ACCUAIR ANALYSIS

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Air Quality Test Report

SMC-17-100

Particulate Testing Services for:

St Marys Cement

Charlevoix, MI

Main and Bypass Stacks

Tested June 29th, 2017

PREPARED FOR
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INTRODUCTION

On June 29th, 2017 AccuAir, LLC (ACCUAIR) was onsite at St. Marys Cement, Inc. to perform air testing at their facility in Charlevoix, Michigan. ACCUAIR was contracted to perform compliance emission testing on the SVMAIN (Main) and SVBYPASS (Bypass) Baghouse Stacks. The test was conducted in accordance with all appropriate United States Environmental Protection Agency (USEPA) methodologies, and the requirements outlined in the facility's Renewable Operating Permit (ROP) MI-ROP-B1559-2014.

The objective of the program was to demonstrate the compliance status of the site according to the requirements of the facility's Federally Enforceable State Operating Permit. Testing on both stacks was performed for the determination of concentrations and mass emission rates for Particulate Matter (PM). Mr. Geoff Resney was the onsite project manager, and was assisted by Mr. Mark Carlson and Mr. Bill Scrimgeour. Mr. Robert Dickman of the Michigan Department of Environmental Quality was onsite to observe during testing.

Testing and analysis procedures used for this project are presented in the United States Environmental Protection Agency (USEPA) document Title 40, Code of Federal Regulations, Part 60 (40 CFR 60), Appendix A; the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, Stationary Source Specific Methods, and on the USEPA Technology Transfer Network Emission Measurement Center (EPA-TTN-EMC) website, Test Methods Section (http://www.epa.gov/ttn/emc/). The methods are discussed in the Performance Test Procedures section of this report. Included in this test report are sections detailing the Test Program, including Executive Summary, Introduction, Sampling Procedures, Source Information, Sample Calculation and Test Results Sections; with Appendices which include calibrations, field data, calculated data, and laboratory data.

The test procedures referenced in this report are in accordance with the Approved Test Plan for this project. Deviations from the Test Plan or published Reference Methods are documented in the Problems, Deviations and/or Exceptions section of this report. A copy of the Test Plan is provided in Appendix H of this report.

Provided in Table 1-1 are the results of the test program.

Source Unit	Analytes, Units	Three Run Average	Combined Total PM lbs/1000 lbs Exhaust Gas	Emissions Limit	PASS?
SVMAIN Stack	PM lbs/hr, lbs/1000 lbs exhaust gas	0.01527	0.0162404	PM 0.25 lbs/1000 lbs exhaust gas	YES
SVBYPASS Stack		0.00097			

Table 1-1. Summary of Performance Test Results

SUMMARY OF RESULTS

Testing was performed using a heated Method 5 train for the determination of PM emitted from the Main and Bypass Stacks. Particulate testing consisted of three (3) 60-min runs in accordance with USEPA Methods 1, 2, 3, 4, and 5 and the approved test protocol. Both Main and Bypass Stacks testing runs were performed simultaneously. Provided in Tables 1-2 are the results of the sampling and operating parameters monitored during testing.

During testing the processes were operated at maximum normal rates with the Roller Mill on. Opacity monitor data, Main Stack Baghouse pressure differential, Bypass Stack Baghouse leak detection data, the raw material feed rates to the kiln and raw mill, as well as the fuel feed rate to the flash furnace and kiln were monitored and recorded during the testing. The recorded data is included in the appendices of this report.

Airflow was determined using USEPA Methods 1 and 2. Molecular weight was determined in ambient air and in accordance with Method 3 The moisture content of the stack gas was measured using Method 4, which was performed inclusively with Method 5. Testing procedures are discussed in more detail in the test methods section. All calculated reference method data is provided in Appendix E, and examples of all calculations are presented in the Sample Calculation section of this report.

Problems, Deviations and/or Exceptions

No problems or deviations were encountered during the testing program that are outside of what is described herein. Note that some nominal issues, mainly during the third test run, with the plant process' raw mill feed and roller mill were encountered during testing. Testing was paused during these issues and resumed after their resolution.

Run No.	1	2	3	
Date	6/29/17	6/29/17	6/29/17	
Start Time	11:47	13:43	15:37	
Stop Time	12:54	14:52	18:11	AVG
Nozzle Diameter, in.	0.207	0.207	0.207	0.207
Barometric Pressure, in. Hg	28.96	28.96	28.96	28.96
Net Sampling Time, minutes	60.0	60.0	60.0	60.0
Leak Check Volume (ft^3)	0.0	0.0	0.0	--
Volume Metered, ft^3	42.597	41.260	43.639	42.499
Avg. DGM Temp, °F	92.50	93.50	93.00	93.00
AVG Δ H, in of H_2O	1.61	1.48	1.67	1.59
AVG ΔH, in Hg	0.1184	0.1088	0.1228	0.1167
DGM Calibration Factor	0.9870	0.9870	0.9870	0.9870
Volume of Gas Collected, dscf	42.597	41.260	40.029	41.295
Total Water Collected, mL	164.0	162.4	133.2	153.2
Volume of Water Vapor, scf	7.733	7.657	6.280	7.223
Moisture, %	16.53	16.84	13.56	15.6
Dry Mole Fraction, 100-%M	0.8347	0.8316	0.8644	0.8436
CO_2 at Stack, % dry	19.99	18.84	20.50	19.78
O_2 at Stack, % dry	8.61	9.70	8.63	8.98
$CO + N_2$, % dry	71.40	71.46	70.87	71.24
Dry Molecular Weight, lb/lb mole	31.54	31.40	31.63	31.52
Excess Air at Stack, %	84.1	105.8	85.6	91.8
Stack Diameter, in.	130.0	130.0	130.0	
Stack Area, sq. in.	13273.2	13273.2	13273.2	13273.2
Static Pressure, in. of H_2O	-0.72	-0.71	-0.72	-0.72
Stack Pressure, in. Hg	28.91	28.91	28.91	28.91
Avg. Stack Temp., °F	246.0	251.0	270.0	255.7
Avg. Sq root of Δ P	1.1180	1.1136	1.2000	1.1439
SDE Average	29.707	29.692	32.422	30.607
Pitot Coefficient	0.84	0.84	0.84	0.84
Stack Gas Velocity, fpm	4398.3	4413.5	4761.5	4524.5
Stack Flowrate, wet acfm	405,416	406,818	438,896	417,043
Stack Flowrate, dry scfm	244,514	242,735	265,112	250,787
Isokinetics, %	114.5	111.7	99.4	108.5

PARTICULATE DATA -- FRONT HALF ONLY				
Front Half Rinse (FHACE), g	0.0028	0.0003	0.0146	0.0059
Particulate Filter (PF), g	0.0105	0.0030	0.0186	0.0107
Total Disolved Solids, g				
Organics, g				
Total Particulate Collected, g	0.0133	0.0033	0.0332	0.0166
Grain Loading, gr/dscf	0.0048	0.0012	0.0128	0.0063
Grain Loading, gr/acf	0.0029	0.0007	0.0077	0.0038
Grain Loading, gr/dscf @ 7% O2	0.0054	0.0015	0.0145	0.0072
PM Emission Rate, lb/Hr	10.10	2.57	29.09	13.92
Total Exhaust Gas Rate, lb/hr	936662.19	936662.19	936662.1875	936662.2
PM lbs/1000lbs Exhaust Gas	**0.0107833**	**0.0027422**	**0.0310577**	**0.0148611**

Table 1-2. SVMAIN Summary of Test Results

Run No.	1	2	3	
Date	6/29/17	6/29/17	6/29/17	
Start Time	11:47	13:43	15:37	
Stop Time	12:54	14:52	18:11	AVG
Nozzle Diameter, in.	0.506	0.506	0.444	0.485
Barometric Pressure, in. Hg	28.96	28.96	28.96	28.96
Net Sampling Time, minutes	60.0	60.0	60.0	60.0
Leak Check Volume (ft^3)	0.0	0.0	0.0	—
Volume Metered, ft^3	54.111	64.910	53.312	57.444
Avg. DGM Temp, °F	92.50	87.50	90.00	90.00
AVG Δ H, in of H$_2$O	2.52	3.57	2.45	2.85
AVG ΔH, in Hg	0.1853	0.2625	0.1801	0.2093
DGM Calibration Factor	0.9870	0.9870	0.9870	0.9870
Volume of Gas Collected, dscf	49.718	60.344	49.198	53.086
Total Water Collected, mL	32.0	36.3	21.5	29.9
Volume of Water Vapor, scf	1.509	1.712	1.014	1.411
Moisture, %	2.95	2.76	2.02	2.6
Dry Mole Fraction, 100-%M	0.9705	0.9724	0.9798	0.9743
CO$_2$ at Stack, % dry	1.38	1.24	1.21	1.28
O$_2$ at Stack, % dry	19.51	19.36	19.35	19.41
CO + N$_2$, % dry	79.11	79.40	79.44	79.32
Dry Molecular Weight, lb/lb mole	29.00	28.97	28.97	28.98
Excess Air at Stack, %	1418.9	1208.8	1192.9	1273.5
Stack Diameter, in.	156.0	156.0	156.0	
Stack Area, sq. in.	19113.4	19113.4	19113.4	19113.4
Static Pressure, in. of H$_2$O	0.02	0.02	0.02	0.02
Stack Pressure, in. Hg	28.96	29.32	28.96	29.08
Avg. Stack Temp., °F	210.0	204.0	204.0	206.0
Avg. Sq root of Δ P	0.2000	0.2646	0.2646	0.2431
SDE Average	5.177	6.818	6.818	6.271
Pitot Coefficient	0.84	0.84	0.84	0.84
Stack Gas Velocity, fpm	808.3	1026.6	1011.3	948.7
Stack Flowrate, wet acfm	107,290	136,259	134,228	125,926
Stack Flowrate, dry scfm	79,490	102,207	101,413	94,370
Isokinetics, %	99.2	92.6	100.0	97.2

PARTICULATE DATA -- FRONT HALF ONLY				
Front Half Rinse (FHACE), g	0.0022	0.0012	0.0016	0.0017
Particulate Filter (PF), g	0.0000	0.0000	0.0000	0.0000
Total Disolved Solids, g				
Organics, g				
Total Particulate Collected, g	0.0022	0.0012	0.0016	0.0
Grain Loading, gr/dscf	0.0007	0.0003	0.0005	0.0005
Grain Loading, gr/acf	0.0005	0.0002	0.0004	0.0004
Grain Loading, gr/dscf @ 7% O2	0.0064	0.0026	0.0043	0.0044
PM Emission Rate, lb/Hr	0.47	0.27	0.44	0.39
Total Exhaust Gas Rate, lb/hr	359090.66	461262.08	457596.73	425983.16
PM lbs/1000lbs Exhaust Gas	0.0012959	0.0005830	0.0009536	0.0009160

Table 1-3. SVBYPASS Summary of Test Results

OPERATING PARAMETERS AND SOURCE INFORMATION

The facility is a dry process operation and acquires shale and limestone materials form a   nearby quarry, as well as other locations, and purchases mill scale, slag, bottom ash, bauxite, sand, iron ore, and gypsum.

SMC prepares the raw materials through pyro-processing that takes place in a kiln and raw mill (in-line kiln/raw mill). The raw materials are dried in the raw mill by recirculated gas from the kiln system. The materials are fed through a preheater/precalciner countercurrent to the hot gas stream from flash furnace. After passing through the kiln, the raw materials are in the form of clinker, which is milled with other constituents to form Portland cement.

The raw material conversion process area, referred to as the in-line kiln/raw mill, contains two process stacks identified as the SVMAIN and SVBYPASS stacks. Two baghouses control the particulate matter generated from the process operations.

Figures 1-1 and 1-2 show the stack and the test location.

Figure 1-1. Bypass Stack and Port Diagram

Traverse Points:	16
Number of Ports:	4
Points/Port:	4
Stack ID:	156.0"
Port Length:	6.0"

CROSS SECTION

Sampling Ports
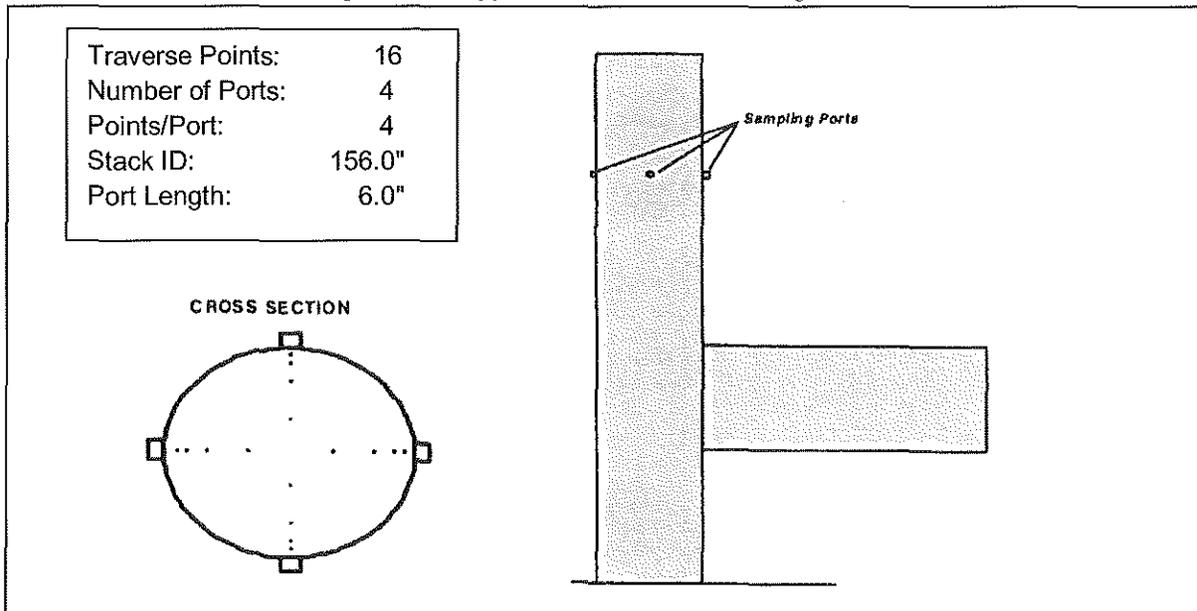
Figure 1-2. Main Stack and Port Diagram

Traverse Points:	12
Number of Ports:	4
Points/Port:	3
Stack ID:	130.0"
Port Length:	6.0"

CROSS SECTION

Sampling Ports
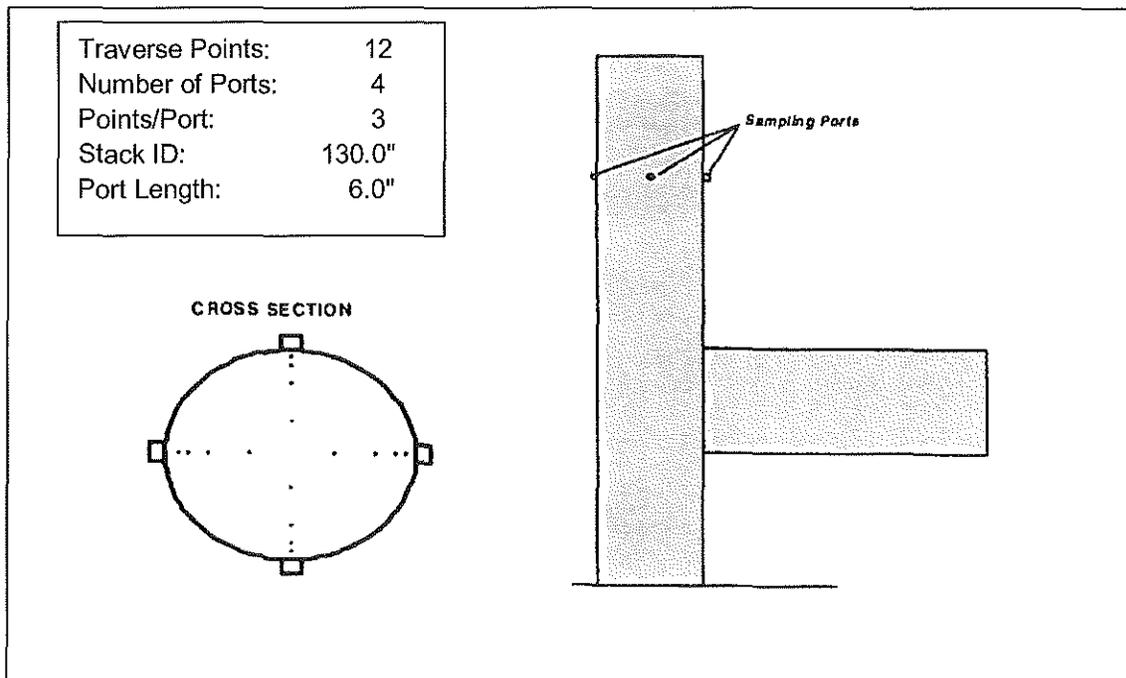
Performance Test Procedures

USEPA Reference Methods

This section provides a detailed description of the individual USEPA Reference Methods employed in this test (40 CFR 60, Appendix A). Schematics of the various sampling systems used to perform the test program on the sources can be found in Figures 1-1 through 1-4. Specifics for the test equipment utilized in this program are presented in Appendix A.

USEPA Method 1: Sample and Velocity Traverses for Stationary Sources

Sampling traverse points were determined based on the ratio of the stack diameter to the upstream and downstream distances of the sampling plane to the closest disturbances. The minimum number of traverse points on the sampling plane is determined from Figure 1-2 and Table 1-2 of 40CFR60, Appendix A, Method 1. *(ACCUAIR SOP: GSC-TM002)*

USEPA Method 2: Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

Velocity and volumetric flow rates were determined from the measurement of the stack gas velocity head with a Type-S Pitot tube and inclined manometer. The Pitot tube was constructed per USEPA Method 2 design specifications. Based on the face opening alignments, external tubing diameter, and base-to-opening plane distances, a coefficient value of 0.84 was assigned to the Pitot tube. *(ACCUAIR SOP: GSC-TM003)*

USEPA Method 3: Determination of Stack Gas Molecular Weight

The composition of the stack gas was determined to be essentially ambient air. Therefore, the dry molecular weight of 29.0 lb/lb-mole from Section 8.6 from Method 2 was used in the calculations. *(ACCUAIR SOP: GSC-TM012)*

USEPA Method 4: Determination of Moisture Content

USEPA Method 4 was performed inclusively with Method 5/202 to measure the moisture content of the stack gas for calculating the volumetric flow rate and molecular weight on a dry basis. The impingers for each high-flow sample train were weighed before and after each run. *(ACCUAIR SOP: GSC-TM016)*

USEPA heated Method 5: Filterable Particulate Matter

Filterable particulate matter (FPM) sampling was conducted utilizing Modified USEPA Method 5 where the probe and filter were separate from, but connected to the impinger train by a heated line. Samples were collected over a 60-minute period. The gas was drawn from the outlet of the source through a nozzle and heated probe liner enclosed in a stainless steel sheath, through a pre-tared heated filter, and into an impinger train for collecting moisture. The probe was equipped with type S pitot tubes for measuring gas velocity and a thermocouple sensor for measuring stack gas temperature. The thermocouple sensor was connected to a digital thermocouple indicator, which was used to measure the stack gas temperature at each sample point. The temperature of the filter exit was monitored to assure that it remained at the proper temperature. A temperature gauge capable of measuring temperature to within 3°C (5.4°F) is installed.

The sample train was connected to a meter box by means of an umbilical cord, which contained a vacuum hose, pitot lines, thermocouple wires and a 4-wire electrical cord. The meter box was used to monitor stack conditions and to facilitate isokinetic sampling. The meter box consists of a leak-free pump used to pull the stack gas through the sample train, fine, and coarse metering valves to control the sampling rate, a vacuum gauge that measures the pressure drop from the sampling nozzle to the metering valves, and a calibrated dry gas meter readable to 0.001 cubic feet (ft^3). The dry gas meter inlet and outlet temperatures were monitored by thermocouples, which were connected to a multichannel thermocouple indicator. The dry gas meter calibration factor, Y, was determined by calibrating the meter against a wet test meter or calibrated dry gas meter. At the outlet of the dry gas meter was a calibrated orifice that was used to monitor the flow of gas through the metering system to assure that samples were collected isokinetically. The pressure drop across the orifice was monitored at each sample point. The pitot tubes utilized to measure stack gas velocity were connected to the control box via the umbilical cord. The control box contained either low and high range magnehelic gauges or an incline manometer, which were used for the velocity measurement.

A stack sample was drawn isokinetically from the stack through a nozzle and unheated probe liner, through an unheated and tared filter. At the exit of the filter housing the sample was then passed through a Method 4 moisture train.

The sample train was recovered with acetone per USEPA Method 5 procedures and the filterable particulate matter quantified gravimetrically after evaporation of the acetone and weighing of the filter. The moisture train impingers were weighed onsite after each run to determine the amount of water collected during sampling.

USEPA Method 9 (not performed)

An observer momentarily observes the emission point at 15 second intervals. After a few seconds, the observation is recorded on a form. Observations are recorded in 5-percent opacity intervals. This continues until the required number of observations are completed. Opacity is determined as an average of consecutive observations over a 30 minute period.
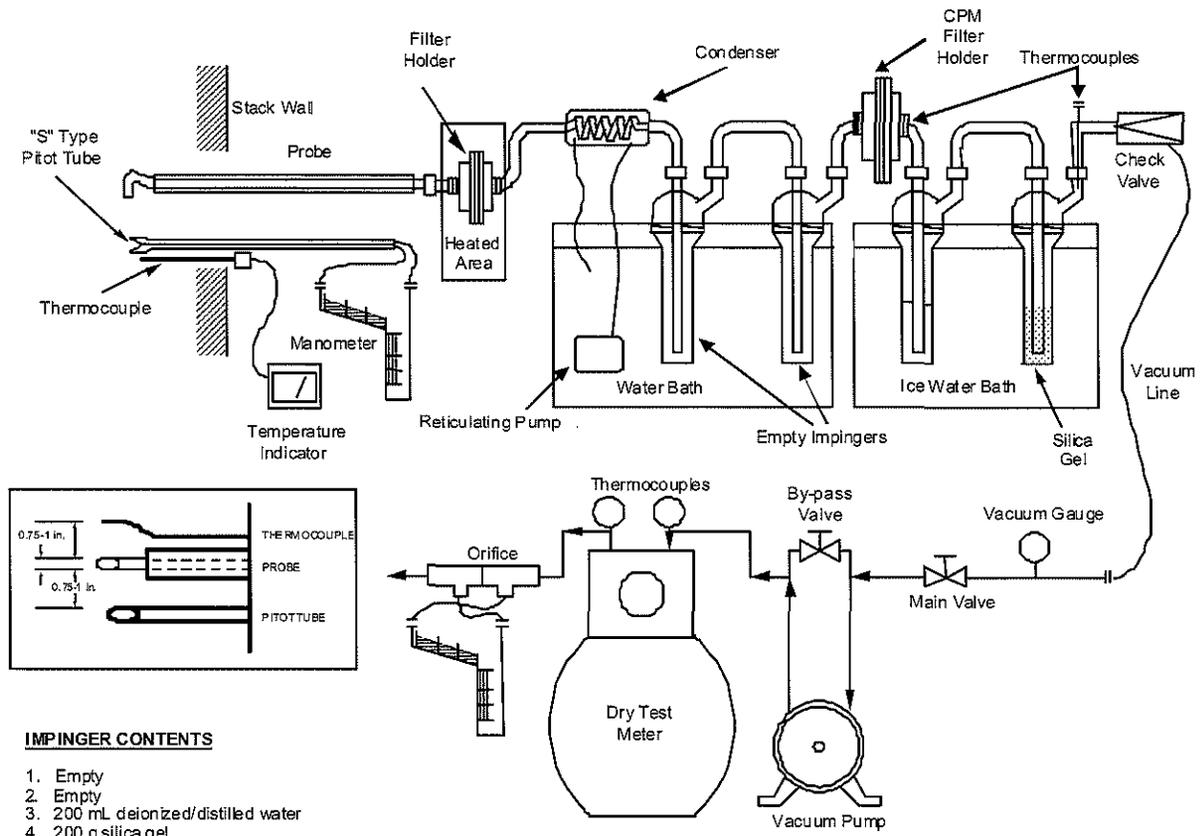
Figure 1-3. USEPA Method 5/202 Sampling Train
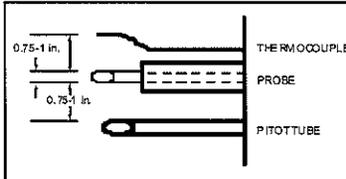
IMPINGER CONTENTS

1. Empty
2. Empty
3. 200 mL deionized/distilled water
4. 200 g silica gel

SAMPLE CALCULATIONS

The following calculations were used in the determination of emission rates for the unit's exhaust.

Absolute Stack Gas Pressure (P_s)

$$P_s = P_{bar} + \frac{P_{static}}{13.6}$$

Where: P_{bar} = Barometric pressure (in. Hg)

P_{static} = Static pressure of stack gas (in. H_2O)

Gas Volume Sampled at Standard Conditions ($V_{m(std)}$)

$$V_{m(std)} = \left(\frac{528}{29.92}\right) x V_m \, x \, Y \left[\frac{P_{bar} + \left(\frac{\Delta H}{13.6}\right)}{T_m}\right]$$

Where: V_m = Actual gas volume sampled (ft^3)

Y = Gas meter calibration factor

P_{bar} = Measured barometric pressure (in. Hg)

ΔH = Average differential pressure (in. H_2O)

T_m = Absolute average meter temperature (°R)

Water Vapor Collected at Standard Conditions ($V_{w(std)}$)

$$V_{w(std)} = 0.04715 \, x \, V_{lc}$$

Where:

V_{lc} = Liquid collected in impingers (g)

Measured Stack Gas Moisture Content (B_{ws})

$$B_{ws} = \frac{V_{w(std)}}{\left(V_{w(std)} + V_{m(std)}\right)}$$

Wet Molecular Weight of Stack Gas

$$M_s = M_d\left(1 - B_{ws}\right) + 18B_{ws}$$

Stack Gas Velocity

$$v_s = (85.49)(C_p)\left(avg\sqrt{\Delta P}\right)\sqrt{\frac{T_s}{(P_s)(M_s)}}$$

Where:

C_p = Pitot coefficient (0.84)
T_s = Average stack temperature (°R)
P_s = Absolute stack gas pressure (in. Hg)
M_s = Molecular weight of stack gas (lb/lb-mole)

Volumetric Flow Rate (Actual cubic feet per min)

$$Q_{aw} = v_s \ x \ A_s \ x \ 60$$

Where:

Q_{aw} = Volumetric flow rate (acfm)
v_s = Stack Gas Velocity (ft/sec)
A_s = Stack Area (ft^2)

Volumetric Flow Rate (Standard Conditions, dry basis)

$$Q_{sd} = \left(\frac{528}{29.92}\right) x \left(Q_{aw}\right) x \left(\frac{P_s}{T_s}\right) x \left(1 - B_{ws}\right)$$

Where:

Q_{sd} = Volumetric flow rate (dscfm)
P_s = Absolute stack gas pressure (in. Hg)
T_s = Average stack temperature (°R)
B_{ws} = Stack moisture content

Particulate Matter Sample and Emission Rate Calculations

Isokinetic Sampling Rate

$$I = \left(\frac{0.0945 \, x \, T_s \, x \, V_{m(std)}}{P_s \, x \, v_s \, x \, A_n \, x \, \theta \, x \, (1 - B_{ws})}\right)$$

Where:

T_s = Stack temperature (°R)
$V_{m(std)}$ = Sample volume at standard conditions (ft^3)
P_s = Absolute stack gas pressure
v_s = Stack gas velocity (fps)
A_n = Area of nozzle opening face (ft^3)
θ = Run time (minutes)
B_{ws} = Stack gas moisture content

Stack Gas Particulate Concentration (grains per dscf)

$$C_s = 0.01543 \, x \frac{m_n}{V_{m(std)}}$$

Where:

C_s = Particulate concentration (gr/dscf)
m_n = Total particulate collected in sample (mg)
$V_{m(std)}$ = Sample volume at standard conditions (ft^3)

Stack Gas Particulate Emission Rate (lb/hr)

$$E = \frac{C_s}{7,000} \, x Q_{std} \, x \, 60$$

Where:

E = Particulate emission rate (lb/hr)
C_s = Particulate concentration (gr/dscf)
Q_{std} = Stack gas flow rate (dscfm)
7,000 = Grains per pound

Stack Gas Particulate Emission Rate (tons/yr)

$$E_{tons} = \frac{E \times 8,760}{2,000}$$

Where:
      E_{tons} = Particulate emission rate (tons/hr)
       E = Particulate emission rate (lb/hr)
     8,760 = Hours per year
     2,000 = Pounds per ton

Process Data Calculations

Total Solids Used (lb/hr)

$$TS = CA \times \frac{CSC}{100} \times CD$$

Where:
     TS = Total Solids Used (lb/hr)
     CA = Coating Applied (gal/hr)
    CSC = Coating Solids Content (% by WT)
     CD = Coating Density (lb/gal)

Solids Applied to Can (lb/hr)

$$SA = CC \times AFW \div 1,000 \div 453.59$$

Where:

     SA = Solids Applied to Cans (lb/hr)
     CC = Cans Coated per Hour
    AFW = Applied Film weight (mg/can)
    1,000 = Milligrams per gram (mg/g)
   453.59 = Grams per pound (g/lb)

Solids Exhausted to Control (lb/hr)

$$SE = TS - SA$$

Where:

     SE = Solids Exhausted to Control (lb/hr)
     TS = Total Solids Used (lb/hr)
     SA = Solids Applied to Cans (lb/hr)

Particulate Collection Efficiency (%)

$$CE = (SE - FPM) \div SE \ x \ 100$$

Where:

CE = Particulate Collection Efficiency (%)
SE = Solids Exhausted to Control (lb/hr)
FPM = Filterable Particulate Matter emission rate (lb/hr)

Particulate lbs per 1000 lbs Exhaust Gas

$$lbs/1000lbs = (E / EGE) x 1000$$

Where:

lbs/1000lbs = Lbs Particulate Per 1000Lbs Exhaust Gas
E = PM Emission Rate (lb/hr)
EGE = Exhaust Gas Emission Rate (lb/hr)