygen, Carbon Dioxide and Molecular Weight.

Stack gas molecular weights were calculated from oxygen (O_2) and carbon dioxide (CO_2) concentrations. A Orsat analyzer was used to measure O_2 and CO_2 concentrations in accordance with 40 CFR 60 Method 3.

4.3 Moisture.

Moisture was measured in accordance with 40 CFR 60 Method 4 during each particulate test run. A sample of the stack gas was drawn into impingers immersed in an ice bath. The gas was cooled below 68°F to condense the moisture from the gas into the impingers. The moisture train consisted of impingers configured as per the associated method (Method 5 or Method 201A. The total weight gain of the impingers and the volume of gas drawn through the impingers were measured to calculate moisture concentration in the stack gas.

Dry gas meters and pitots were calibrated at the Optimal laboratory prior to job mobilization. A post-test calibration on each meter was performed at the conclusion of the test project to verify that calibration was maintained throughout sampling.

4.4 Flow Rate and Total Suspended Particulate Matter (RTO)

EPA Method 5 was used to determine the total filterable particulate concentration at the test location. A sample of the gas stream was withdrawn isokinetically and the particulate was collected in the nozzle and probe and on a heated filter. Sample analysis was gravimetric.

Pretest Preparation

All glassware was cleaned with detergent, rinsed with tap water, distilled water and acetone prior to shipment to the test location. The meter, thermometers, and pitot tube were calibrated prior to shipment. Sampling nozzles were calibrated on site.

Apparatus

The probe nozzle was made of borosilicate glass of buttonhook design with a taper angle of less than 30°. The probe was constructed of stainless steel and equipped with a glass liner and heater capable of maintaining a constant temperature of 250°F ± 25°F for the test duration, to prevent moisture condensation in the probe. The probe was also equipped with a pitot tube for constant monitoring of the stack gas velocity and a thermocouple accurate to within ± 2°F to measure the stack gas temperature. The filter holder was made of borosilicate glass with a Teflon support. A filter heating system capable of maintaining a temperature of 250°F ± 25°F and a thermocouple accurate to within ± 2°F were utilized. The metering system included: a vacuum gauge, leak free pump, thermometers accurate to within ± 5.4°F and a dry gas meter accurate to within 2 percent. Differential pressure gauges were used, one to measure stack gas velocity and the other for orifice differential pressure readings. The condenser system consisted of an ice bath and four leak-free glass impingers and connecting leak-free glassware. The first two impingers contained 100-ml of water. The third impinger remained empty and the fourth contained a tared amount of silica gel.

Reagents
Glass fiber filters with 99.95% efficiency, <0.05% penetration, on 0.3-micron dioctyl phthalate smoke particles were used. Acetone of reagent grade, <0.001 residue, was used.

Sampling
The filters were desiccated for 24 hours and weighed to a constant weight (within 0.5 mg) between weighings. The filter weight was considered constant when two consecutive weights taken at least six hours apart were within 0.5 mg of each other. The sample points were selected according to procedures outlined in EPA Method 1. The stack pressure, temperature, and velocity heads were determined using EPA Method 2. The nozzle size was selected for isokinetic sampling based upon the velocity head range.

The sample train was assembled using ball joint style glassware with Teflon coated o-rings on the joints to ensure a leak free seal. The impingers were placed in an ice bath for the duration of the test.

The entire sampling train was leak checked and had <0.02-cfm leakage prior to any sampling. The probe was placed in the stack and the system allowed to heat. The sampling commenced when the probe and filter reached sampling temperature. The sampling time was 120 minutes and the sampling volume was greater than sixty (60) standard cubic feet (scf).

After the test, the sample train was leak checked. If the leakage was less than the maximum allowable amount (0.02 cfm or 4% of the average sampling rate) the results were considered allowable.

Sample Recovery
A 100-ml sample of acetone was taken as reagent blank. The filter was removed from the filter holder and placed in a clean, labeled container. The probe nozzle, probe fitting, probe liner, and front half of the filter holder were washed with acetone and this rinse saved. The liquid levels were then marked for transportation to the laboratory. Both the tared drying column and impinger condensate were weighed to the nearest gram on a top loader balance. The total net weight was used in the moisture calculation.

Analysis
The filter was placed in a desiccator for 24 hours and weighed to a constant weight. The acetone wash was evaporated to dryness at ambient temperature and pressure, desiccated for 24 hours and weighed to a constant weight. The acetone blank was evaporated and weighed to constant weight as well. The acetone residue was then adjusted for the acetone blank residue. The filter weight and acetone wash weight yielded the total particulate mass.

4.5 Flow Rate and PM_{10} / $PM_{2.5}$ (filterable particulate matter less than 10 and 2.5 microns)
Method 201A was used to measure PM_{10} and $PM_{2.5}$ emissions. Particles greater than 10 microns were removed from the gas and collected in a customized (enlarged) in-stack cyclone-sizing device. Particles less than 10 microns but greater than 2.5 microns were collected downstream of the first cyclone in the cyclone turn around cup and in a second cyclone. Particles less than 2.5 microns passed through both cyclones and collected in the second

cyclone turn around cup and surfaces leading to a heated glass fiber filter. The particulate was recovered from the turn-around cups and other surfaces with nylon brushes and acetone rinses. Acetone rinses the particulate mass on the filter were analyzed gravimetrically.

The exact cut-point (size) was calculated and reported along with the mass of particulate collected in each fraction of the sampling train. Based on the sizing device specifications and the stack gas conditions, the required flow rate (ΔH) through the sizing device was calculated to maintain 10 micron (±1 micron) and 2.5 micron cut points (±0.25 microns). A velocity range (Δp_{min} and Δp_{max} values) was determined for each available nozzle, with a nozzle chosen that best fit the necessary range of Δp's for isokinetic sampling. Velocity pressure and average stack gas temperature data collected for each test were used to calculate the sample time (dwell time) at each point. Sampling was performed at a constant flow rate to maintain the 2.5-micron (±0.25 micron) and 10 micron (±1.0 micron) cut-points of the cyclones.

The cyclone turn around cup, front half of the filter holder and connecting tubes were recovered for particulate matter. The filterable $PM_{2.5}$ particulate consisted of two fractions.

- Filter plus brushed solids from cyclone turnaround cup and connecting tubes
- Acetone rinse of the front half of filter holder

The entire sampling was placed under a vacuum and checked for leaks prior to initiating each test. After the conclusion of the test, the cyclones were removed before conducting a post-test leak check from the end of the probe. The $PM_{2.5}$ flow rate at actual cyclone conditions were then calculated. Test results are considered acceptable if three conditions are met.

- $9\mu m < D50_{10} < 11\mu m$,
- $2.25\mu m < D50_{2.5} < 2.75\mu m$,
- no point is outside the Δp_{min} and Δp_{max}, or, that each point is 80-120% isokinetic and no more than one sampling point is outside the Δp_{min} and Δp_{max}.

One point on the third MeltPour run was below the minimum velocity head, resulting in a single-point isokinetic rate above the maximum allowable 120%.

4.6 Determination Condensable Particulate Matter.

EPA Method 202 was followed to measure condensable organic and inorganic particulate matter emissions in conjunction with the Method 5 and 201A sampling described above. Method 202 measures the condensable particulate matter (CPM) collected after the heated filter.

In accordance with Method 202 requirements, all glassware was cleaned prior to testing with soap and water, rinsed with water, acetone and finally hexane. The glassware was then baked at 572 °F for six hours (glassware was not shared between sources).

The 202 portion of the sampling train, beginning at the exit of the Method 5 or 201A heated filters, consisted of a borosilicate glass coil condenser, two impingers, a CPM filter and two additional impingers. The first impinger started dry and acted as a condensate (drop out) impinger for CPM. The second impinger was a modified Greenburg-Smith insert and also started dry for collection CPM. The first two impingers were placed in a water bath that was kept between 65°F and 85°F. Between the second and third impinger was a Teflon membrane

filter. The exit of the Teflon filter was maintained between 65°F and 85°F. The third impinger, containing 100ml of deionized water, and the fourth impinger, containing silica gel, acted as a moisture trap. The sample gas exiting the last impinger was maintained at a temperature below 68°F for the duration of each test.

Procedures for selecting sampling locations and for the operation of the apparatus were derived from EPA Method 1. The sampling apparatus was leak-checked before and after the test run.

Post-test Nitrogen Purge

Immediately following the post-test leak check, the entire condenser system (coil condenser to silica gel impinger) was purged with ultra-pure nitrogen (N_2) at a rate of 14 liters per minute, for 60 minutes. Before the purge began, the condensate collected in the knock-out impinger was added to the second impinger (modified Greenburg-Smith). During the purge, the coil condenser recirculation pump remained on and appropriate temperatures of the condenser system were maintained.

Particulate Matter Sample Recovery

CPM Sample Recovery - The condenser coil and impinger catches were weighed. The weight gain was added to the silica gel weight gain of the fourth impinger to determine the stack gas moisture content.

The condensate of the first two impingers was recovered into a glass sample container (container No. 1). The entire condenser system (coil condenser to front half of the CPM filter holder) was rinsed twice with DIUF water contributing less than 1 mg/L and saved in container No. 1. The condenser system was then rinsed with acetone and this rinse saved in container No. 2. The condenser system was then rinsed twice with hexane and these rinses added to container No. 2. The liquid levels were marked and the samples kept cool for transportation to the laboratory. The CPM filter was recovered and placed into a glass petri dish. Analysis was performed per EPA Method 202 procedures by DAT Laboratories in Plain City, Ohio.