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Comprehensive Emissions Test Report

Cintas Corporation
PM, PM-10, PM-2.5
Compliance Testing

Testing Date(s): April 18-20, 2017
Report Date: June 15, 2017
Revision Date: No revision to date

10-11-18
rec'd from Permits

ACCREDITED
Cert #3819.01 (ISO/IEC 17025:2005)
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STAC
STACK TESTING ACCREDITATION COUNCIL

Report Prepared For:

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3 Bedford Farms Drive
Bedford, NH 03110

Telephone No.: (603) 391-3327

Subject Facility:

Cintas Corporation
3149 Wilson Drive NW
Grand Rapids, MI 49544

Regulatory Permit No.:

Subject Emission Sources:
Industrial Laundry Dryer

Test Locations:
Exhaust

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Pace Project No. 12-17-0378

P0697_TEST_20170418

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Regulatory Summary

Subject Facility: Cintas Corporation
Plant Address: 3149 Wilson Drive NW
Grand Rapids, MI 49544

Air Permit No.:
Facility ID No.:

Emission Unit Name	Textile	Regulated Constituent	Regulatory Citations	Regulatory Reporting Units	Average Test Result
Industrial Laundry Dryer	Bar Towels	Particulate	NA	LB/LB of clean dry textile	1.29E-03 LB/LB of clean dry textile
		PM-10			2.12E-04 LB/LB of clean dry textile
		PM-2.5			1.36E-04 LB/LB of clean dry textile
	Dust Mops	Particulate	NA	LB/LB of clean dry textile	8.53E-04 LB/LB of clean dry textile
		PM-10			1.71E-04 LB/LB of clean dry textile
		PM-2.5			1.06E-04 LB/LB of clean dry textile
	Shop Towels	Particulate	NA	LB/LB of clean dry textile	1.56E-03 LB/LB of clean dry textile
		PM-10			1.05E-03 LB/LB of clean dry textile
		PM-2.5			9.41E-04 LB/LB of clean dry textile
	Floor Mats	Particulate	NA	LB/LB of clean dry textile	5.70E-04 LB/LB of clean dry textile
		PM-10			5.69E-05 LB/LB of clean dry textile
		PM-2.5			3.95E-05 LB/LB of clean dry textile

Executive Summary

Haley & Aldrich, Inc. contracted Pace Analytical Services, LLC to perform particulate (PM), PM-10, and PM-2.5 emissions compliance testing on an Industrial Laundry Dryer Exhaust at the Cintas Corporation facility located in Grand Rapids, Michigan. Testing was performed on April 18-20, 2017. Summary results are highlighted in the following table:

Test Results Summary

Parameter	Run 1	Run 2	Run 3	Average
Bar Towels				
Concentration, GR/DSCF				
PM-2.5	0.0013	0.0018	0.0026	0.0019
PM-10	0.0021	0.0028	0.0040	0.0030
PM	0.0171	0.0161	0.0218	0.0183
Mass Rate, LB/HR				
PM-2.5	0.08	0.11	0.16	0.12
PM-10	0.13	0.17	0.24	0.18
PM	1.07	0.98	1.33	1.13
Dust Mops				
Concentration, GR/DSCF				
PM-2.5	0.0063	0.0010	0.0012	0.0028
PM-10	0.0073	0.0034	0.0045	0.0051
PM	0.0278	0.0197	0.0320	0.0265
Mass Rate, LB/HR				
PM-2.5	0.41	0.06	0.07	0.18
PM-10	0.47	0.21	0.29	0.32
PM	1.79	1.22	2.02	1.68
Shop Towels				
Concentration, GR/DSCF				
PM-2.5	0.0129	0.0123	0.0124	0.0126
PM-10	0.0140	0.0138	0.0140	0.0139
PM	0.0197	0.0220	0.0205	0.0207
Mass Rate, LB/HR				
PM-2.5	0.81	0.79	0.78	0.79
PM-10	0.88	0.88	0.88	0.88
PM	1.24	1.40	1.29	1.31
Floor Mats				
Concentration, GR/DSCF				
PM-2.5	0.0005	0.0006	0.0028	0.0013
PM-10	0.0013	0.0013	0.0031	0.0019
PM	0.0251	0.0160	0.0190	0.0200
Mass Rate, LB/HR				
PM-2.5	0.04	0.04	0.19	0.09
PM-10	0.09	0.09	0.22	0.13
PM	1.74	1.13	1.32	1.40

Introduction

Pace Analytical Services, LLC personnel conducted PM, PM-10, and PM-2.5 emission compliance testing on an Industrial Laundry Dryer Exhaust at the Cintas Corporation facility located in Grand Rapids, Michigan. Dan Schoess and Nate Hibbard performed on-site testing activities. Terry Borgerding provided administrative project management. Jim Parkhurst and Lisa Autrey with Cintas Corporation and Tina Berceli-Boyle with Haley & Aldrich, Inc. coordinated plant activities during testing. Tom Gasloli and Adam Shaffer with the Michigan Department of Environmental Quality (MDEQ) were on-site to witness testing. Pace Analytical Services, LLC prepared a comprehensive test protocol that was submitted to the MDEQ and approved prior to testing. On-site sampling activities consisted of the following measurements for each textile:

- Particulate, PM-10, PM-2.5, three independent samplings.
- Orsat gas composition, integrated gas samples collected concurrent with above.
- Volumetric airflow, measurements before and after each constituent test run.
- Volumetric airflow, measurements collected in conjunction with isokinetic testing.

The project objectives were to quantify PM, PM-10, and PM-2.5 emission constituents in order to establish PM, PM-10, and PM-2.5 emission factors for industrial dryers on each textile (bar towels, dust mops, shop towels, and floor mats). These measurements were performed at normal operating conditions. Quality protocols comply with regulatory compliance testing requirements.

Subsequent sections summarize the test results and provide descriptions of the process and test methods. Supporting information and raw data are in the appendices.

Results Summary

Results of PM, PM-10, and PM-2.5 determinations while processing bar towels are summarized in Table 1. Results of PM, PM-10, and PM-2.5 determinations while processing dust mops are summarized in Table 2. Results of PM, PM-10, and PM-2.5 determinations while processing shop towels are summarized in Table 3. Results of PM, PM-10, and PM-2.5 determinations while processing floor mats are summarized in Table 4. Subsequent tables provide expanded detail of the testing results.

<PM-2.5 filterable particulate (M201A), organic condensable particulate, and inorganic condensable particulate (EPA Method 202) were combined to report PM-2.5 particulate matter. <PM-10 filterable particulate (M201A), organic condensable particulate, and inorganic condensable particulate (EPA Method 202) were combined to report PM-10 particulate matter. Total filterable particulate (M201A), organic condensable particulate, and inorganic condensable particulate (EPA Method 202) were combined to report total particulate matter.

The Dryer 3 Stack diameter is small enough that some flow bias is created by blockage from the PM-10/PM-2.5 sampling head. The blockage acts to increase measured velocity pressures because the same amount of air travels through a smaller space. While the elevated velocity pressure values are pertinent to method calculations for sampling rates and quality control, they would provide artificially high volumetric airflow data and particulate mass rates. Pursuant to Method 201A, EPA Method 1A/2 was used to alternatively measure actual airflows. Since a secondary test location was not available, airflow measurements were made through the same ports before and after PM-10/PM-2.5 runs when production allowed. The unbiased airflows were then used to report volumetric airflow and calculate emission rates (LB/HR).

An Intermediate Data Summary for each run is included in Appendix C. On these tables, the average square root of the velocity pressures, gas velocity and volumetric airflow reflect the measurements gathered during the EPA Method 201A runs rather than the separate airflow measurements. These are needed to calculate the correct isokinetic variation and other quality control parameters. A separate sheet named "Information to Correct M201A Airflows/LB/HR and Assimilate Run 3 Airflow" shows the derivation of velocity pressures used to calculate non-blockage airflows.

The project was designed to complete a test on each of four industrial laundry classes. One run for each class was performed consecutively on a single day. The second run for each class was performed the next day and Run 3 completed the last day. Auxiliary airflow measurements were performed as production allowed. Velocities to calculate Run 3 airflows were assimilated from Runs 1 and 2.

The data in this report are indicative of emission characteristics of the measured sources for process conditions at the time of the test. Representations to other sources and test conditions are beyond the scope of this report.

Summary Tables

Cintas Corporation

Grand Rapids, MI
Pace Project No. 12-17-0378

Table 1

Results Summary
Industrial Laundry Dryer Stack
Test 1 - Bar Towels

Parameter	**Run 1**	**Run 2**	**Run 3**	**Average**
Date of Run	4/18/17	4/19/17	4/20/17	
Time of Run	0830-1039	0829-1013	0839-1023	
Clean Dry Textile Throughput, LB/HR	1,033	837	808	893
Volumetric Flow Rate (Rounded to 10 CFM)				
ACFM	8,870	8,770	8,830	8,820
DSCFM	7,280	7,100	7,140	7,170
Gas Temperature, °F	153	150	146	150
Gas Moisture Content, %v/v	3.1	4.1	4.6	3.9
Gas Composition, %v/v, dry				
Carbon Dioxide, CO2	0.4	0.4	0.4	0.4
Oxygen, O2	20.3	20.3	20.2	20.3
Nitrogen, N2 (by difference)	79.3	79.3	79.3	79.3
Particulate Concentration, GR/DSCF				
< 2.5 µm Particulate Matter	0.0013	0.0018	0.0026	0.0019
< 10 µm Particulate Matter	0.0021	0.0028	0.0040	0.0030
Total Particulate Matter	0.0171	0.0161	0.0218	0.0183
Particulate Mass Rate, LB/HR				
< 2.5 µm Particulate Matter	0.08	0.11	0.16	0.12
< 10 µm Particulate Matter	0.13	0.17	0.24	0.18
Total Particulate Matter	1.07	0.98	1.33	1.13
Particulate Mass Rate, LB/LB of Textile				
< 2.5 µm Particulate Matter	7.93E-05	1.30E-04	1.99E-04	1.36E-04
< 10 µm Particulate Matter	1.30E-04	2.05E-04	3.02E-04	2.12E-04
Total Particulate Matter	1.03E-03	1.17E-03	1.65E-03	1.29E-03

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Table 2

Results Summary
Industrial Laundry Dryer Stack
Test 2 - Dust Mops

Parameter	**Run 1**	**Run 2**	**Run 3**	**Average**
Date of Run	4/18/17	4/19/17	4/20/17	
Time of Run	1159-1533	1100-1436	1054-1446	
Clean Dry Textile Throughput, LB/HR	1,588	2,380	2,200	2,056
Volumetric Flow Rate (Rounded to 10 CFM)				
ACFM	9,190	8,890	9,020	9,030
DSCFM	7,510	7,220	7,360	7,370
Gas Temperature, °F	154	148	142	148
Gas Moisture Content, %v/v	3.6	4.0	4.3	4.0
Gas Composition, %v/v, dry				
Carbon Dioxide, CO_2	0.4	0.4	0.4	0.4
Oxygen, O_2	20.3	20.4	20.3	20.3
Nitrogen, N_2 (by difference)	79.3	79.3	79.3	79.3
Particulate Concentration, GR/DSCF				
< 2.5 µm Particulate Matter	0.0063	0.0010	0.0012	0.0028
< 10 µm Particulate Matter	0.0073	0.0034	0.0045	0.0051
Total Particulate Matter	0.0278	0.0197	0.0320	0.0265
Particulate Mass Rate, LB/HR				
< 2.5 µm Particulate Matter	0.41	0.06	0.07	0.18
< 10 µm Particulate Matter	0.47	0.21	0.29	0.32
Total Particulate Matter	1.79	1.22	2.02	1.68
Particulate Mass Rate, LB/LB of Textile				
< 2.5 µm Particulate Matter	2.56E-04	2.69E-05	3.39E-05	1.06E-04
< 10 µm Particulate Matter	2.95E-04	8.97E-05	1.30E-04	1.71E-04
Total Particulate Matter	1.13E-03	5.12E-04	9.18E-04	8.53E-04

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Table 3

Results Summary
Industrial Laundry Dryer Stack
Test 3 - Shop Towels

Parameter	**Run 1**	**Run 2**	**Run 3**	**Average**
Date of Run	4/18/17	4/19/17	4/20/17	
Time of Run	1611-1857	1508-1659	1518-1718	
Clean Dry Textile Throughput, LB/HR	897	814	823	845
Volumetric Flow Rate (Rounded to 10 CFM)				
ACFM	9,140	9,220	9,200	9,190
DSCFM	7,340	7,440	7,350	7,380
Gas Temperature, °F	172	156	161	163
Gas Moisture Content, %v/v	2.4	3.5	3.3	3.1
Gas Composition, %v/v, dry				
Carbon Dioxide, CO2	0.3	0.4	0.4	0.4
Oxygen, O2	20.5	20.4	20.3	20.4
Nitrogen, N2 (by difference)	79.2	79.3	79.3	79.2
Particulate Concentration, GR/DSCF				
< 2.5 µm Particulate Matter	0.0129	0.0123	0.0124	0.0126
< 10 µm Particulate Matter	0.0140	0.0138	0.0140	0.0139
Total Particulate Matter	0.0197	0.0220	0.0205	0.0207
Particulate Mass Rate, LB/HR				
< 2.5 µm Particulate Matter	0.81	0.79	0.78	0.79
< 10 µm Particulate Matter	0.88	0.88	0.88	0.88
Total Particulate Matter	1.24	1.40	1.29	1.31
Particulate Mass Rate, LB/LB of Textile				
< 2.5 µm Particulate Matter	9.07E-04	9.67E-04	9.49E-04	9.41E-04
< 10 µm Particulate Matter	9.79E-04	1.08E-03	1.07E-03	1.05E-03
Total Particulate Matter	1.38E-03	1.72E-03	1.57E-03	1.56E-03

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Table 4

Results Summary
Industrial Laundry Dryer Stack
Test 4 - Floor Mats

Parameter	**Run 1**	**Run 2**	**Run 3**	**Average**
Date of Run	4/18/17	4/19/17	4/20/17	
Time of Run	1942-2222	1836-2128	1808-2021	
Clean Dry Textile Throughput, LB/HR	2,635	2,494	2,211	2,447
Volumetric Flow Rate (Rounded to 10 CFM)				
ACFM	9,570	9,800	9,730	9,700
DSCFM	8,060	8,280	8,090	8,140
Gas Temperature, °F	146	141	143	143
Gas Moisture Content, %v/v	1.8	1.5	2.5	1.9
Gas Composition, %v/v, dry				
Carbon Dioxide, CO_2	0.3	0.3	0.3	0.3
Oxygen, O_2	20.6	20.6	20.5	20.6
Nitrogen, N_2 (by difference)	79.2	79.2	79.2	79.2
Particulate Concentration, GR/DSCF				
< 2.5 µm Particulate Matter	0.0005	0.0006	0.0028	0.0013
< 10 µm Particulate Matter	0.0013	0.0013	0.0031	0.0019
Total Particulate Matter	0.0251	0.0160	0.0190	0.0200
Particulate Mass Rate, LB/HR				
< 2.5 µm Particulate Matter	0.04	0.04	0.19	0.09
< 10 µm Particulate Matter	0.09	0.09	0.22	0.13
Total Particulate Matter	1.74	1.13	1.32	1.40
Particulate Mass Rate, LB/LB of Textile				
< 2.5 µm Particulate Matter	1.36E-05	1.74E-05	8.74E-05	3.95E-05
< 10 µm Particulate Matter	3.45E-05	3.75E-05	9.86E-05	5.69E-05
Total Particulate Matter	6.59E-04	4.55E-04	5.96E-04	5.70E-04

Detail Tables

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Grand Rapids, MI
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Table 5

Major Gases and Moisture Results
Industrial Laundry Dryer Stack
Test 1 - Bar Towels

Parameter	**Run 1**	**Run 2**	**Run 3**
Date of Run	4/18/17	4/19/17	4/20/17
Time of Run	0830-1039	0829-1013	0839-1023
Major Gas Constituents - Instrumental, % v/v			
Dry Basis (as measured)			
Carbon Dioxide	0.41	0.44	0.44
Oxygen	20.25	20.29	20.24
Nitrogen (by difference)	79.34	79.27	79.32
Wet Basis (calculated)			
Carbon Dioxide	0.40	0.42	0.42
Oxygen	19.62	19.47	19.31
Nitrogen	76.86	76.05	75.68
Portable Oxygen Monitor Result			
Time Weighted Average, %O_2	20.6	20.6	20.5
Moisture Collected, ml	21.5	27.0	32.5
Moisture Content, %v/v	3.12	4.06	4.60
Moisture Content if Saturated, %v/v	27.95	26.22	23.64
Relative Humidity, % rH	11%	15%	19%
Molecular Weight of Flue Gas, lb/lb-mole			
Dry	28.88	28.88	28.88
Wet	28.54	28.44	28.38

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Table 6

Major Gases and Moisture Results
Industrial Laundry Dryer Stack
Test 2 - Dust Mops

Parameter	**Run 1**	**Run 2**	**Run 3**
Date of Run	4/18/17	4/19/17	4/20/17
Time of Run	1159-1533	1100-1436	1054-1446
Major Gas Constituents - Instrumental, % v/v			
Dry Basis (as measured)			
Carbon Dioxide	0.44	0.38	0.43
Oxygen	20.27	20.37	20.28
Nitrogen (by difference)	79.29	79.25	79.29
Wet Basis (calculated)			
Carbon Dioxide	0.42	0.36	0.41
Oxygen	19.55	19.56	19.41
Nitrogen	76.45	76.08	75.88
Portable Oxygen Monitor Result			
Time Weighted Average, $\%O_2$	20.2	20.4	20.1
Moisture Collected, ml	25.0	29.0	31.0
Moisture Content, %v/v	3.58	4.00	4.30
Moisture Content if Saturated, %v/v	28.07	24.90	21.41
Relative Humidity, % rH	13%	16%	20%
Molecular Weight of Flue Gas, lb/lb-mole			
Dry	28.88	28.88	28.88
Wet	28.49	28.44	28.41

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Table 7

Major Gases and Moisture Results
Industrial Laundry Dryer Stack
Test 3 - Shop Towels

Parameter	**Run 1**	**Run 2**	**Run 3**
Date of Run	4/18/17	4/19/17	4/20/17
Time of Run	1611-1857	1508-1659	1518-1718
Major Gas Constituents - Instrumental, % v/v			
Dry Basis (as measured)			
Carbon Dioxide	0.34	0.39	0.41
Oxygen	20.48	20.36	20.31
Nitrogen (by difference)	79.18	79.25	79.28
Wet Basis (calculated)			
Carbon Dioxide	0.33	0.38	0.40
Oxygen	19.98	19.65	19.63
Nitrogen	77.24	76.49	76.63
Portable Oxygen Monitor Result			
Time Weighted Average, $\%O_2$	20.3	20.3	20.1
Moisture Collected, ml	18.0	23.0	23.5
Moisture Content, %v/v	2.45	3.48	3.35
Moisture Content if Saturated, %v/v	43.52	30.30	34.18
Relative Humidity, % rH	6%	11%	10%
Molecular Weight of Flue Gas, lb/lb-mole			
Dry	28.87	28.88	28.88
Wet	28.61	28.50	28.51

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Table 8

Major Gases and Moisture Results
Industrial Laundry Dryer Stack
Test 4 - Floor Mats

Parameter	**Run 1**	**Run 2**	**Run 3**
Date of Run	4/18/17	4/19/17	4/20/17
Time of Run	1942-2222	1836-2128	1808-2021
Major Gas Constituents - Instrumental, % v/v			
Dry Basis (as measured)			
Carbon Dioxide	0.27	0.27	0.28
Oxygen	20.55	20.57	20.54
Nitrogen (by difference)	79.18	79.16	79.18
Wet Basis (calculated)			
Carbon Dioxide	0.27	0.27	0.27
Oxygen	20.19	20.27	20.02
Nitrogen	77.79	78.00	77.19
Portable Oxygen Monitor Result			
Time Weighted Average, $\%O_2$	20.4	20.7	20.5
Moisture Collected, ml	14.0	10.5	17.5
Moisture Content, %v/v	1.76	1.46	2.51
Moisture Content if Saturated, %v/v	23.35	20.43	21.60
Relative Humidity, % rH	8%	7%	12%
Molecular Weight of Flue Gas, lb/lb-mole			
Dry	28.87	28.87	28.87
Wet	28.67	28.71	28.59

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Table 9

Particulate Results
Industrial Laundry Dryer Stack
Test 1 - Bar Towels

Parameter	**Run 1**	**Run 2**	**Run 3**
Date of Run	4/18/17	4/19/17	4/20/17
Time of Run	0830-1039	0829-1013	0839-1023
Sample Duration, Minutes	82.1	76.1	81.8
Average Flue Gas Temperature, °F	153.4	150.4	146.2
Moisture Content of Flue Gas, %v/v	3.1	4.1	4.6
Volumetric Flow Rate (Rounded to 10 CFM)			
ACFM	8,870	8,770	8,830
SCFM	7,520	7,400	7,480
DSCFM	7,280	7,100	7,140
Particulate Collected, mg Blank Corrected			
PM_{10} Cyclone - >10 μm Filterable	30.4	25.9	36.7
$PM_{2.5}$ Cyclone - 2.5 - 10 μm Filterable	1.7	2.0	2.8
Filter Catch - <2.5 μm Filterable	1.0	0.5	1.0
CPM_{ORG} - Organic Condensible	0.88	1.1	1.7
CPM_{INORG} - Inorganic Condensible	0.8	1.9	2.7
Actual PM10 Cut Diameter, μm	10.9	10.5	10.5
Actual PM2.5 Cut Diameter, μm	2.44	2.30	2.31
Particulate Concentration, GR/DSCF			
< 2.5 μm Filterable PM	0.0005	0.0003	0.0005
< 10 μm Filterable PM	0.0013	0.0013	0.0019
Filterable Particulate Matter	0.0163	0.0146	0.0197
Organic Condensible PM	0.0004	0.0006	0.0008
Inorganic Condensible PM	0.0004	0.0010	0.0013
Particulate Emission Rate, LB/HR			
< 2.5 μm Filterable PM	0.03	0.02	0.03
< 10 μm Filterable PM	0.08	0.08	0.11
Filterable Particulate Matter	1.02	0.89	1.20
Organic Condensible PM	0.03	0.03	0.05
Inorganic Condensible PM	0.02	0.06	0.08

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Table 10

Particulate Results
Industrial Laundry Dryer Stack
Test 2 - Dust Mops

Parameter	**Run 1**	**Run 2**	**Run 3**
Date of Run	4/18/17	4/19/17	4/20/17
Time of Run	1159-1533	1100-1436	1054-1446
Sample Duration, Minutes	82.2	84.7	83.7
Average Flue Gas Temperature, °F	153.6	148.3	142.3
Moisture Content of Flue Gas, %v/v	3.6	4.0	4.3
Volumetric Flow Rate (Rounded to 10 CFM)			
ACFM	9,190	8,890	9,020
SCFM	7,790	7,520	7,690
DSCFM	7,510	7,220	7,360
Particulate Collected, mg Blank Corrected			
PM_{10} Cyclone - >10 μm Filterable	42.2	34.5	57.9
$PM_{2.5}$ Cyclone - 2.5 - 10 μm Filterable	1.9	5.1	7.0
Filter Catch - <2.5 μm Filterable	0.9	0.6	0.7
CPM_{ORG} - Organic Condensible	11.21	0.72	1.78
CPM_{INORG} - Inorganic Condensible	0.9	0.9	0.0
Actual PM10 Cut Diameter, μm	10.7	10.6	10.6
Actual PM2.5 Cut Diameter, μm	2.39	2.35	2.32
Particulate Concentration, GR/DSCF			
< 2.5 μm Filterable PM	0.0004	0.0003	0.0003
< 10 μm Filterable PM	0.0014	0.0027	0.0037
Filterable Particulate Matter	0.0219	0.0189	0.0312
Organic Condensible PM	0.0055	0.0003	0.0008
Inorganic Condensible PM	0.0004	0.0004	0.0000
Particulate Emission Rate, LB/HR			
< 2.5 μm Filterable PM	0.028	0.017	0.021
< 10 μm Filterable PM	0.089	0.166	0.232
Filterable Particulate Matter	1.412	1.171	1.967
Organic Condensible PM	0.352	0.021	0.053
Inorganic Condensible PM	0.027	0.026	0.000

Cintas Corporation

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Table 11

Particulate Results
Industrial Laundry Dryer Stack
Test 3 - Shop Towels

Parameter	**Run 1**	**Run 2**	**Run 3**
Date of Run	4/18/17	4/19/17	4/20/17
Time of Run	1611-1857	1508-1659	1518-1718
Sample Duration, Minutes	86.1	76.7	82.1
Average Flue Gas Temperature, °F	172.2	156.3	161.3
Moisture Content of Flue Gas, %v/v	2.4	3.5	3.3
Volumetric Flow Rate (Rounded to 10 CFM)			
ACFM	9,140	9,220	9,200
SCFM	7,520	7,710	7,610
DSCFM	7,340	7,440	7,350
Particulate Collected, mg Blank Corrected			
PM_{10} Cyclone - >10 µm Filterable	12.5	16.0	13.3
$PM_{2.5}$ Cyclone - 2.5 - 10 µm Filterable	2.3	2.9	3.4
Filter Catch - <2.5 µm Filterable	1.8	4.7	4.6
CPM_{ORG} - Organic Condensible	25.94	18.67	20.38
CPM_{INORG} - Inorganic Condensible	0.5	0.6	0.7
Actual PM10 Cut Diameter, µm	10.7	10.6	10.6
Actual PM2.5 Cut Diameter, µm	2.42	2.35	2.37
Particulate Concentration, GR/DSCF			
< 2.5 µm Filterable PM	0.0008	0.0024	0.0022
< 10 µm Filterable PM	0.0019	0.0039	0.0038
Filterable Particulate Matter	0.0076	0.0121	0.0103
Organic Condensible PM	0.0119	0.0096	0.0098
Inorganic Condensible PM	0.0002	0.0003	0.0003
Particulate Emission Rate, LB/HR			
< 2.5 µm Filterable PM	0.05	0.15	0.14
< 10 µm Filterable PM	0.12	0.25	0.24
Filterable Particulate Matter	0.48	0.77	0.65
Organic Condensible PM	0.75	0.61	0.62
Inorganic Condensible PM	0.02	0.02	0.02

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Table 12

Particulate Results
Industrial Laundry Dryer Stack
Test 4 - Floor Mats

Parameter	**Run 1**	**Run 2**	**Run 3**
Date of Run	4/18/17	4/19/17	4/20/17
Time of Run	1942-2222	1836-2128	1808-2021
Sample Duration, Minutes	94.1	84.9	80.4
Average Flue Gas Temperature, °F	146.2	140.5	142.6
Moisture Content of Flue Gas, %v/v	1.8	1.5	2.5
Volumetric Flow Rate (Rounded to 10 CFM)			
ACFM	9,570	9,800	9,730
SCFM	8,210	8,400	8,290
DSCFM	8,060	8,280	8,090
Particulate Collected, mg Blank Corrected			
PM_{10} Cyclone - >10 μm Filterable	56.8	31.7	32.9
$PM_{2.5}$ Cyclone - 2.5 - 10 μm Filterable	1.9	1.5	0.7
Filter Catch - <2.5 μm Filterable	0.5	0.7	0.7
CPM_{ORG} - Organic Condensible	0.71	0.59	0.76
CPM_{INORG} - Inorganic Condensible	0.0	0.0	4.3
Actual PM10 Cut Diameter, μm	10.8	10.8	10.6
Actual PM2.5 Cut Diameter, μm	2.42	2.40	2.32
Particulate Concentration, GR/DSCF			
< 2.5 μm Filterable PM	0.0002	0.0003	0.0004
< 10 μm Filterable PM	0.0010	0.0010	0.0007
Filterable Particulate Matter	0.0248	0.0157	0.0166
Organic Condensible PM	0.0003	0.0003	0.0004
Inorganic Condensible PM	0.0000	0.0000	0.0021
Particulate Emission Rate, LB/HR			
< 2.5 μm Filterable PM	0.02	0.02	0.02
< 10 μm Filterable PM	0.07	0.07	0.05
Filterable Particulate Matter	1.72	1.12	1.15
Organic Condensible PM	0.02	0.02	0.03
Inorganic Condensible PM	0.00	0.00	0.14

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Table 13

Airflow Measurement Results
Industrial Laundry Dryer Stack
Test 1 - 4, Run 1

Parameter	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**	**Run 7**
Date of Run	4/17/17	4/18/17	4/18/17	4/18/17	4/18/17	4/18/17	4/18/17
Time of Measurement	1940	0815	1042	1153	1607	1900	1939
Barometric Pressure, Inches Hg	29.49	29.49	29.49	29.49	29.49	29.49	29.49
Static Pressure, Inches WC	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47
Absolute Gas Pressure (In. Hg)	29.46	29.46	29.46	29.46	29.46	29.46	29.46
Average Gas Temperature, °F	153.4	153.4	153.4	153.6	172.2	172.2	146
Moisture Determination Proc.: Psychro metric (Wb-Tb) Temp Measure ments							
Average Moisture Content, %v/v	3.1	3.1	3.1	3.6	2.5	2.5	1.8
Gas Molecular Weight (Instrumental), lb/lb-mole							
Dry	28.88	28.88	28.88	28.88	28.87	28.87	28.87
Wet	28.54	28.54	28.54	28.48	28.60	28.60	28.68
Flue Gas Average Velocity, FPS	39.84	40.85	39.31	41.49	42.18	40.50	43.24
Duct Cross-sectional Area, Sq. Ft	3.69	3.69	3.69	3.69	3.69	3.69	3.69
Volumetric Flow Rate (Rounded to 10 CFM)							
ACFM	8,810	9,040	8,700	9,180	9,330	8,960	9,570
SCFM	7,470	7,660	7,370	7,780	7,680	7,370	8,210
DSCFM	7,240	7,420	7,140	7,500	7,480	7,190	8,060

Cintas Corporation

Grand Rapids, MI
Pace Project No. 12-17-0378

Table 14

Airflow Measurement Results
Industrial Laundry Dryer Stack
Test 1 - 4, Run 2

Parameter	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**
Date of Run	4/19/17	4/19/17	4/19/17	4/19/17	4/19/17	4/19/17
Time of Measurement	0826	1015	1057	1438	1833	2145
Barometric Pressure, Inches Hg	29.20	29.20	29.20	29.20	29.20	29.20
Static Pressure, Inches WC	-0.47	-0.47	-0.47	-0.47	-0.47	-0.47
Absolute Gas Pressure (In. Hg)	29.17	29.17	29.17	29.17	29.17	29.17
Average Gas Temperature, °F	150.4	150.4	148.7	148.7	140.5	141
Moisture Determination Proc.: Psychro metric (Wb-Tb) Temp Measure ments						
Average Moisture Content, %v/v	4.1	4.1	4.0	4.0	1.5	1.5
Gas Molecular Weight (Instrumental), lb/lb-mole						
Dry	28.88	28.88	28.88	28.88	28.87	28.87
Wet	28.43	28.43	28.44	28.44	28.71	28.71
Flue Gas Average Velocity, FPS	40.11	39.17	42.01	38.37	44.07	44.50
Duct Cross-sectional Area, Sq. Ft	3.69	3.69	3.69	3.69	3.69	3.69
Volumetric Flow Rate (Rounded to 10 CFM)						
ACFM	8,870	8,670	9,290	8,490	9,750	9,840
SCFM	7,490	7,310	7,860	7,180	8,360	8,440
DSCFM	7,180	7,010	7,550	6,890	8,240	8,320

Process Description

Cintas Corporation owns and operates an industrial laundering facility in Grand Rapids, Michigan.

For this project, particulate (PM, PM-10, PM-2.5) testing was performed on an Industrial Laundry Dryer Exhaust. Testing was performed while drying four different types of textiles: dust mops, shop towels, bar towels, and floor mats. The textiles have different load-drying times. The dust mops, shop towels, and bar towels have load drying times of approximately 20-30 minutes per cycle with 10-15 minutes between each cycle for loading and unloading. The drying cycle for floor mats is approximately 10 minutes with 10-15 minutes between each cycle for loading and unloading. Three test runs were conducted for each textile. Sampling was performed during normal drying and was paused between dryer cycles.

Dryer cycle times and load weights were recorded during testing and are included in Appendix E.

Test Procedures

EPA Method 1 specifies test location acceptability criteria and defines the minimum number of traverse points for representative sampling. Linear measurements from upstream and downstream flow disturbances and the duct equivalent diameter are compared and the distances related to number of diameters. A flow disturbance can be defined as anything that changes or upsets the direction of flow within the duct including bends, dampers, fans, shape or size transitions, and open flames. Method 1 stipulates that test ports should be located at least eight diameters downstream and two diameters upstream of any flow disturbance. The minimum acceptable criteria are two diameters downstream and 0.5 diameters upstream of flow disturbances. The test location must also be free of cyclonic or multidirectional flow. Once the distances have been determined, the values are used to select the minimum number of traverse points for representative sampling. Shorter distances require a greater number of traverse points. The test site configuration and measurement details are documented on EPA Method 1 Field Data Sheet.

Pace FSD conducted this method as written with no deviations.

EPA Method 2 defines procedures used to measure linear velocity and volumetric flow rate of a confined gas stream. Using traverse points determined by EPA Method 1, multiple differential pressure measurements (pitot impact opening versus static pressure) are made using a pitot tube and differential pressure gauge. The individual measurements are averaged and combined with the gas density to calculate the average gas velocity. The velocity and duct cross-sectional area are used to calculate the volumetric flow rate. The volumetric flow rate is expressed as actual cubic feet per minute (ACFM), standard cubic feet per minute (SCFM), and dry standard cubic feet per minute (DSCFM). The technician maintains comprehensive test records on EPA Method 2 Field Data Sheet. Details of the equipment used to measure gas velocity include:

Pitot Tube:	S-Type
Differential Pressure Gauge:	Oil or Electronic Digital Manometer
Temperature Device:	Type K Thermocouple
Barometer Type:	Electronic Digital Barometer
Gas Density Determination:	EPA Method 3
Gas Moisture Determination:	EPA Method 4

Pace FSD conducted this method as written with no deviations.

EPA Method 3A defines procedures to measure carbon dioxide (CO_2) and oxygen (O_2) concentrations from stationary sources. A stainless steel sampling probe and a sampling line draw a sample of the gas stream from the duct to a thermo-electric gas conditioner to remove moisture. The conditioned gas stream is delivered to an infrared gas analyzer to quantify CO_2 concentrations and paramagnetic gas analyzer quantifies O_2 concentrations. Zero grade cylinder air or a zero gas generator provides zero gas.

Span gases include varying concentrations of EPA Protocol 1 CO_2/O_2 mixed standards specific to the target calibration range. A computerized data acquisition system logs CO_2/O_2 concentrations for one-minute averages. The logged results are integrated to test periods and tabulated with standardized spreadsheets in Microsoft Excel. The operator also maintains comprehensive test records on the Gas Monitoring Field Data Sheet. Equipment used for CO_2/O_2 testing includes:

Probe Material:	Stainless Steel
Moisture Removal:	Thermo-electric
Transfer Line:	Teflon™
Analytical Technique:	Non-dispersive Infrared Detector (CO_2)
	Paramagnetic Detector (O_2)
Calibration Gas:	EPA Protocol 1

Pace FSD conducted this method as written with no deviations.

EPA Method 4 - Isokinetic defines procedures to measure the moisture content of emission gas streams from stationary sources. The moisture content of the gas stream is determined in conjunction with an isokinetic sampling train. Collected water condensate is measured from the back half of the isokinetic train. Method 4 equations convert the condensed liquid volume to a gas volume. The water vapor volume compared with the dry standard gas volume collected through the isokinetic train determines the moisture content of the emissions gas stream and is reported in percent by volume. Equipment used for measuring moisture content includes:

Probe Material:	Borosilicate glass or Stainless Steel
Filter Media:	Glass or Quartz fiber
Impinger Train Material:	Borosilicate Glass
Desiccant:	Drierite
Condensate Measure:	Graduated Cylinder or Electronic Scale
Desiccant Measure:	Electronic Scale

Pace FSD conducted this method as written with no deviations.

EPA Method 201A defines procedures to measure particulate matter equal to or less than 10 microns (PM-10) and 2.5 microns (PM-2.5) from stationary sources. Using traverse points determined from EPA Method 1 and incorporating procedures from EPA Methods 2, 3, 4, and 5, a sample gas stream is drawn from the emission stream at a constant rate through an in-stack sizing devices: a PM-10 cyclone followed by a PM-2.5 cyclone. The cyclones separator classifies particulate matter at 10-micron (μm) and 2.5-micron (μm) aerodynamic cut diameters (nominal). Cyclones collect particulate matter at the cut size and larger. The omission of either cyclone excludes the measurement of that particle cut size from the method. The cyclones are followed by an in-stack glass fiber filter to collect remaining filterable particulate (less than the cut diameter). The sample gas moves through a heated sampling probe to the back half of the sampling train. This method is used in conjunction with Method 202 when the gas stream temperature exceeds 85°F to collect condensable particulate which is included as PM-2.5. See separate summary for Method 202. The back half of the train consists of glass impingers and a desiccant packed drying column to quantitatively collect water vapor. An ice bath maintains the impinger train temperature (outlet) at 68°F or less. Sample recovery and train clean up are performed after each run using procedures to ensure sample integrity and quantitative recovery. Sample fractions are processed from the cyclone heads into separate sample containers using a brush and acetone. Gravimetric analysis is applied to determine the particulate mass for each size fraction. The train operator maintains comprehensive test records on EPA Method 201A Field Data Sheet. Details of PM-10 and PM-2.5 particulate testing include:

Nozzle/Probe Material:	Stainless Steel
PM-2.5 Separator:	Stainless Steel Cyclone
PM-10 Separator:	Stainless Steel Cyclone
Filter Holder Material:	Stainless Steel
Filter Media:	Glass-fiber, >99.95% efficient at 0.3 um
Impinger Train Material:	Borosilicate Glass
Recovery Reagents:	Acetone
	Deionized Water
Control Train:	EPA Method 17
Analytical Technique:	Gravimetric

Pace FSD conducted this method with the following project situational deviations.
The diameter of the stack tested was small enough that some flow bias is created by blockage from the PM-10/PM-2.5 sampling head. Pursuant to Method 201A, EPA Method 1A/2 was used to alternatively measure actual airflows. Since a secondary test location was not available, airflow measurements were made through the same ports before and after PM-10/PM-2.5 runs when production allowed. The unbiased airflows were then used to report volumetric airflow and calculate emission rates (LB/HR).

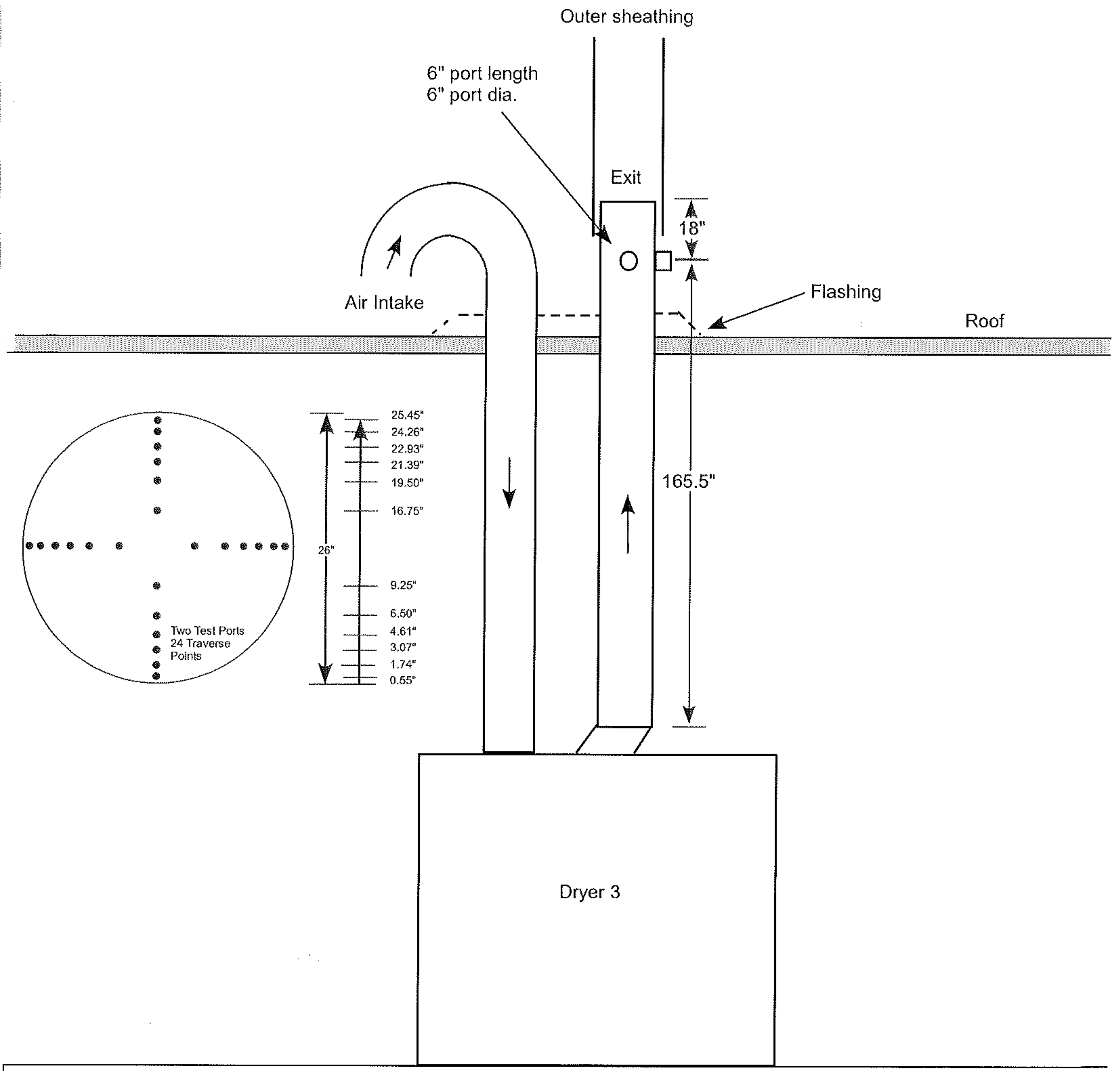
EPA Method 202 defines procedures to determine organic and inorganic condensable particulate matter (CPM) emissions from stationary sources. The CPM is collected in a condensate knock-out impinger and Teflon filter after filterable PM has been collected by either Method 5 or Method 201A. The gas stream is sample isokinetically following EPA Method 5 or Method 201A procedures. The Method 202 CPM train collects condensable and soluble particulate. The gas stream is initially cooled with a spiral condenser using recirculated cool water to maintain a sample gas temperature of 85F or less. Condensate from the spiral condenser collects in glass, stemless, dropout impingers. The intent of the condenser and dropout impinger is to minimize gas/water contact to reduce collection of unintended artifacts. The dropout impinger is followed by a second impinger to provide overflow capacity. A Teflon filter, also maintained at 85F or less is used to collect any remaining organic CPM. The filter is followed by an iced, water prepared impinger and desiccant packed drying column to quantitatively collect remaining moisture. Immediately after sampling, the Method 202 CPM train is purged with nitrogen (N_2) to liberate dissolved sulfur dioxide (SO_2) gases. The contents of the dropout and backup impingers prior to the CPM filter are measured, weighed, and transferred to an appropriate sample bottle. CPM is quantitatively recovered with water, acetone, and hexane rinses. The CPM filter and water are extracted with hexane and combined with solvent rinses to determine the organic CPM. Following extraction, the water is dried and the residue measured as the inorganic CPM. The combination of both fractions represents the total condensable particulate matter (CPM). The train operator maintains comprehensive test records on appropriate Field Data Sheets.

Filter Holder Material:	Glass, Stainless Steel (316 or equivalent), or Fluoropolymer-coated Stainless Steel
Filter Media:	Teflon, >99.95% efficient at 0.3 um
Impinger Train Material:	Borosilicate Glass
Impinger Reagents:	Deionized Water
Recovery Reagents:	Acetone Hexane Deionized Water
Control Train:	EPA Method 17
Analytical Technique:	Gravimetric

Pace FSD conducted this method as written with no deviations.

Pace Analytical
Field Services Division

Figure 1
Cintas Corporation
Grand Rapids, MI
Dryer 3 Stack
DAS \ 04/17



Report Signatures

Field Testing and Reporting Performed by: Pace Analytical Services, LLC
Field Services Division
1700 Elm Street, Suite 200
Minneapolis, MN 55414

Field Testing Affirmation

All field testing was performed in accordance with stated test methods subject to modifications and deviations listed herein. Raw field data presented in this report accurately reflects results and information as recorded at the time of tests or otherwise noted.

Date 6/15/2017

Daniel Schoess, QSTI
Team Lead

Report Affirmation

To the best of my knowledge, this report accurately represents the compiled field and laboratory information with no material omissions, alterations or misrepresentations.

Date 6/15/17

Beth Kelm
Client Coordinator

Responsible Charge Affirmation

I have reviewed the information herein and it is approved for distribution.

Date 6/15/17

Terence J. Borgerding, QSTI
Operations Manager, Air