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REPORT OF SELECTED METALS, HCL, HF, AND PM/PM10 EMISSIONS TESTING ON FURNACES 3002, 4003, 4004, GENERAL EXHAUST AND DEGAS EXHAUST STACKS AT COSMA CASTING (CCMI) LOCATED IN BATTLE CREEK, MI

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SEPTEMBER 28-30, 2020
STACK TEST GROUP, INC. PROJECT NO. 20-3302

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1.0 INTRODUCTION

The Stack Test Group, Inc. conducted particulate, PM/PM10, selected metals (cadmium, manganese, and nickel), hydrogen chloride (HCL) and hydrogen fluoride (HF) emission testing on three furnace exhaust stacks (3002, 4003, and 4004) along with one general exhaust stack and a Degas exhaust stack at Cosma Castings (CCMI) facility in Battle Creek, MI. Testing was conducted on September 28, 29, and 30 2020. The purpose of this testing was to determine the concentrations and emissions rates of the above listed parameters exhausting from the stacks.

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All testing followed the guidelines of U.S. EPA Reference Methods 1 through 4, 5, 26A, 29, and 201A. This report contains a summary of results for the above mentioned tests and all the supporting field, process, and computer generated data.

Testing was conducted while Cosma Castings (CCMI) personnel operated all the units at normal conditions and as close to the maximum rate as possible. A copy of the the operating data is included in Appendix F.

2.0 SAMPLING AND ANALYTICAL PROCEDURES

2.1 Exhaust Gas Parameters

2.1.1 Traverse and Sampling Points

Testing was conducted on each of the exhaust stacks for the above units. The number of velocity traverse and sample measurement points the stack were determined using EPA Method 1.

The sample ports on all stacks were located a minimum of 2 equivalent diameters downstream and a minimum of 0.5 equivalent diameters upstream of the nearest flow disturbance. Velocity and sample measurements were taken at each of 24 points, 12 points in each of the two ports set at 90° to each other.

2.1.2 Velocity Traverse

Velocity measurements were performed during each emission test in accordance with EPA Method 2. An "S" type Pitot Tube with an attached type "K" thermocouple was used to conduct the velocity traverse.

2.1.3 Gas Composition

Gas composition for oxygen, carbon dioxide, and nitrogen was determined employing EPA Method 3A. A continuous gas sample was collected during each emission test. Gas analysis was conducted using a fyrite.

2.1.4 Moisture Content

The exhaust gas moisture content was determined using EPA Method 4 for all tests. Moisture content was determined by drawing the gas sample through four impingers in the sample train. Volumetric analysis was used to measure the condensed moisture in the first three impingers while gravimetric analysis of silica gel was used to measure moisture collected in the fourth impinger.

2.2 Particulate (Method 201A/202 and 5/202)

2.2.1 Sample Collection

Particulate emissions were determined in accordance with USEPA Reference Methods 1, 2, 3, 4, 5 and 202. These Methods are titled:

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	Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight
Method 4	Determination of Moisture Content from Stationary Sources
Method 5	Determination of Particulate Matter Emissions from Stationary Sources
Method 201A	PM10 and PM2.5 Constant Sampling Rate Procedure
Method 202	Dry Impinger Method for Determining Condensable Particulate Emissions from Stationary Sources

These methods appear in detail in Title 40 of the Code of Federal Regulations (CFR), Part 60, Appendix A.

The Method 201A/202 sampling train consisted of the following components.

1. PM10 and 2.5 Cyclone with 47 mm glass microfiber filter with stainless steel nozzle.
2. Teflon lined probe unheated.
3. Filter bypass.
4. Condenser, Drop out Impinger, 2 Modified Greenburg-Smith Impingers, Teflon CPM Filter in a dual insulated ice water bath in the following sequence:
   - A. Method 23 Vertical Condenser.
   - B. Method 23 Knockout Impinger.
   - C. Modified Greenburg-Smith Impinger Empty.
   - D. Glass Filter Assembly Containing a Teflon Filter.
   - E. Modified Greenburg-Smith Impinger with 100 mls of Water.
   - F. Known Amount of Silica Gel.
5. Sampling gas measuring system.

The Method 5/202 sampling train consisted of the following components.

1. Appropriately sized nozzle.
2. Glass lined probe heated to 248 ± 25°F.
3. Heated glass fiber filter to 248 ± 25°F.
4. Condenser, Drop out Impinger, 2 Modified Greenburg-Smith Impingers, Teflon CPM Filter in a dual insulated ice water bath in the following sequence:
   A. Method 23 Vertical Condenser.
   B. Method 23 Knockout Impinger.
   C. Modified Greenburg-Smith Impinger Empty.
   D. Glass Filter Assembly Containing a Teflon Filter.
   E. Modified Greenburg-Smith Impinger with 100 mls of Water.
   F. Modified Greenburg-Smith Inpinger with a known Amount of Silica Gel.
5. Sampling gas measuring system.

2.2.2 Sample Duration and Frequency

The Method 201A/202 train samples were collected in triplicate with each test lasting approximately 60 minutes in duration. The Method 5/202 train samples were collected in triplicate with each test lasting 60 minutes in duration. A minimum sample size of 30 dry standard cubic feet (dscf) was collected for each test.

2.2.3 Sample Recovery

Upon completion of each test the sampling train was removed from the stack. The probe, nozzle, and prefilter glassware were rinsed, brushed and placed into a labeled container. The filter was placed into a separate container. The impingers were weighed for moisture gain. There was no moisture in the dry impinger side, so no purging was needed. The impingers and connecting glassware were rinsed twice with DI and placed into a separate. The impingers and connecting glassware were then rinsed with acetone once and twice with hexane and placed into a separate container. The CPM filter was placed in a separate container.

Upon completion of each test run on, the 201A/202 sampling train was removed from the stack. The probe, nozzle, and prefilter glassware were rinsed and brushed with acetone, and placed into a labeled container. The filter was placed into a separate container. The impingers were weighed for moisture gain. No moisture was measured in the front impingers, so purging with nitrogen was not necessary. The impingers and connecting glassware were then rinsed twice with DI water and placed into a separate container. The impingers and connecting glassware were then rinsed once with acetone and twice with hexane and placed into a separate container. The CPM filter was placed in a separate container.

2.2.4 Analytical Procedures

The total particulate mass was determined by adding the weight of the particulate from the probe and prefilter wash with the particulate on the filter.

2.2.5 Blanks

Blanks for the PM10 sampling train were prepared by recovering an acetone sample in the same manner listed above.

2.2.6 Calibrations

All sampling equipment was calibrated according to the procedures outlined in EPA Reference Methods 1 through 5, 201A and 202.

The acetone wash containing the particulate from the probe wash and prefilter glassware was placed into a tared beaker, evaporated to dryness, desiccated for 24 hours, and then weighed in 6 hour intervals to a constant weight. An acetone blank was also analyzed and subtracted from the particulate weight of the acetone wash.

The tared glass fiber filter was desiccated for 24 hours, and then weighed every six hours to constant weight.

2.3 Method 29 (Cd, Mn, Ni)

2.3.1 Sample Collection

Metals emissions were determined in accordance with USEPA Reference Methods 1,2,3,4 and 29. These Methods are titled:

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	Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight
Method 4	Determination of Moisture Content from Stationary Sources
Method 29	Determination of Metals Emissions from Stationary Sources

These methods appear in detail in Title 40 of the Code of Federal Regulations (CFR), Part 60, Appendix A.

The Method 29 sampling train consisted of the following components.

1. Appropriately sized glass nozzle
2. Sample probe with heated glass liner
3. Heated Quartz filter with Teflon frit
4. Four impingers in an insulated ice water bath in the following sequence:
   - A. Modified Greenburg-Smith design containing 5%HNO_3/ 10%H_2O_2.
   - B. Greenburg-Smith design containing 5%HNO_3/10%H_2O_2.
   - C. Modified Greenburg-Smith design empty
   - D. Known amount of Silica Gel.
5. Sampling gas measuring system.

2.3.2 Sample Duration and Frequency

The Method 29 train samples were collected in triplicate with each test lasting 60 minutes in duration. A minimum sample size of 30 dry standard cubic feet (dscf) was collected for each test.

2.3.3 Sample Recovery

Upon completion of each test the sampling train was removed from the stack. The probe, nozzle, and prefilter glassware were rinsed and brushed with 0.1N nitric acid and placed into a labeled container. The filter was placed into a separate container. The impingers were weighed for moisture gain. The contents of the impingers were then placed into a separate labeled container. The impingers and all connecting glassware were then rinsed three times with 0.1N nitric acid and placed into the same container. All sample containers were pre-cleaned glass amber jars with Teflon lined lids.

2.3.4 Analytical Procedures

The samples were analyzed according to the procedures of U.S. EPA Method 29. The laboratory report is included in Appendix C.

2.3.5 Blanks

Blanks for the Method 29 train were prepared by recovering a blank sample train in the same manner listed above.

2.3.6 Calibrations

All sampling equipment was calibrated according to the procedures outlined in EPA Reference Method 29.

2.4 26A (HCL, HF)

2.4.1 Sample Collection

HCl emissions were determined following the guidelines of USEPA Reference Methods 1,2,3,4, and 26A. These Methods are titled:

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	Gas Analysis for Carbon Dioxide, Oxygen, Excess Air and Dry Molecular Weight
Method 4	Determination of Moisture Content from Stationary Sources
Method 26A	Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources - Isokinetic Method

These methods appear in detail in Title 40 of the Code of Federal Regulations (CFR), Part 60, Appendix A.

The Method 26A sampling train consisted of the following components.

1. Appropriately sized glass nozzle

2. Sample probe with heated glass liner
3. Heated Teflon filter
4. Four impingers in an insulated ice water bath in the following sequence:
   A. Greenburg-Smith design containing 100 ml 0.1N H2SO4.
   B. Greenburg-Smith design containing 100 ml 0.1N H_2SO_4.
   C. Modified Greenburg-Smith design empty
   D. Known amount of silica gel.
5. Sampling gas measuring system.

2.4.2 Sample Duration and Frequency

The Method 26A train samples were collected in triplicate with each test lasting sixty minutes in duration. A minimum sample size of 30 dry standard cubic feet (dscf) was collected for each test.

2.4.3 Sample Recovery

Upon completion of each test the sampling train was removed from the stack. The probe, nozzle, and prefilter glassware were rinsed and brushed with acetone and discarded. The filter was also discarded. The first three impingers were weighed for moisture gain and the contents put into a labeled sample container. The impingers were then rinsed with DI water and placed into the same container. The fourth impinger was weighed for moisture gain.

2.4.4 Analytical Procedures

The samples were analyzed according to the procedures of U.S. EPA Method 29. The laboratory report is included in Appendix C.

2.4.5 Blanks

Blanks for the HCL sampling train were prepared by recovering a sampling train in the same manner listed above.

2.4.6 Calibrations

All sampling equipment was calibrated according to the procedures outlined in EPA Reference Method 5 and 26A.

3.0 TEST RESULTS

Presented in this section are the results of this test series. Test results are reported in Tables 3.1 through 3.13.

Copies of the calculations used to determine these emission rates may be found in Appendix A. Copies of the field data sheets are presented in Appendix B. Copies of the analytical results are presented in Appendix C. Copies of equipment calibrations are presented in Appendix E.

Table 3.1

Particulate/PM-10/PM-2.5 Results
Cosma-CCMI
20-3302
09/28/20
Furnace #4003-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	09:00 AM	10:55 AM	01:15 PM	
Finish Time:	10:06 AM	12:00 PM	02:19 PM	
Stack Gas Temperature, degrees F:	469.46	418.17	646.21	511.28
% Carbon Dioxide:	2.0	2.0	2.0	2.0
% Oxygen:	18.5	18.0	18.0	18.2
% Moisture:	3.52	3.26	4.19	3.66
Molecular Weight dry, lb/lb-Mole:	29.06	29.04	29.04	29.05
Molecular Weight wet, lb/lb-Mole:	28.67	28.68	28.58	28.64
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	26.50	26.77	31.80	28.36
Stack Gas Flow Rate, ACFM:	8,332	8,416	9,998	8,915
Stack Gas Flow Rate, SCFM:	4,551	4,866	4,589	4,669
Stack Gas Flow Rate, DSCF/HR:	263,450	282,437	263,783	269,890
Stack Gas Flow Rate, DSCFM:	4,391	4,707	4,396	4,498
PM Results:				
Grains Per DSCF:	0.0070	0.0038	0.0049	0.0052
LBS/DSCF:	9.994E-07	5.412E-07	7.013E-07	7.473E-07
LBS/HR:	0.263	0.153	0.185	0.200
PM-10 Results:				
Grains Per DSCF:	0.0070	0.0038	0.0049	0.0052
LBS/DSCF:	9.994E-07	5.412E-07	7.013E-07	7.473E-07
LBS/HR:	0.263	0.153	0.185	0.200
PM-2.5 Results:				
Grains Per DSCF:	0.0070	0.0038	0.0049	0.0052
LBS/DSCF:	9.994E-07	5.412E-07	7.013E-07	7.473E-07
LBS/HR:	0.263	0.153	0.185	0.200

Table 3.2

Metals (M29) Results
Cosma-CCMI
20-3302
09/28/20
Furnace #4003-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	09:00 AM	10:55 AM	01:15 PM	
Finish Time:	10:06 AM	12:00 PM	02:19 PM	
Stack Gas Temperature, degrees F:	469.58	418.25	622.67	503.5
% Carbon Dioxide:	2.0	2.0	2.0	2.0
% Oxygen:	18.5	18.0	18.0	18.2
% Moisture:	3.36	3.20	5.19	3.92
Molecular Weight dry, lb/lb-Mole:	29.06	29.04	29.04	29.05
Molecular Weight wet, lb/lb-Mole:	28.69	28.69	28.47	28.61
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	26.79	27.70	30.85	28.45
Stack Gas Flow Rate, ACFM:	8,423	8,709	9,699	8,944
Stack Gas Flow Rate, SCFM:	4,600	5,035	4,548	4,728
Stack Gas Flow Rate, DSCF/HR:	266,740	292,404	258,737	272,627
Stack Gas Flow Rate, DSCFM:	4,446	4,873	4,312	4,544
Nickel Results:				
Nickel (Ni), ug:	6.83	4.15	3.57	4.85
Grains Per DSCF:	1.657E-06	9.457E-07	8.214E-07	1.142E-06
LBS/DSCF:	2.368E-10	1.352E-10	1.174E-10	1.631E-10
LBS/HOUR:	1.053E-06	6.586E-07	5.062E-07	7.393E-07
Cadmium Results:				
Cadmium (Cd), ug:	0.817	0.875	0.739	0.810
Grains Per DSCF:	1.983E-07	1.994E-07	1.700E-07	1.892E-07
LBS/DSCF:	2.833E-11	2.850E-11	2.430E-11	2.704E-11
LBS/HOUR:	7.557E-06	8.332E-06	6.287E-06	7.392E-06
Manganese Results:				
Manganese (Mn), ug:	30.1	5.49	6.81	14.13
Grains Per DSCF:	7.304E-06	1.251E-06	1.567E-06	3.374E-06
LBS/DSCF:	1.044E-09	1.788E-10	2.239E-10	4.822E-10
LBS/HOUR:	2.784E-04	5.228E-05	5.794E-05	1.295E-04

Table 3.3

PM/PM-10/PM-2.5Results
Cosma-CCMI
20-3302
9/28&29/2020
Furnace #4004-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	09:00 AM	11:07 AM	01:15 PM	
Finish Time:	10:07 AM	12:11 PM	02:19 PM	
Stack Gas Temperature, degrees F:	373.58	438.38	569.33	460.43
% Carbon Dioxide:	2.5	2.0	1.5	2.0
% Oxygen:	18.5	18.5	19.0	18.67
% Moisture:	4.29	4.25	3.98	4.18
Molecular Weight dry, lb/lb-Mole:	29.14	29.06	29.00	29.07
Molecular Weight wet, lb/lb-Mole:	28.66	28.59	28.56	28.60
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	24.53	24.70	28.91	26.05
Stack Gas Flow Rate, ACFM:	7,712	7,766	9,089	8,189
Stack Gas Flow Rate, SCFM:	4,697	4,389	4,483	4,523
Stack Gas Flow Rate, DSCF/HR:	269,745	252,128	258,286	260,053
Stack Gas Flow Rate, DSCFM:	4,496	4,202	4,305	4,334
PM Results:				
Grains Per DSCF:	0.0028	0.0034	0.0030	0.0031
LBS/DSCF:	3.982E-07	4.879E-07	4.254E-07	4.372E-07
LBS/HR:	0.107	0.123	0.110	0.113
PM-10 Results:				
Grains Per DSCF:	0.00015	0.00018	0.00016	0.00016
LBS/DSCF:	2.082E-08	2.552E-08	2.225E-08	2.286E-08
LBS/HR:	0.0056	0.0064	0.0057	0.0059
PM-2.5 Results:				
Grains Per DSCF:	0.00000	0.00000	0.00000	0.00000
LBS/DSCF:	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LBS/HR:	0.0000	0.0000	0.0000	0.0000

Table 3.4

Metals (M29) Results
Cosma-CCMI
20-3302
09/28/20
Furnace #4004-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	09:01 AM	11:08 AM	01:16 PM	
Finish Time:	10:08 AM	12:12 PM	02:20 PM	
Stack Gas Temperature, degrees F:	475.79	454.21	579.67	503.2
% Carbon Dioxide:	2.5	2.0	1.5	2.0
% Oxygen:	18.5	18.5	19.0	18.7
% Moisture:	4.71	4.43	5.40	4.85
Molecular Weight dry, lb/lb-Mole:	29.14	29.06	29.00	29.07
Molecular Weight wet, lb/lb-Mole:	28.62	28.57	28.41	28.53
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	25.73	24.20	29.78	26.57
Stack Gas Flow Rate, ACFM:	8,090	7,608	9,363	8,354
Stack Gas Flow Rate, SCFM:	4,383	4,219	4,566	4,389
Stack Gas Flow Rate, DSCF/HR:	250,582	241,954	259,156	250,564
Stack Gas Flow Rate, DSCFM:	4,176	4,033	4,319	4,176
Nickel Results:				
Nickel (Ni), ug:	4.95	4.57	3.08	4.20
Grains Per DSCF:	1.542E-06	1.511E-06	8.797E-07	1.311E-06
LBS/DSCF:	2.204E-10	2.160E-10	1.257E-10	1.874E-10
LBS/HOUR:	5.522E-05	5.226E-05	3.258E-05	4.669E-05
Cadmium Results:				
Cadmium (Cd), ug:	0.421	0.446	0.403	0.423
Grains Per DSCF:	1.312E-07	1.475E-07	1.151E-07	1.313E-07
LBS/DSCF:	1.874E-11	2.108E-11	1.645E-11	1.876E-11
LBS/HOUR:	4.697E-06	5.100E-06	4.263E-06	4.687E-06
Manganese Results:				
Manganese (Mn), ug:	7.49	8.30	3.78	6.52
Grains Per DSCF:	2.333E-06	2.745E-06	1.080E-06	2.053E-06
LBS/DSCF:	3.335E-10	3.923E-10	1.543E-10	2.933E-10
LBS/HOUR:	8.356E-05	9.492E-05	3.999E-05	7.282E-05

Table 3.5

PM/PM-10/PM2.5
Cosma-CCMI
20-3302
9/28&29/2020
General Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	03:35 PM	09:24 AM	10:59 AM	
Finish Time:	04:39 PM	10:29 AM	12:03 PM	
Stack Gas Temperature, degrees F:	103	111	92	102.0
% Carbon Dioxide:	0.0	0.0	0.0	0.0
% Oxygen:	21.0	21.0	21.0	21.0
% Moisture:	2.11	2.33	2.46	2.30
Molecular Weight dry, lb/lb-Mole:	28.84	28.84	28.84	28.84
Molecular Weight wet, lb/lb-Mole:	28.61	28.59	28.57	28.59
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	14.63	14.85	14.54	14.67
Stack Gas Flow Rate, ACFM:	8,444	8,571	8,392	8,469
Stack Gas Flow Rate, SCFM:	7,655	7,613	7,711	7,660
Stack Gas Flow Rate, DSCF/HR:	449,596	446,158	451,279	449,011
Stack Gas Flow Rate, DSCFM:	7,493	7,436	7,521	7,484
PM Results:				
Grains Per DSCF:	0.0011	0.0008	0.0003	0.0007
LBS/DSCF:	1.632E-07	1.168E-07	3.940E-08	1.065E-07
LBS/HR:	0.073	0.052	0.018	0.048
PM-10 Results:				
Grains Per DSCF:	0.0009	0.0010	0.0008	0.0009
LBS/DSCF:	1.248E-07	1.363E-07	1.182E-07	1.265E-07
LBS/HR:	0.056	0.061	0.053	0.057
PM-2.5 Results:				
Grains Per DSCF:	0.0015	0.0022	0.0013	0.0017
LBS/DSCF:	2.209E-07	3.213E-07	1.872E-07	2.431E-07
LBS/HR:	0.099	0.143	0.084	0.109
PM/PM-10 (Including PM-2.5) Results:				
Grains Per DSCF:	0.0036	0.0040	0.0024	0.0033
LBS/DSCF:	5.089E-07	5.744E-07	3.448E-07	4.761E-07
LBS/HR:	0.229	0.256	0.156	0.214

Table 3.6

HCl/HF (M26A) Results
Cosma-CCMI
20-3302
9/28&29/2020
General-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	03:35 PM	09:24 AM	10:59 AM	
Finish Time:	04:39 PM	10:29 AM	12:03 PM	
Stack Gas Temperature, degrees F:	102.63	110.54	93.08	102.1
% Carbon Dioxide:	0.0	0.0	0.0	0.0
% Oxygen:	21.0	21.0	21.0	21.0
% Moisture:	2.59	2.43	1.63	2.22
Molecular Weight dry, lb/lb-Mole:	28.84	28.84	28.84	28.84
Molecular Weight wet, lb/lb-Mole:	28.56	28.58	28.66	28.60
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	15.05	14.70	14.50	14.75
Stack Gas Flow Rate, ACFM:	8,687	8,485	8,369	8,514
Stack Gas Flow Rate, SCFM:	7,831	7,543	7,675	7,683
Stack Gas Flow Rate, DSCF/HR:	457,671	441,554	452,980	450,735
Stack Gas Flow Rate, DSCFM:	7,628	7,359	7,550	7,512
HCl Results:				
HCl Concentration, mg:	<0.064	<0.072	<0.063	<0.066
Grains Per DSCF:	<2.423E-05	<2.803E-05	<2.448E-05	<2.558E-05
LBS/DSCF:	<3.462E-09	<4.005E-09	<3.499E-09	<3.656E-09
LBS/HR:	1.585E-03	1.768E-03	1.585E-03	1.646E-03
HF Results:				
HF Concentration, mg:	<0.065	<0.074	<0.064	<0.068
Grains Per DSCF:	<3.490E-05	<3.973E-05	<3.436E-05	<3.633E-05
LBS/DSCF:	<4.987E-09	<5.678E-09	<4.910E-09	<5.192E-09
LBS/HR:	<7.904E-12	<1.004E-11	<7.783E-12	<8.576E-12

Table 3.7

PM/PM-10/PM-2.5 Results
Cosma-CCMI
20-3302
09/29/20
Furnace #3002-Exhaust

Test No:	T2	T3	T4	Avg.
Start Time:	12:55 PM	02:39 PM	04:28 PM	
Finish Time:	01:58 PM	03:44 PM	05:34 PM	
Stack Gas Temperature, degrees F.	452.04	397.63	632.0	493.89
% Carbon Dioxide:	2.0	2.0	2.5	2.2
% Oxygen:	18.5	18.0	18.5	18.33
% Moisture:	3.56	3.65	3.63	3.61
Molecular Weight dry, lb/lb-Mole:	29.06	29.04	29.14	29.08
Molecular Weight wet, lb/lb-Mole:	28.67	28.64	28.74	28.68
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	26.69	24.33	27.13	26.05
Stack Gas Flow Rate, ACFM:	8,391	7,649	8,530	8,190
Stack Gas Flow Rate, SCFM:	4,665	4,522	3,960	4,382
Stack Gas Flow Rate, DSCF/HR:	269,919	261,418	228,987	253,441
Stack Gas Flow Rate, DSCFM:	4,499	4,357	3,816	4,224
PM Results:				
Grains Per DSCF:	0.0028	0.0064	0.0024	0.0039
LBS/DSCF:	4.007E-07	9.166E-07	3.394E-07	5.522E-07
LBS/HR:	0.108	0.240	0.078	0.142
PM-10 Results:				
Grains Per DSCF:	0.0028	0.0064	0.0024	0.0039
LBS/DSCF:	4.007E-07	9.166E-07	3.394E-07	5.522E-07
LBS/HR:	0.108	0.240	0.078	0.142
PM-2.5 Results:				
Grains Per DSCF:	0.0028	0.0064	0.0024	0.0039
LBS/DSCF:	4.007E-07	9.166E-07	3.394E-07	5.522E-07
LBS/HR:	0.108	0.240	0.078	0.142

Table 3.8

Metals (M29) Results
Cosma-CCMI
20-3302
09/29/20
Furnace #3002-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	12:55 PM	02:39 PM	04:25 PM	
Finish Time:	01:58 PM	03:43 PM	05:34 PM	
Stack Gas Temperature, degrees F:	400.42	393.83	625.46	473.2
% Carbon Dioxide:	2.0	2.0	2.5	2.2
% Oxygen:	18.5	18.0	18.5	18.3
% Moisture:	3.09	2.81	4.15	3.35
Molecular Weight dry, lb/lb-Mole:	29.06	29.04	29.14	29.08
Molecular Weight wet, lb/lb-Mole:	28.72	28.73	28.68	28.71
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	25.19	25.38	28.15	26.24
Stack Gas Flow Rate, ACFM:	7,920	7,979	8,850	8,250
Stack Gas Flow Rate, SCFM:	4,667	4,740	4,134	4,513
Stack Gas Flow Rate, DSCF/HR:	271,349	276,398	237,738	261,828
Stack Gas Flow Rate, DSCFM:	4,522	4,607	3,962	4,364
Nickel Results:				
Nickel (Ni), ug:	5.59	4.16	1.66	3.80
Grains Per DSCF:	1.424E-06	1.051E-06	4.282E-07	9.678E-07
LBS/DSCF:	2.035E-10	1.502E-10	6.119E-11	1.383E-10
LBS/HOUR:	5.523E-05	4.150E-05	1.455E-05	3.709E-05
Cadmium Results:				
Cadmium (Cd), ug:	12.5	16.7	11.0	13.4
Grains Per DSCF:	3.185E-06	4.218E-06	2.837E-06	3.414E-06
LBS/DSCF:	4.551E-10	6.028E-10	4.055E-10	4.878E-10
LBS/HOUR:	1.235E-04	1.666E-04	9.639E-05	1.288E-04
Manganese Results:				
Manganese (Mn), ug:	10.8	31.1	4.48	15.46
Grains Per DSCF:	2.752E-06	7.856E-06	1.156E-06	3.921E-06
LBS/DSCF:	3.932E-10	1.123E-09	1.651E-10	5.603E-10
LBS/HOUR:	1.067E-04	3.103E-04	3.926E-05	1.521E-04

Table 3.9

PM/PM-10/PM-2.5 Results
Cosma-CCMI
20-3302
09/29/20
Degas-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	12:41 PM	02:27 PM	04:09 PM	
Finish Time:	01:45 PM	03:30 PM	05:13 PM	
Stack Gas Temperature, degrees F:	95.5	96.83	100.42	97.58
% Carbon Dioxide:	0.0	0.0	0.0	0.0
% Oxygen:	21.0	21.0	21.0	21.0
% Moisture:	1.64	1.76	1.94	1.78
Molecular Weight dry, lb/lb-Mole:	28.84	28.84	28.84	28.84
Molecular Weight wet, lb/lb-Mole:	28.66	28.65	28.63	28.65
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	24.07	24.26	24.34	24.22
Stack Gas Flow Rate, ACFM:	505	509	511	509
Stack Gas Flow Rate, SCFM:	461	464	463	463
Stack Gas Flow Rate, DSCF/HR:	27,226	27,352	27,216	27,265
Stack Gas Flow Rate, DSCFM:	454	456	454	454
PM Results:				
Grains Per DSCF:	0.0354	0.0466	0.0982	0.0601
LBS/DSCF:	5.059E-06	6.665E-06	1.403E-05	8.586E-06
LBS/HR:	0.138	0.182	0.382	0.234
PM-10 Results:				
Grains Per DSCF:	0.0017	0.0023	0.0048	0.0030
LBS/DSCF:	2.49E-07	3.28E-07	6.90E-07	4.22E-07
LBS/HR:	0.0068	0.0090	0.0188	0.0115
PM-2.5 Results:				
Grains Per DSCF:	0.0000	0.0000	0.0000	0.0000
LBS/DSCF:	0.000E+00	0.000E+00	0.000E+00	0.000E+00
LBS/HR:	0.000	0.000	0.000	0.000

Table 3.10

Metals (M29) Results
Cosma-CCMI
20-3302
09/29/20
Degas-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	12:41 PM	02:27 PM	04:10 PM	
Finish Time:	01:45 PM	03:38 PM	05:14 PM	
Stack Gas Temperature, degrees F:	95.5	96.83	100.42	97.6
% Carbon Dioxide:	0.0	0.0	0.0	0.0
% Oxygen:	21.0	21.0	21.0	21.0
% Moisture:	1.45	1.62	1.85	1.64
Molecular Weight dry, lb/lb-Mole:	28.84	28.84	28.84	28.84
Molecular Weight wet, lb/lb-Mole:	28.68	28.66	28.64	28.66
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	24.06	24.26	24.47	24.26
Stack Gas Flow Rate, ACFM:	505	509	514	510
Stack Gas Flow Rate, SCFM:	461	464	465	463
Stack Gas Flow Rate, DSCF/HR:	27,277	27,391	27,377	27,348
Stack Gas Flow Rate, DSCFM:	455	457	456	456
Nickel Results:				
Nickel (Ni), ug:	5.45	14.80	22.60	14.28
Grains Per DSCF:	1.639E-06	4.438E-06	6.644E-06	4.240E-06
LBS/DSCF:	2.342E-10	6.343E-10	9.494E-10	6.060E-10
LBS/HOUR:	6.388E-06	1.737E-05	2.599E-05	1.658E-05
Cadmium Results:				
Cadmium (Cd), ug:	2.43	9.52	10.10	7.35
Grains Per DSCF:	7.307E-07	2.855E-06	2.969E-06	2.185E-06
LBS/DSCF:	1.044E-10	4.080E-10	4.243E-10	3.122E-10
LBS/HOUR:	2.848E-06	1.118E-05	1.162E-05	8.546E-06
Manganese Results:				
Manganese (Mn), ug:	203.0	284.0	304.0	263.7
Grains Per DSCF:	6.104E-05	8.517E-05	8.937E-05	7.853E-05
LBS/DSCF:	8.723E-09	1.217E-08	1.277E-08	1.122E-08
LBS/HOUR:	2.379E-04	3.334E-04	3.496E-04	3.070E-04

Table 3.11

HCl/HF (M26A) Results
Cosma-CCMI
20-3302
09/30/20
Degas-Exhaust

Test No:	T1	T2	T3	Avg.
Start Time:	08:14 AM	09:35 AM	10:53 AM	
Finish Time:	09:16 AM	10:37 AM	11:54 AM	
Stack Gas Temperature, degrees F:	95.33	95.83	95.17	95.4
% Carbon Dioxide:	0.0	0.0	0.0	0.0
% Oxygen:	21.0	21.0	21.0	21.0
% Moisture:	1.49	1.57	1.53	1.53
Molecular Weight dry, lb/lb-Mole:	28.84	28.84	28.84	28.84
Molecular Weight wet, lb/lb-Mole:	28.68	28.67	28.67	28.67
Velocity and Flow Results:				
Average Stack Gas Velocity FPS:	24.01	24.08	24.06	24.05
Stack Gas Flow Rate, ACFM:	504	506	505	505
Stack Gas Flow Rate, SCFM:	458	459	459	459
Stack Gas Flow Rate, DSCF/HR:	27,095	27,127	27,148	27,123
Stack Gas Flow Rate, DSCFM:	452	452	452	452
HCl Results:				
HCl Concentration, mg:	<0.067	<0.078	<0.083	<0.076
Grains Per DSCF:	<1.792E-05	<2.094E-05	<2.219E-05	<2.035E-05
LBS/DSCF:	<2.561E-09	<2.993E-09	<3.170E-09	<2.908E-09
LBS/HR:	<6.938E-05	<8.118E-05	<8.607E-05	<7.888E-05
HF Results:				
HF Concentration, mg:	<0.068	<0.080	<0.085	<0.078
Grains Per DSCF:	<3.668E-05	<4.315E-05	<4.585E-05	<4.189E-05
LBS/DSCF:	<5.242E-09	<6.167E-09	<6.552E-09	<5.987E-09
LBS/HR:	<3.637E-13	<5.006E-13	<5.639E-13	<4.761E-13

Table 3.12

HCl/HF (M26A) Results
Cosma-CCMI
20-3302
9/28&29/2020

	T1-Cleaning	T1-Cleaning	T4-Cleaning
Test No:	4003	3002	4004
Start Time:	03:35 PM	10:59 AM	09:24 AM
Finish Time:	04:39 PM	12:03 PM	10:27 AM
Stack Gas Temperature, degrees F:	657.46	627.33	599.83
% Carbon Dioxide:	2.0	2.0	2.0
% Oxygen:	18.5	18.5	18.5
% Moisture:	3.65	3.70	4.63
Molecular Weight dry, lb/lb-Mole:	29.06	29.06	29.06
Molecular Weight wet, lb/lb-Mole:	28.66	28.65	28.55
Velocity and Flow Results:			
Average Stack Gas Velocity FPS:	30.33	29.33	28.01
Stack Gas Flow Rate, ACFM:	9,536	9,221	8,806
Stack Gas Flow Rate, SCFM:	4,326	4,300	4,239
Stack Gas Flow Rate, DSCF/HR:	250,112	248,438	242,573
Stack Gas Flow Rate, DSCFM:	4,169	4,141	4,043
HCl Results:			
HCl Concentration, mg:	1.32	4.70	1.69
Grains Per DSCF:	3.123E-04	1.172E-03	4.136E-04
LBS/DSCF:	4.463E-08	1.675E-07	5.910E-08
LBS/HR:	1.116E-02	4.162E-02	1.434E-02
HF Results:			
HF Concentration, mg:	0.104	2.290	0.979
Grains Per DSCF:	5.585E-05	1.230E-03	5.225E-04
LBS/DSCF:	7.981E-09	1.757E-07	7.466E-08
LBS/HR:	8.908E-11	7.313E-09	1.070E-09

Table 3.13

Cleaning (PM/PM-10) Results
Cosma-CCMI
20-3302

Test No:	Furnace #4003 T4-Cleaning	Furnace #4004 T4-Cleaning	Furnace #3002 T1-Cleaning
Start Time:	03:35 PM	09:24 AM	10:59 AM
Finish Time:	04:39 PM	10:27 AM	12:02 PM
Stack Gas Temperature, degrees F:	752.6	628.0	632.13
% Carbon Dioxide:	1.5	2.5	1.5
% Oxygen:	18.5	18.0	19.0
% Moisture:	4.32	3.95	3.60
Molecular Weight dry, lb/lb-Mole:	28.98	29.12	29.00
Molecular Weight wet, lb/lb-Mole:	28.51	28.68	28.60
Velocity and Flow Results:			
Average Stack Gas Velocity FPS:	32.67	30.38	29.12
Stack Gas Flow Rate, ACFM:	10,271	9,551	9,155
Stack Gas Flow Rate, SCFM:	4,300	4,451	4,250
Stack Gas Flow Rate, DSCF/HR:	246,881	256,506	245,831
Stack Gas Flow Rate, DSCFM:	4,115	4,275	4,097
Particulate Results (Including PM-10 & PM-2.5):			
Grains Per DSCF:	0.0036	0.0040	0.0024
LBS/DSCF:	5.089E-07	5.744E-07	3.448E-07
LBS/HR:	0.229	0.256	0.156
PM-10 Results (Including PM-2.5):			
Grains Per DSCF:	0.0024	0.0032	0.0021
LBS/DSCF:	3.457E-07	4.576E-07	3.054E-07
LBS/HR:	0.155	0.204	0.138
PM-2.5 Results:			
Grains Per DSCF:	0.0015	0.0022	0.0013
LBS/DSCF:	2.209E-07	3.213E-07	1.872E-07
LBS/HR:	0.099	0.143	0.084

APPENDIX A

SAMPLE CALCULATIONS

COSMA CASTINGS (CCMI)
BATTLE CREEK, MI

STG Project No: 20-3302

SAMPLE CALCULATIONS

The tables presenting the results are generated electronically from raw data. It may not be possible to exactly duplicate these results using a calculator. The reference method data, results and all calculations are carried to sixteen decimal places throughout. The final table is formatted to an appropriate number of significant figures.

1. Volume of water collected (wscf)

$$V_{wstd} = (0.04707)(V_{lc})$$

Where:

V_{lc}	total volume of liquid collected in impingers and silica gel (ml)
V_{wstd}	volume of water collected at standard conditions (ft^3)
0.04707	conversion factor (ft^3/ml)

2. Volume of gas metered, standard conditions (dscf)

$$V_{mstd} = \frac{(17.64)(V_m)\left(P_{bar} + \frac{\Delta H}{13.6}\right)(Y_d)}{(460 + T_m)}$$

Where:

P_{bar}	barometric pressure (in. Hg)
T_m	average dry gas meter temperature (°F)
V_m	volume of gas sample through the dry gas meter at meter conditions (ft^3)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
Y_d	gas meter correction factor (dimensionless)
ΔH	average pressure drop across meter box orifice (in. H_2O)
17.64	conversion factor (°R/in. Hg)
13.6	conversion factor (in. H_2O/in. Hg)
460	°F to °R conversion constant

3. Sample gas pressure (in. Hg)

$$P_s = P_{bar} + \left(\frac{P_g}{13.6}\right)$$

Where:

P_{bar}	barometric pressure (in. Hg)
P_g	sample gas static pressure (in. H_2O)
P_s	absolute sample gas pressure (in. Hg)
13.6	conversion factor (in. H_2O/in. Hg)

4. Actual vapor pressure (in. Hg)[1]

$$P_v = P_s$$

Where:

P_v	vapor pressure, actual (in. Hg)
P_s	absolute sample gas pressure (in. Hg)

[1] For effluent gas temperatures over 212°F, P_v is assumed to be equal to P_s.

SAMPLE CALCULATIONS (CONTINUED)

5. Moisture content (%)

$$B_{wo} = \frac{V_{wstd}}{V_{mstd} + V_{wstd}}$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume (%)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
V_{wstd}	volume of water collected at standard conditions (ft^3)

6. Saturated moisture content (%)

$$B_{ws} = \frac{(P_v)}{(P_s)}$$

Where:

B_{ws}	proportion of water vapor in the gas stream by volume at saturated conditions (%)
P_s	absolute sample gas pressure (in. Hg)
P_v	vapor pressure, actual (in. Hg)

Whichever moisture value is smaller is used for B_{wo} in the following calculations.

7. Molecular weight of dry gas stream (lb/lb·mole)

$$M_d = M_{CO_2}\frac{(CO_2)}{(100)} + M_{O_2}\frac{(O_2)}{(100)} + M_{CO+N_2}\frac{(CO+N_2)}{(100)}$$

Where:

Md	dry molecular weight of sample gas (lb/lb·mole)
M_{CO_2}	molecular weight of carbon dioxide (lb/lb·mole)
M_{O_2}	molecular weight of oxygen (lb/lb·mole)
M_{CO+N_2}	molecular weight of carbon monoxide and nitrogen (lb/lb·mole)
CO_2	proportion of carbon dioxide in the gas stream by volume (%)
O_2	proportion of oxygen in the gas stream by volume (%)
$CO+N_2$	proportion of carbon monoxide and nitrogen in the gas stream by volume (%)
100	conversion factor (%)

8. Molecular weight of sample gas (lb/lb·mole)

$$M_s = (M_d)(1 - B_{wo}) + (M_{H_2O})(B_{wo})$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume
M_d	dry molecular weight of sample gas (lb/lb·mole)
M_{H_2O}	molecular weight of water (lb/lb·mole)
M_s	molecular weight of sample gas, wet basis (lb/lb·mole)

SAMPLE CALCULATIONS (CONTINUED)

9. Velocity of sample gas (ft/sec)

$$V_s = (K_p)(C_p)\left(\overline{\sqrt{\Delta P}}\right)\left(\sqrt{\frac{(\overline{T_s} + 460)}{(M_s)(P_s)}}\right)$$

Where:

K_p	velocity pressure coefficient (dimensionless)
C_p	pitot tube constant
M_s	molecular weight of sample gas, wet basis (lb/lb·mole)
P_s	absolute sample gas pressure (in. Hg)
T_s	average sample gas temperature (°F)
V_s	sample gas velocity (ft/sec)
$\sqrt{\Delta P}$	average square roots of velocity heads of sample gas (in. H_2O)
460	°F to °R conversion constant

10. Total flow of sample gas (acfm)

$$Q_a = (60)(A_s)(V_s)$$

Where:

A_s	cross sectional area of sampling location (ft^2)
Q_a	volumetric flow rate at actual conditions (acfm)
V_s	sample gas velocity (ft/sec)
60	conversion factor (sec/min)

11. Total flow of sample gas (dscfm)

$$Q_{std} = \frac{(Q_a)(P_s)(17.64)(1 - B_{wo})}{(\overline{T_s} + 460)}$$

Where:

B_{wo}	proportion of water vapor in the gas stream by volume
P_s	absolute sample gas pressure (in. Hg)
Q_a	volumetric flow rate at actual conditions (acfm)
Q_{std}	volumetric flow rate at standard conditions, dry basis (dscfm)
T_s	average sample gas temperature (°F)
17.64	conversion factor (°R/in. Hg)
460	°F to °R conversion constant

SAMPLE CALCULATIONS (CONTINUED)

12. Percent isokinetic (%)

$$I = \frac{(0.09450)(\overline{T_s} + 460)(V_{mstd})}{(P_s)(V_s)\left(\frac{(D_n)^2(\pi)}{(144)(4)}\right)(\Theta)(1 - B_{wo})}$$

Where:

D_n	diameter of nozzle (in)
B_{wo}	proportion of water vapor in the gas stream by volume
I	percent of isokinetic sampling (%)
P_s	absolute sample gas pressure (in. Hg)
T_s	average sample gas temperature (°F)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
V_s	sample gas velocity (ft/sec)
Θ	total sampling time (min)
0.09450	constant
460	°F to °R conversion constant

13. Particulate/Metals/HCl concentration (gr/dscf)

$$C_{gr/dscf} = \frac{(15.43)(m_n)}{V_{mstd}}$$

Where:

$C_{gr/dscf}$	measured concentration in the gas stream (gr/dscf)
m_n	total amount of particulate matter collected, corrected for applicable reagent blank (g)
V_{mstd}	volume of gas sample through the dry gas meter at standard conditions (ft^3)
15.43	conversion factor (gr/g)

14. Particulate/Metals/HCl emission (lb/hr)

$$E_{lb/hr} = \frac{(C_{gr/dscf})(Q_{std})(60)}{7{,}000}$$

Where:

$C_{gr/dscf}$	measured concentration in the gas stream (gr/dscf)
$E_{lb/hr}$	emission rate (lb/hr)
Q_{std}	volumetric flow rate at standard conditions, dry basis (dscfm)
60	conversion factor (min/hr)
7,000	conversion factor (gr/lb)

APPENDIX B

FIELD DATA SHEETS