MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE COMMUNICATION

TO: Caryn Owens, Cadillac District Office
Field Operations Section, Air Quality Division

FROM: Jeremy Howe, Cadillac District Office
Field Operations Section, Air Quality Division

DATE: November 14, 2013

SUBJECT: SRN B1824, MI-ROP-B1824-2008b
EUPELLETCOOLING
EUPELLPROD
EU#6BOILER

The report of emission testing at Morton Salt in Manistee has been reviewed. The following sources were tested:

- EU#6BOILER
  - Particulate Matter (PM)
  - Sulfur Dioxide (SO_2)
- EUPELLPROD
  - PM
- EUPELLETCOOLING
  - PM

This testing was required by MI-ROP-B1824-2008b.

The test protocol was received June 26, 2013 and approved July 1, 2013. The testing was performed August 6 and 7, 2013. The report was received September 3, 2013. The results for tests are as follows:

Emission Unit	Pollutant	Permit Limit	Test Result	% of Limit	Unit
EUPELLETCOOLING	PM	0.032	0.004	12.5	lb/1000lb
EUPELLPROD	PM	0.03	0.01	33.3	lb/1000lb dry
EU#6BOILER	PM	0.30	0.02	6.7	lb/1000lb @ 50% EA
EU#6BOILER	SO2	2.5	1.4	56.0	lb/mmBtu

Methodology and Results

Testing was performed in accordance with 40 CFR, Part 60, Appendix A, Methods 1, 2, 3A, 4, 5 and 6C. Testing was performed with the EU#6BOILER producing steam at 125 kpph; the facility contact stated that this was its maximum capacity. SO_2 was determined using Method 6C, PM was determined using Method 5.

Report/Testing Issues

- EUPELLETCOOLING
  - Method 1
    - Ports were not aligned at 90 degrees to each other
      - Ports are supposed be aligned at 90 degrees to each other per Section 11.3.1.1
  - Method 2
    - Cyclonic flow check not adequately documented
      - Method 2 cannot be used if cyclonic conditions exist per Section 1.2
- EUPELLPROD
  - Method 1
    - Outside points were located within one inch of stack wall
      - Not allowed per Section 11.3.2.1
  - Method 2
    - Cyclonic flow check not adequately documented
      - Method 2 cannot be used if cyclonic conditions exist per Section 1.2
  - Method 17
    - Run 1 Port 2 Point 1 not sampled isokinetically (119.0%)
    - Run 2 Port 2 Point 7 not sampled isokinetically (82.7%)
    - Run 2 Port 2 Point 6 not sampled isokinetically (121.3%)
    - Run 3 Port 2 Point 6 not sampled isokinetically (116.2%)
      - Method 17 Section 8.1.5 refers to Method 5 for Sample Train Operation
      - A sampling rate of 90%-110% isokinetic must be maintained throughout the sampling run per Method 5 Section 8.5
- EU#6BOILER
  - Method 2
    - Cyclonic flow check not adequately documented
      - Method 2 cannot be used if cyclonic conditions exist per Section 1.2
  - Method 6C
    - Cylinder gases used were outside of SO_2 observed
      - Method 6C Section 7.1 refers to Method 7E Section 7.1 for calibration gas requirements
      - Cylinder gases do not meet requirements in Method 7E Section 7.1

Discussion

Location of traverse points within an inch of the wall does not affect results to an appreciable amount. The points were only a quarter of an inch off and during sampling the probe could be off by this much at any point. Furthermore, being close to the wall could bias the results high as particles collected on the wall could come off and become a part of the sample.

Cyclonic flow check was not documented adequately on any stack. All that was recorded was something to the effect of " Cyc Flow Ck = OK < 5° ". This is not documentation, but a summary. It would be similar if the tester reported only the highest one minute average for SO_2 on each run and used this to compare against the limit. Furthermore, EUPELLETCOOLING cyclonic flow check was <u>not</u> done on both ports. EUPELLETCOOLING also had a strange flow profile in that the highest flow was not in the middle of the stack. EUPELLETCOOLING has a wet scrubber upstream which looked like it was designed to induce cyclonic flow. Adding to the complications EUPELLETCOOLING ports did not allow for sampling in equal areas of the stack since they were at 45 degrees to each other.

Cyclonic flow is a problem and not allowed because either the tester is measuring the flow of the flue gas as it moves up the stack and not catching the particulate because the nozzle is not pointed into the flow or the nozzle is into the flow stream, but the flow being measured is flue gas swirling around the inside of the stack.

It is not uncommon that a couple of points would not be sampled isokinetically. EUPELLETPROD need to be sampled at 24 points, which means the tester had to change points every 2.5 minutes. There is a lot to accomplish at each point, so it is not surprising a couple were off. The vast majority of points passed isokinetics and each run overall passed.

All PM limits were in units of lb/1000lbs. This is a density or concentration unit; flow is not used in the calculations. However, PM has to be sampled isokinetically which involves the flow rate in its calculation and also pointing the probe into the flow. It would be difficult to evaluate a PM result if cyclonic flow existed. However, these tests are not completely useless. No source tested had a result greater than a third of its limit. This means that the results would have to be off by at least two orders of magnitude to show a violation. There are a fair number of safeguards in the methods to allow for a variety of stack conditions and human error and almost no test is done without some issue. Thus, it is difficult to imagine that any of the tested sources are emitting more than their PM limits, even though we may not have the most accurate number to go by.

Finally, SO_2 calibration cylinders were not sized correctly. However, the lowest cylinder (848.9 ppm) corresponded to their EU#6BOILER limit of 2.5 lb/mmBtu. EPA has cylinder values sized in their methods to provide linearity over a wide range. Linearity is not a worry here since their limit was a point and not somewhere between two points.

Of note, EU#6BOILER SO_2 varied a fair amount during the three runs. SO2 ppm went from 300 to 500 during Run 1, stayed at 500 ppm for Run 2, and went from 500 down to 400 for Run 3. I am not sure what if anything this means, but encourage you to look at the graph in the attachments.

Summary
See the attached summary sheet for results. These results are acceptable with reservation to the AQD and can be used to determine compliance. Please review the process data included in the report to make a final compliance determination.

If you have any questions regarding this review, please contact me by telephone at 231-876-4416, or by e-mail at howej1@michigan.gov

JH:
Attachments

NETWORK ENVIRONMENTAL INCORPORATED

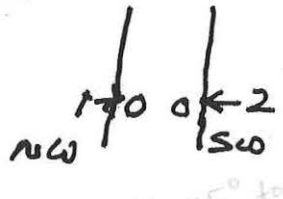
PITOT TRAVERSE DATA FORM	Date: 8/6/13
Plant: Morton Salt	
Source: Pellet Cooler	Staff: BYRD/EGERMANS
Stack Size, Inches 17 ~~3/16~~"	Barometric Pressure, "Hg 29.10
Gas Temperature, °F Dry _____ Wet _____	Static Pressure, "H_2O -1.8
Pitot Tube# 3	Standard ☐ S-Type ☐ C_p 0.82

Point Location Inches	Port	Velocity Pressure "H_2O		Port	Velocity Pressure "H_2O	Port	Velocity Pressure "H_2O	Port	Velocity Pressure "H_2O
0.75	1	1.7	80	1		1		1	
2.48	2	1.7	80	2		2		2	
5.03	3	2.1	80	3		3		3	
11.97	4	2.5	80	4		4		4	
14.52	5	3.4	80	5		5		5	
16.25	6	3.7	80	6		6		6	
	7			7		7		7	
	8			8		8		8	
	9			9		9		9	
	10			10		10		10	
	11			11		11		11	
	12			12		12		12	

Wall Thickness

Zero Point 1.5"

Port Size/Type 3" Coup



Cyc Flow Ck = OK < 5°

1.01140 GKGS
1 14310

Nozzle = 0.182
0.182
0.182

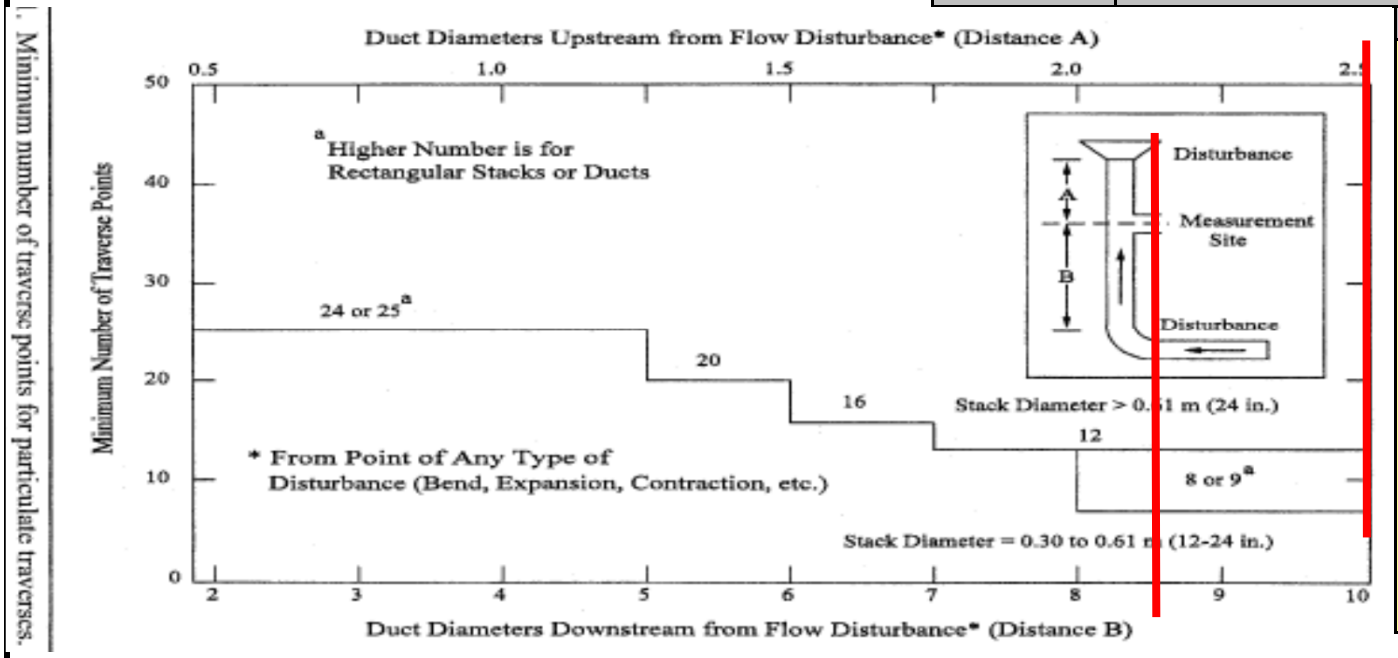
Plant:	Morton Salt	Capacity during Test:	
Permit #:	MI-ROP-B1824-2008b	Design Capacity:	
SRN:	B1824	SCC Code:	
Tested by:	Network	Date Tested:	August 6, 2013
Reviewed By:	Jeremy Howe	Date Reviewed:	November 13, 2013
Pollutants:	PM	Purpose of Test:	Compliance
Source:	EUPELLETCOOLING		

lb/1000lb, Actual

Run #	particulate mg	gas sampled lb/ft³	gas sampled lb	part conc lb/1000lb	iso %	iso max %	iso min %
1	9.60	0.07422	4.031	0.005	100.5	102.8	98.2
2	5.80	0.07408	4.023	0.003	101.4	104.4	98.7
3	7.30	0.07399	4.019	0.004	101.3	103.2	98.6
Avg	**7.57**	**0.07410**	**4.024**	**0.004**			
Limit				**0.032**			

Notes:

Duct Diameters	dd	TP Needed	TP Chosen	TP per Diameter
Upstream from disturbance (dd)	6.35	12		0
Downstream from disturbance (dd)	8.47	12	12	6
				6 Traverse Points Needed Each Diameter



Comments

Cyclonic flow not documented adequately. Ports not aligned at 90 degrees.

Traverse Point #	Fraction of Stack	Distance far wall to outside of port	Port Length	Stack Diameter	Distance from far wall	Distance from far wall + port	Consultant Distance from far wall + port	Difference
1	4.4	0.00	0.00	17.00	1.00	1.00	0.75	-0.25
2	14.6	0.00	0.00	17.00	2.48	2.48	2.48	0.00
3	29.6	0.00	0.00	17.00	5.03	5.03	5.03	0.00
4	70.4	0.00	0.00	17.00	11.97	11.97	11.97	0.00
5	85.4	0.00	0.00	17.00	14.52	14.52	14.52	0.00
6	95.6	0.00	0.00	17.00	16.00	16.00	16.25	0.25
7	0.0	0.00	0.00	17.00	0.00	0.00		0.00
8	0.0	0.00	0.00	17.00	0.00	0.00		0.00
9	0.0	0.00	0.00	17.00	0.00	0.00		0.00
10	0.0	0.00	0.00	17.00	0.00	0.00		0.00
11	0.0	0.00	0.00	17.00	0.00	0.00		0.00
12	0.0	0.00	0.00	17.00	0.00	0.00		0.00

http://www.epa.gov/ttn/emc/promgate/m-01.pdf

Run 1

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	82.3	2.48	1.558	75.8		55.808	100.5
Start						663.238	
1-12	82	3.10	1.761	70	70	668.350	98.8
1-11	82	3.10	1.761	70	70	673.490	99.3
1-10	82	2.50	1.581	75	69	678.270	102.4
1-9	82	2.30	1.517	79	70	682.760	99.9
1-8	82	1.90	1.378	82	70	686.930	101.8
1-7	82	1.40	1.183	83	71	690.550	102.7
1-6							
1-5							
1-4							
1-3							
1-2							
1-1							
2-12	82	3.40	1.844	78	71	695.920	98.2
2-11	83	3.50	1.871	83	72	701.500	100.2
2-10	83	2.90	1.703	85	73	706.620	100.7
2-9	83	2.10	1.449	85	73	710.960	100.4
2-8	83	1.90	1.378	85	74	715.150	101.8
2-7	82	1.60	1.265	86	74	719.046	102.8
2-6							
2-5							
2-4							
2-3							
2-2							
2-1							

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			16.0	16.0	8.0	
Initial				0.0		
Gain	0.0	0.0	16.0	16.0	8.0	24.0

Comments

Thousandths digit not recorded on intermediate points.

O2 Content of Gas Stream			20.90	% by Volume		Dry
CO2 Content of Gas Stream			0.00	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			78.20	% by Volume		Dry
Diameter of Stack			17.00	in		
Cross Sectional Area of Stack			1.58	ft²		
DGM Cal Factor	Y		0.9945	Dimensionless		
Pitot Tube Cal Factor	Cp		0.82	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		1.56	in H2O		
Stack Temp	Ts		82.33	F		
Absolute Stack Temp	Ts(abs)		542.33	R		
Stack Static Pressure			-1.80	in H2O		
Stack Static Pressure	Pg		-0.1324	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		28.97	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	0.753	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.38	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	53.18	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.021	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	28.94	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	28.72	lb/lb-mol		
Gas Collected from Stack @ STP			54.31	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.905	SCFM		Wet
Nozzle Diameter			0.182	in		
Area of Nozzle	An		0.000181	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	88	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			5,290	ft/min	FM	Wet
Average Stack Gas Actual Velocity			317,394	ft/hr	FH	Wet
Average Stack Gas Actual Flow			139	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			8,338	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			500,292	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			131	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			7,884	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			473,057	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			129	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			7,720	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	463,213	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Run 2

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	82.8	2.65	1.610	82.0		58.613	101.4
Start						718.980	
1-12	81	3.30	1.817	76	74	724.600	104.4
1-11	83	3.60	1.897	82	74	730.210	99.6
1-10	82	2.90	1.703	87	75	735.340	100.8
1-9	82	2.20	1.483	88	76	739.880	102.2
1-8	82	1.90	1.378	89	76	744.120	102.6
1-7	82	1.80	1.342	90	77	748.198	101.2
1-6							
1-5							
1-4							
1-3							
1-2							
1-1							
2-12	82	3.80	1.949	85	77	753.950	98.7
2-11	83	3.80	1.949	89	78	759.760	99.4
2-10	84	2.80	1.673	91	78	764.840	101.3
2-9	84	2.10	1.449	90	79	769.330	103.4
2-8	84	1.80	1.342	90	79	773.480	103.2
2-7	84	1.80	1.342	89	79	777.593	102.4
2-6							
2-5							
2-4							
2-3							
2-2							
2-1							

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			22.0	22.0	9.0	
Initial				0.0		
Gain	0.0	0.0	22.0	22.0	9.0	31.0

Comments

Thousandths digit not recorded on intermediate points.

O2 Content of Gas Stream			20.90	% by Volume		Dry
CO2 Content of Gas Stream			0.00	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			78.20	% by Volume		Dry
Diameter of Stack			17.00	in		
Cross Sectional Area of Stack			1.58	ft²		
DGM Cal Factor	Y		0.9945	Dimensionless		
Pitot Tube Cal Factor	Cp		0.82	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		1.61	in H2O		
Stack Temp	Ts		82.75	F		
Absolute Stack Temp	Ts(abs)		542.75	R		
Stack Static Pressure			-1.80	in H2O		
Stack Static Pressure	Pg		-0.1324	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		28.97	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	1.035	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.42	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	55.21	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.026	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	28.94	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	28.66	lb/lb-mol		
Gas Collected from Stack @ STP			56.67	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.944	SCFM		Wet
Nozzle Diameter			0.182	in		
Area of Nozzle	An		0.000181	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	91	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			5,477	ft/min	FM	Wet
Average Stack Gas Actual Velocity			328,593	ft/hr	FH	Wet
Average Stack Gas Actual Flow			144	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			8,632	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			517,945	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			136	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			8,156	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			489,373	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			132	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			7,946	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	476,767	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Run 3

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	84.2	2.57	1.585	83.0		57.549	101.3
Start						778.459	
1-12	81	3.50	1.871	79	78	783.950	98.6
1-11	84	3.50	1.871	82	78	789.510	100.1
1-10	84	2.90	1.703	86	78	794.660	101.5
1-9	84	2.20	1.483	88	78	799.190	102.3
1-8	84	1.90	1.378	88	79	803.440	103.2
1-7	84	1.60	1.265	88	79	807.337	103.1
1-6							
1-5							
1-4							
1-3							
1-2							
1-1							
2-12	84	3.40	1.844	84	79	812.780	99.1
2-11	85	3.30	1.817	86	79	818.350	103.0
2-10	85	2.90	1.703	88	79	823.450	100.4
2-9	85	2.20	1.483	90	79	827.960	101.7
2-8	85	1.80	1.342	92	80	832.090	102.7
2-7	85	1.60	1.265	94	80	836.008	103.2
2-6							
2-5							
2-4							
2-3							
2-2							
2-1							

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			26.0	26.0	8.0	
Initial				0.0		
Gain	0.0	0.0	26.0	26.0	8.0	34.0

Comments

Thousandths digit not recorded on intermediate points.

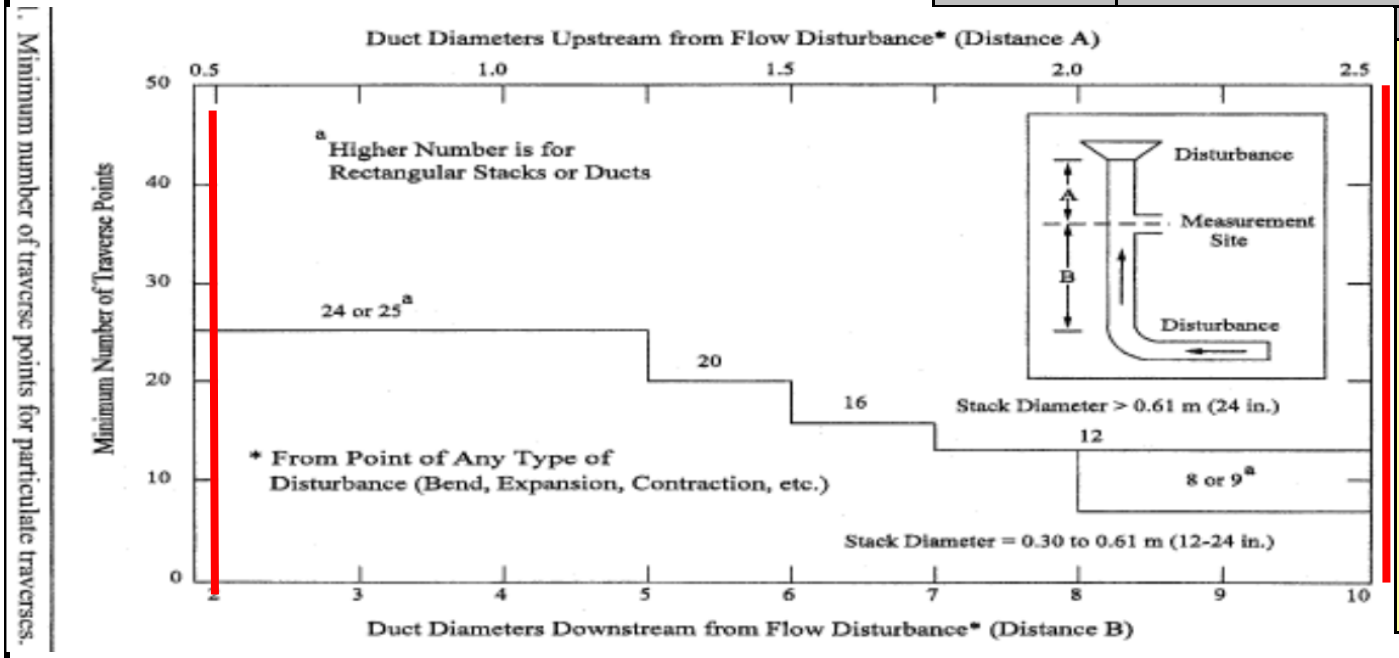
O2 Content of Gas Stream			20.90	% by Volume		Dry
CO2 Content of Gas Stream			0.00	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			78.20	% by Volume		Dry
Diameter of Stack			17.00	in		
Cross Sectional Area of Stack			1.58	ft²		
DGM Cal Factor	Y		0.9945	Dimensionless		
Pitot Tube Cal Factor	Cp		0.82	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		1.59	in H2O		
Stack Temp	Ts		84.17	F		
Absolute Stack Temp	Ts(abs)		544.17	R		
Stack Static Pressure			-1.80	in H2O		
Stack Static Pressure	Pg		-0.1324	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		28.97	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	1.224	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.38	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	54.11	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.029	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	28.94	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	28.63	lb/lb-mol		
Gas Collected from Stack @ STP			55.71	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.928	SCFM		Wet
Nozzle Diameter			0.182	in		
Area of Nozzle	An		0.000181	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	90	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			5,402	ft/min	FM	Wet
Average Stack Gas Actual Velocity			324,093	ft/hr	FH	Wet
Average Stack Gas Actual Flow			142	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			8,514	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			510,852	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			134	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			8,024	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			481,415	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			130	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			7,793	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	467,582	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Plant:	Morton Salt	Capacity during Test:	
Permit #:	MI-ROP-B1824-2008b	Design Capacity:	
SRN:	B1824	SCC Code:	
Tested by:	Network	Date Tested:	August 6, 2013
Reviewed By:	Jeremy Howe	Date Reviewed:	November 13, 2013
Pollutants:	PM	Purpose of Test:	Compliance
Source:	EUPELLPROD		

	lb/1000lb, Dry							
Run #	particulate mg	gas sampled lb/ft³	gas sampled lb	part conc lb/1000lb	iso %	iso max %	iso min %	Notes:
1	16.20	0.07349	3.346	0.01	101.6	119.0	96.2	
2	11.10	0.07311	3.328	0.01	102.0	121.3	82.7	
3	14.70	0.07309	3.328	0.01	102.6	116.2	92.3	
Avg	**14.00**	**0.07323**	**3.334**	**0.01**				
Limit				**0.03**				

Duct Diameters	dd	TP Needed	TP Chosen	TP per Diameter
Upstream from disturbance (dd)	6.00	12		0
Downstream from disturbance (dd)	2.00	24	24	12
			12	Traverse Points Needed Each Diameter



Comments

Outside points are less than 1 inch from wall. These need to be located at 1 inch per M-1 11.3.2.1. Cyclonic flow not documented adequately.

Traverse Point #	Fraction of Stack	Distance far wall to outside of port	Port Length	Stack Diameter	Distance from far wall	Distance from far wall + port	Consultant Distance from far wall + port	Difference
1	2.1	0.00	0.00	36.00	1.00	1.00	0.76	-0.24
2	6.7	0.00	0.00	36.00	2.41	2.41	2.41	0.00
3	11.8	0.00	0.00	36.00	4.25	4.25	4.25	0.00
4	17.7	0.00	0.00	36.00	6.37	6.37	6.37	0.00
5	25.0	0.00	0.00	36.00	9.00	9.00	9.00	0.00
6	35.6	0.00	0.00	36.00	12.82	12.82	12.82	0.00
7	64.4	0.00	0.00	36.00	23.18	23.18	23.18	0.00
8	75.0	0.00	0.00	36.00	27.00	27.00	27.00	0.00
9	82.3	0.00	0.00	36.00	29.63	29.63	29.63	0.00
10	88.2	0.00	0.00	36.00	31.75	31.75	31.75	0.00
11	93.3	0.00	0.00	36.00	33.59	33.59	33.59	0.00
12	97.9	0.00	0.00	36.00	35.00	35.00	35.24	0.24

http://www.epa.gov/ttn/emc/promgate/m-01.pdf

Run 1

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	108.8	1.76	1.322	92.3		47.624	101.6
Start						175.806	
1-12	109	1.90	1.378	85	84	177.820	100.4
1-11	109	1.95	1.396	84	84	179.980	106.4
1-10	110	1.95	1.396	86	84	181.950	97.0
1-9	110	1.90	1.378	89	84	184.000	102.0
1-8	109	1.90	1.378	91	84	186.050	101.6
1-7	110	1.90	1.378	93	85	188.200	106.5
1-6	110	1.75	1.323	95	85	190.080	96.8
1-5	110	1.60	1.265	96	85	191.960	101.2
1-4	111	1.50	1.225	97	86	193.740	98.9
1-3	111	1.40	1.183	98	86	195.520	102.3
1-2	110	1.25	1.118	99	87	197.190	101.2
1-1	108	1.20	1.095	99	87	198.806	99.6
2-12	109	2.00	1.414	94	87	200.870	99.2
2-11	109	2.00	1.414	98	88	202.990	101.4
2-10	108	1.90	1.378	100	88	205.070	101.7
2-9	108	1.95	1.396	101	88	207.140	99.8
2-8	108	1.65	1.285	102	89	209.080	101.5
2-7	108	1.70	1.304	103	89	211.070	102.5
2-6	108	2.00	1.414	104	90	213.100	96.2
2-5	108	2.10	1.449	104	90	215.300	101.8
2-4	107	2.00	1.414	105	90	217.450	101.7
2-3	107	1.85	1.360	105	91	219.500	100.7
2-2	107	1.55	1.245	105	91	221.400	102.0
2-1	107	1.30	1.140	105	91	223.430	***119.0***

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			10.0	10.0	7.0	
Initial				0.0		
Gain	0.0	0.0	10.0	10.0	7.0	17.0

Comments
TP 2-1 not sampled isokinetically. Thousandths digit not recorded on intermediate points.

O2 Content of Gas Stream			20.90	% by Volume		Dry
CO2 Content of Gas Stream			0.00	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			78.20	% by Volume		Dry
Diameter of Stack			36.00	in		
Cross Sectional Area of Stack			7.07	ft²		
DGM Cal Factor	Y		1.0105	Dimensionless		
Pitot Tube Cal Factor	Cp		0.82	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		1.32	in H2O		
Stack Temp	Ts		108.79	F		
Absolute Stack Temp	Ts(abs)		568.79	R		
Stack Static Pressure			-0.85	in H2O		
Stack Static Pressure	Pg		-0.0625	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		29.04	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	0.471	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.33	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	44.73	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.018	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	28.94	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	28.75	lb/lb-mol		
Gas Collected from Stack @ STP			45.53	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.759	SCFM		Wet
Nozzle Diameter			0.182	in		
Area of Nozzle	An		0.000181	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	77	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			4,590	ft/min	FM	Wet
Average Stack Gas Actual Velocity			275,402	ft/hr	FH	Wet
Average Stack Gas Actual Flow			541	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			32,445	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			1,946,699	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			489	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			29,322	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			1,759,334	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			480	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			28,807	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	1,728,394	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Run 2

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	109.6	1.74	1.317	96.7		47.758	102.0
Start						223.495	
1-12	109	2.00	1.414	92	91	225.710	106.6
1-11	110	1.90	1.378	93	91	227.670	96.9
1-10	110	1.85	1.360	96	91	229.850	108.9
1-9	110	1.85	1.360	98	91	231.700	92.3
1-8	110	1.75	1.323	100	91	233.720	103.4
1-7	110	1.60	1.265	101	91	235.600	100.5
1-6	110	2.00	1.414	101	91	237.720	101.4
1-5	110	2.00	1.414	103	91	239.870	102.7
1-4	111	1.95	1.396	103	92	241.980	102.1
1-3	111	1.75	1.323	104	92	243.970	101.6
1-2	110	1.40	1.183	103	92	245.780	103.2
1-1	110	1.40	1.183	102	92	247.567	102.0
2-12	110	1.95	1.396	100	92	249.660	101.4
2-11	111	1.80	1.342	101	92	251.690	102.4
2-10	111	1.95	1.396	101	92	253.800	102.3
2-9	110	1.85	1.360	103	92	255.900	104.2
2-8	109	2.00	1.414	103	92	258.020	101.0
2-7	109	1.95	1.396	105	93	259.740	***82.7***
2-6	109	1.90	1.378	105	93	262.230	***121.3***
2-5	109	1.65	1.285	104	93	264.190	102.6
2-4	108	1.50	1.225	104	93	266.040	101.4
2-3	108	1.35	1.162	103	93	267.820	102.9
2-2	108	1.30	1.140	104	93	269.580	103.6
2-1	108	1.20	1.095	105	94	271.253	102.3

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			14.0	14.0	8.0	
Initial				0.0		
Gain	0.0	0.0	14.0	14.0	8.0	22.0

Comments

TP 2-7 and 2-6 not sampled isokinetically. Thousandths digit not recorded on intermediate points.

O2 Content of Gas Stream			20.90	% by Volume		Dry
CO2 Content of Gas Stream			0.00	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			78.20	% by Volume		Dry
Diameter of Stack			36.00	in		
Cross Sectional Area of Stack			7.07	ft²		
DGM Cal Factor	Y		1.0105	Dimensionless		
Pitot Tube Cal Factor	Cp		0.82	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		1.32	in H2O		
Stack Temp	Ts		109.63	F		
Absolute Stack Temp	Ts(abs)		569.63	R		
Stack Static Pressure			-0.85	in H2O		
Stack Static Pressure	Pg		-0.0625	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		29.04	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	0.659	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.38	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	44.50	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.023	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	28.94	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	28.69	lb/lb-mol		
Gas Collected from Stack @ STP			45.53	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.759	SCFM		Wet
Nozzle Diameter			0.182	in		
Area of Nozzle	An		0.000181	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	76	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			4,580	ft/min	FM	Wet
Average Stack Gas Actual Velocity			274,789	ft/hr	FH	Wet
Average Stack Gas Actual Flow			540	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			32,373	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			1,942,369	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			487	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			29,214	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			1,752,852	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			476	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			28,549	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	1,712,970	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Run 3

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	110.2	1.71	1.302	98.0		47.539	102.6
Start						271.540	
1-12	110	1.90	1.378	94	93	273.670	105.0
1-11	111	1.90	1.378	96	93	275.700	100.0
1-10	111	1.90	1.378	97	93	277.810	103.9
1-9	111	1.85	1.360	100	93	279.870	102.5
1-8	111	1.80	1.342	101	93	281.930	103.8
1-7	111	1.80	1.342	102	93	284.050	106.8
1-6	111	1.60	1.265	103	93	285.940	100.9
1-5	111	1.55	1.245	103	93	287.870	104.6
1-4	111	1.40	1.183	104	93	289.570	96.9
1-3	110	1.35	1.162	103	93	291.360	103.8
1-2	109	1.20	1.095	104	93	293.050	103.7
1-1	109	1.20	1.095	103	93	294.733	103.3
2-12	108	2.05	1.432	100	93	296.840	99.1
2-11	108	1.95	1.396	102	93	298.990	103.5
2-10	108	1.90	1.378	103	93	301.100	102.8
2-9	108	1.80	1.342	104	93	303.120	101.0
2-8	108	1.70	1.304	104	93	305.130	103.4
2-7	109	1.80	1.342	105	94	307.130	100.0
2-6	110	1.80	1.342	105	94	309.450	***116.2***
2-5	111	2.00	1.414	106	94	311.390	92.3
2-4	112	2.00	1.414	106	94	313.420	96.7
2-3	112	1.90	1.378	106	94	315.580	105.6
2-2	112	1.40	1.183	106	95	317.380	102.4
2-1	112	1.20	1.095	106	94	319.079	104.5

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			13.0	13.0	9.0	
Initial				0.0		
Gain	0.0	0.0	13.0	13.0	9.0	22.0

Comments
TP 2-6 not sampled isokinetically. TP 2-5 was used to compensate isokinetics. Thousandths digit not recorded on intermediate points.

O2 Content of Gas Stream			20.90	% by Volume		Dry
CO2 Content of Gas Stream			0.00	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			78.20	% by Volume		Dry
Diameter of Stack			36.00	in		
Cross Sectional Area of Stack			7.07	ft²		
DGM Cal Factor	Y		1.0105	Dimensionless		
Pitot Tube Cal Factor	Cp		0.82	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		1.30	in H2O		
Stack Temp	Ts		110.17	F		
Absolute Stack Temp	Ts(abs)		570.17	R		
Stack Static Pressure			-0.85	in H2O		
Stack Static Pressure	Pg		-0.0625	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		29.04	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	0.612	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.42	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	44.19	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.023	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	28.94	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	28.69	lb/lb-mol		
Gas Collected from Stack @ STP			45.23	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.754	SCFM		Wet
Nozzle Diameter			0.182	in		
Area of Nozzle	An		0.000181	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	75	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			4,530	ft/min	FM	Wet
Average Stack Gas Actual Velocity			271,797	ft/hr	FH	Wet
Average Stack Gas Actual Flow			534	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			32,020	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			1,921,220	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			481	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			28,869	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			1,732,120	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			470	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			28,207	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	1,692,440	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Plant:	Morton Salt	Capacity during Test:	≈ 125kpph steam
Permit #:	MI-ROP-B1824-2008b	Design Capacity:	
SRN:	B1824	SCC Code:	
Tested by:	Network	Date Tested:	August 7, 2013
Reviewed By:	Jeremy Howe	Date Reviewed:	November 13, 2013
Pollutants:	SO2, PM	Purpose of Test:	Compliance
Source:	Boiler #6		

lb/1000lb, Actual

Run #	particulate mg	gas sampled lb/ft³	gas sampled lb	part conc lb/1000lb	iso %	iso max %	iso min %
1	43.10	0.07548	4.142	0.023	100.5	103.1	99.2
2	38.80	0.07535	4.134	0.021	100.5	105.7	95.7
3	34.30	0.07505	4.118	0.018	101.1	103.9	99.6
Avg	**38.73**	**0.07529**	**4.131**	**0.021**			
Limit				-			

Notes:

lb/1000lb, Actual @ 50% EA

Run #	part conc lb/1000lb	Md lb/lb-mol	Bwo %	emission lb/hr	iso %	iso max %	iso min %
1	0.023	30.12	7.549	0.027	100.5	103.1	99.2
2	0.021	30.08	7.655	0.024	100.5	105.7	95.7
3	0.018	30.05	8.440	0.022	101.1	103.9	99.6
Avg	**0.021**	**30.08**	**7.881**	**0.02**			
Limit				**0.30**			

Notes

Run 1

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	338.4	0.42	0.643	82.8		53.941	100.5
Start						836.342	
1-1	338	0.41	0.640	73	73	840.730	100.2
1-2	339	0.46	0.678	77	73	845.410	100.6
1-3	340	0.47	0.686	82	73	850.120	99.9
1-4	340	0.43	0.656	87	75	854.720	101.3
1-5	338	0.38	0.616	90	75	859.050	100.9
1-6	338	0.27	0.520	93	76	862.794	103.1
1-7							
1-8							
1-9							
1-10							
1-11							
1-12							
2-1	329	0.39	0.624	85	77	867.150	99.3
2-2	338	0.48	0.693	91	78	871.970	99.6
2-3	339	0.51	0.714	95	79	877.000	100.5
2-4	341	0.46	0.678	97	80	881.770	100.3
2-5	342	0.40	0.632	98	81	886.170	99.2
2-6	339	0.33	0.574	98	82	890.283	101.6
2-7							
2-8							
2-9							
2-10							
2-11							
2-12							

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			80.0	80.0	8.0	
Initial				0.0		
Gain	0.0	0.0	80.0	80.0	8.0	88.0

Comments

O2 Content of Gas Stream			9.30	% by Volume		Dry
CO2 Content of Gas Stream			10.25	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			79.54	% by Volume		Dry
Diameter of Stack			78.00	in		
Cross Sectional Area of Stack			33.18	ft²		
DGM Cal Factor	Y		0.9945	Dimensionless		
Pitot Tube Cal Factor	Cp		0.83	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		0.64	in H2O		
Stack Temp	Ts		338.42	F		
Absolute Stack Temp	Ts(abs)		798.42	R		
Stack Static Pressure			-0.58	in H2O		
Stack Static Pressure	Pg		-0.0427	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		29.06	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	3.765	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.38	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	50.73	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.075	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	30.12	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	29.21	lb/lb-mol		
Gas Collected from Stack @ STP			54.87	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.915	SCFM		Wet
Nozzle Diameter			0.313	in		
Area of Nozzle	An		0.000534	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	44	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			2,654	ft/min	FM	Wet
Average Stack Gas Actual Velocity			159,246	ft/hr	FH	Wet
Average Stack Gas Actual Flow			1,468	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			88,071	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			5,284,276	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			946	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			56,742	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			3,404,517	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			874	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			52,459	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	3,147,519	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Run 2

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	343.2	0.44	0.664	89.0		56.177	100.5
Start						890.558	
1-1	337	0.41	0.640	82	81	895.280	105.7
1-2	340	0.50	0.707	88	81	900.010	95.7
1-3	344	0.53	0.728	94	81	905.050	99.0
1-4	345	0.49	0.700	97	82	909.950	99.9
1-5	346	0.43	0.656	98	82	914.710	103.6
1-6	339	0.33	0.574	99	83	918.740	99.1
1-7							
1-8							
1-9							
1-10							
1-11							
1-12							
2-1	339	0.44	0.663	91	83	923.370	99.3
2-2	345	0.49	0.700	95	84	928.410	102.7
2-3	346	0.53	0.728	98	84	933.520	100.0
2-4	347	0.45	0.671	100	85	938.210	99.5
2-5	345	0.42	0.648	100	84	942.800	100.6
2-6	345	0.30	0.548	100	85	946.735	102.0
2-7							
2-8							
2-9							
2-10							
2-11							
2-12							

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			84.0	84.0	8.0	
Initial				0.0		
Gain	0.0	0.0	84.0	84.0	8.0	92.0

Comments

O2 Content of Gas Stream			9.79	% by Volume		Dry
CO2 Content of Gas Stream			9.86	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			79.45	% by Volume		Dry
Diameter of Stack			78.00	in		
Cross Sectional Area of Stack			33.18	ft²		
DGM Cal Factor	Y		0.9945	Dimensionless		
Pitot Tube Cal Factor	Cp		0.83	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		0.66	in H2O		
Stack Temp	Ts		343.17	F		
Absolute Stack Temp	Ts(abs)		803.17	R		
Stack Static Pressure			-0.58	in H2O		
Stack Static Pressure	Pg		-0.0427	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		29.06	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	3.953	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.38	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	52.23	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.077	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	30.08	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	29.15	lb/lb-mol		
Gas Collected from Stack @ STP			56.56	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.943	SCFM		Wet
Nozzle Diameter			0.313	in		
Area of Nozzle	An		0.000534	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	46	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			2,751	ft/min	FM	Wet
Average Stack Gas Actual Velocity			165,068	ft/hr	FH	Wet
Average Stack Gas Actual Flow			1,522	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			91,291	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			5,477,476	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			974	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			58,469	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			3,508,120	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			900	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			53,993	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	3,239,556	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Run 3

Flow Traverse				Dry Gas Meter			Isokinetics
Port-Pt	Stack Tp (F)	ΔP (in H2O)	Sq Rt ΔP	Tp In (F)	Tp Out (F)	Samp Vol (ft³)	%
Avg	344.2	0.43	0.656	89.5		55.509	101.1
Start						947.375	
1-1	343	0.43	0.656	83	83	951.940	100.9
1-2	346	0.49	0.700	88	83	956.840	101.3
1-3	346	0.51	0.714	93	82	961.820	100.6
1-4	347	0.47	0.686	97	83	966.680	101.9
1-5	346	0.42	0.648	99	83	971.380	103.9
1-6	341	0.27	0.520	99	84	975.045	100.4
1-7							
1-8							
1-9							
1-10							
1-11							
1-12							
2-1	341	0.44	0.663	90	84	979.650	99.6
2-2	342	0.49	0.700	95	84	984.570	100.5
2-3	344	0.51	0.714	98	84	989.630	101.3
2-4	344	0.47	0.686	100	85	994.490	101.1
2-5	345	0.41	0.640	100	85	999.010	100.8
2-6	345	0.30	0.548	100	85	1002.884	101.0
2-7							
2-8							
2-9							
2-10							
2-11							
2-12							

Impingers						
	1	2	3	Total 1-3	Silica	Total
Final			92.0	92.0	9.0	
Initial				0.0		
Gain	0.0	0.0	92.0	92.0	9.0	101.0

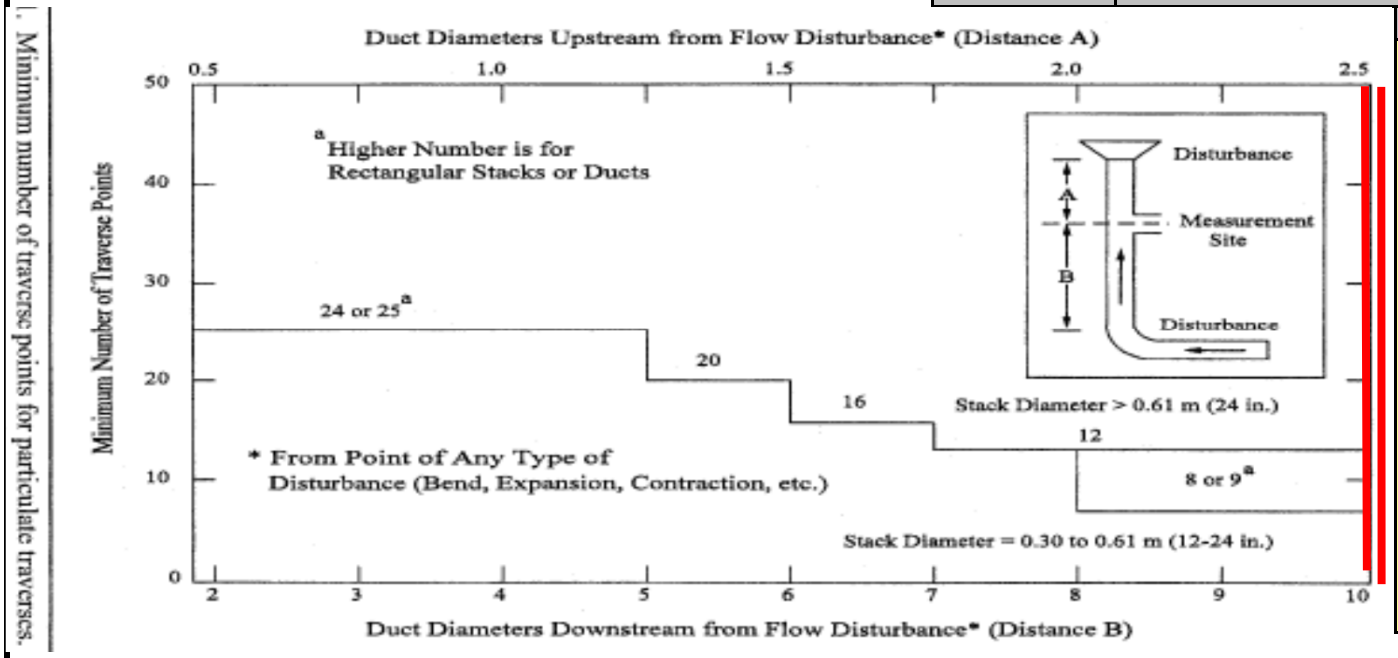
Comments

O2 Content of Gas Stream			10.05	% by Volume		Dry
CO2 Content of Gas Stream			9.66	% by Volume		Dry
Ar Content of Gas Stream			0.90	% by Volume		Dry
N2+CO Content of Gas Stream			79.38	% by Volume		Dry
Diameter of Stack			78.00	in		
Cross Sectional Area of Stack			33.18	ft²		
DGM Cal Factor	Y		0.9945	Dimensionless		
Pitot Tube Cal Factor	Cp		0.83	Dimensionless		
Velocity Head of Stack Gas	$\sqrt{\Delta p_{avg}}$		0.66	in H2O		
Stack Temp	Ts		344.17	F		
Absolute Stack Temp	Ts(abs)		804.17	R		
Stack Static Pressure			-0.58	in H2O		
Stack Static Pressure	Pg		-0.0427	in Hg		
Barometric Pressure	Pbar		29.10	in Hg		
Absolute Stack Pressure	Ps		29.06	in Hg		
Condensed H2O Vol @ STP	Vwc(std)	EQ 4-1	4.330	SCF		
Silica H2O Vol @ STP	Vwsg(std)	EQ 4-2	0.42	SCF		
DGM Vol @ STP	Vm(std)	EQ 4-3	51.57	DSCF		
Gas Stream H2O Vapor	Bws	EQ 4-4	0.084	Proportion by Vol		
Gas Stream Molecular Weight Dry	Md	EQ 3-1	30.05	lb/lb-mol		
Gas Stream Molecular Weight Wet	Ms	EQ 2-6	29.04	lb/lb-mol		
Gas Collected from Stack @ STP			56.33	SCF		Wet
Moisture Collection Time			60	Minutes		
Gas Collection Rate			0.939	SCFM		Wet
Nozzle Diameter			0.313	in		
Area of Nozzle	An		0.000534	ft²		
Average Stack Gas Actual Velocity	Vs	EQ 2-7	45	ft/sec	FS	Wet
Average Stack Gas Actual Velocity			2,727	ft/min	FM	Wet
Average Stack Gas Actual Velocity			163,639	ft/hr	FH	Wet
Average Stack Gas Actual Flow			1,508	ft³/sec	ACFS	Wet
Average Stack Gas Actual Flow			90,501	ft³/min	ACFM	Wet
Average Stack Gas Actual Flow			5,430,042	ft³/hr	ACFH	Wet
Average Stack Gas Flow @ STP			965	ft³/sec	SCFS	Wet
Average Stack Gas Flow @ STP			57,890	ft³/min	SCFM	Wet
Average Stack Gas Flow @ STP			3,473,416	ft³/hr	SCFH	Wet
Average Stack Gas Dry Flow @ STP			883	ft³/sec	DSCFS	Dry
Average Stack Gas Dry Flow @ STP			53,004	ft³/min	DSCFM	Dry
Average Stack Gas Dry Flow @ STP	Q	EQ 2-8	3,180,268	ft³/hr	DSCFH	Dry

Notes: To edit sheet just unprotect it under the "Review" tab. Metric flows: m³/hr = ft³/min x 1.7

Duct Diameters	dd	TP Needed	TP Chosen	TP per Diameter
Upstream from disturbance (dd)	2.00	12		0
Downstream from disturbance (dd)	8.00	12	12	6
			6	Traverse Points Needed Each Diameter

Comments

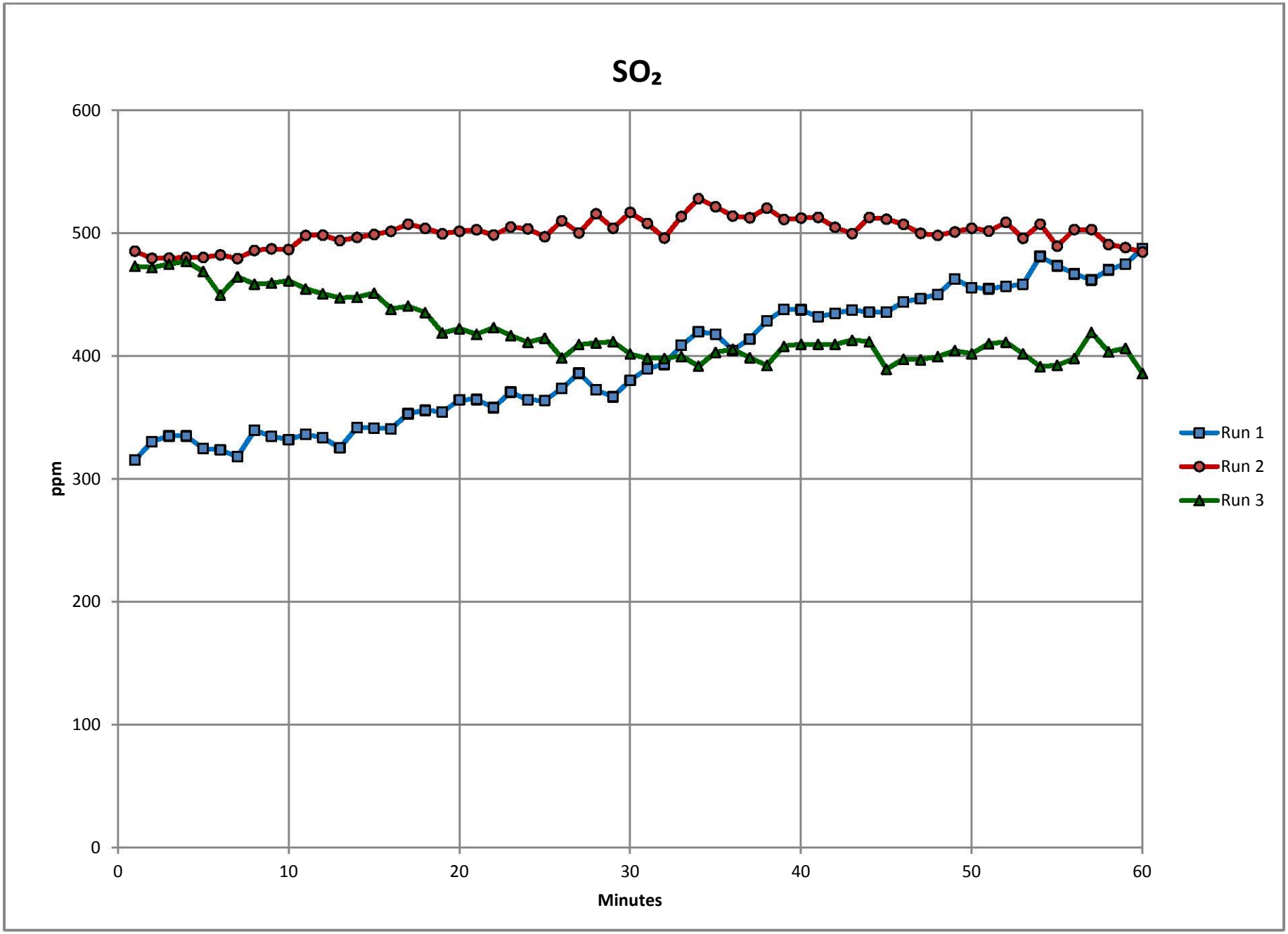


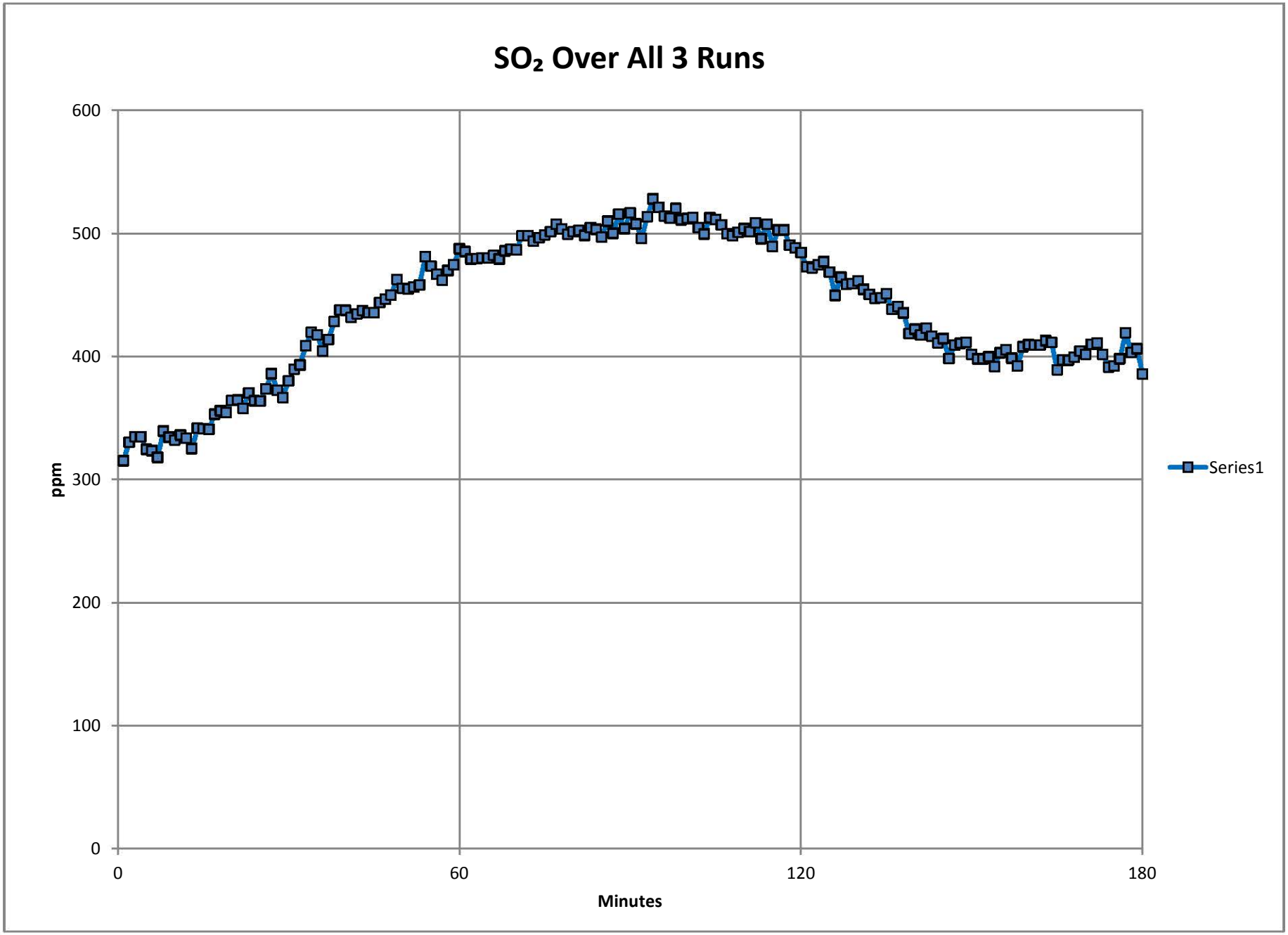
Traverse Point #	Fraction of Stack	Distance far wall to outside of port	Port Length	Stack Diameter	Distance from far wall	Distance from far wall + port	Consultant Distance from far wall + port	Difference
1	4.4	0.00	0.00	78.00	3.43	3.43	3.43	0.00
2	14.6	0.00	0.00	78.00	11.39	11.39	11.39	0.00
3	29.6	0.00	0.00	78.00	23.09	23.09	23.09	0.00
4	70.4	0.00	0.00	78.00	54.91	54.91	54.91	0.00
5	85.4	0.00	0.00	78.00	66.61	66.61	66.61	0.00
6	95.6	0.00	0.00	78.00	74.57	74.57	74.57	0.00
7	0.0	0.00	0.00	78.00	0.00	0.00		0.00
8	0.0	0.00	0.00	78.00	0.00	0.00		0.00
9	0.0	0.00	0.00	78.00	0.00	0.00		0.00
10	0.0	0.00	0.00	78.00	0.00	0.00		0.00
11	0.0	0.00	0.00	78.00	0.00	0.00		0.00
12	0.0	0.00	0.00	78.00	0.00	0.00		0.00

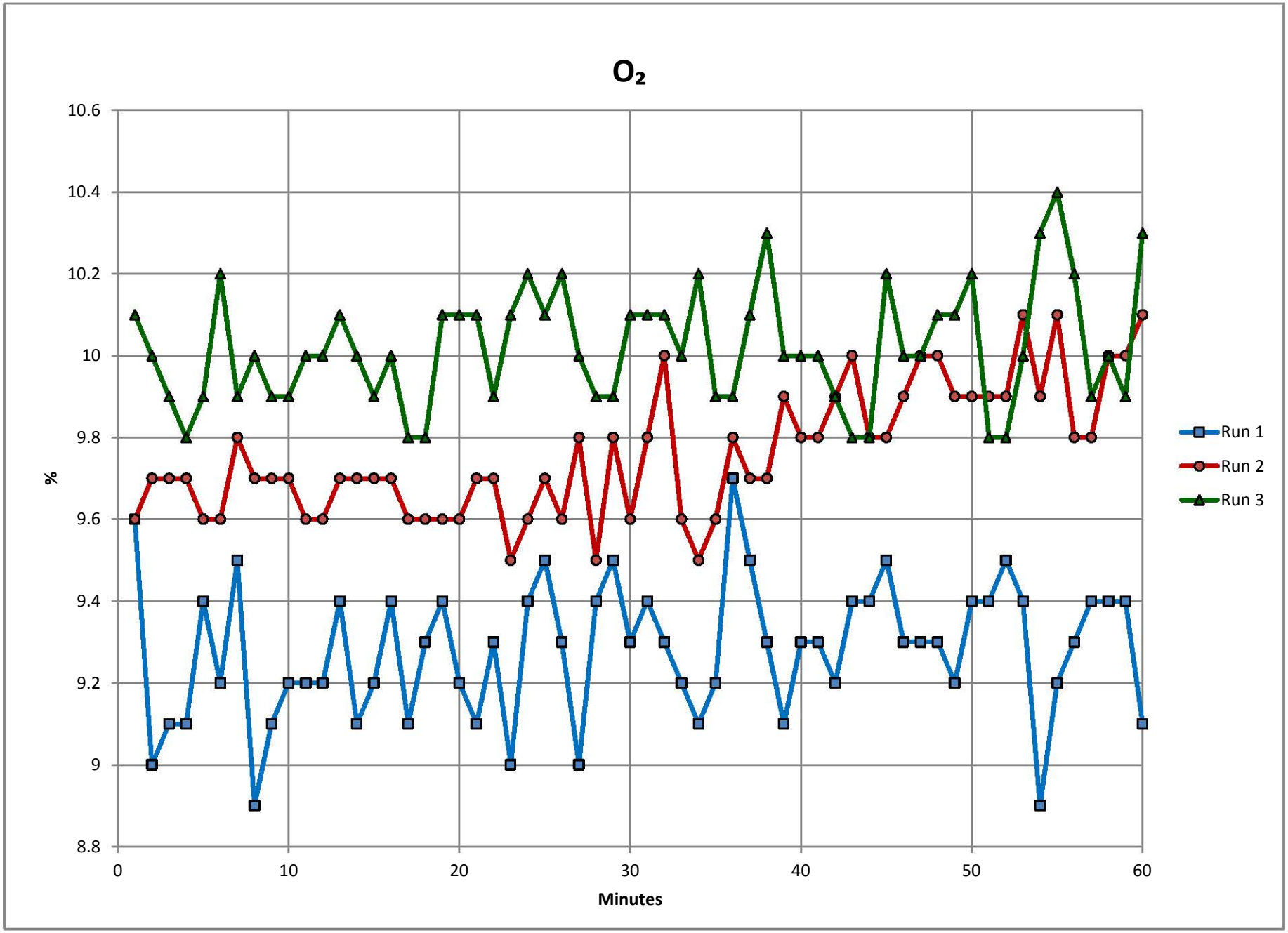
http://www.epa.gov/ttn/emc/promgate/m-01.pdf

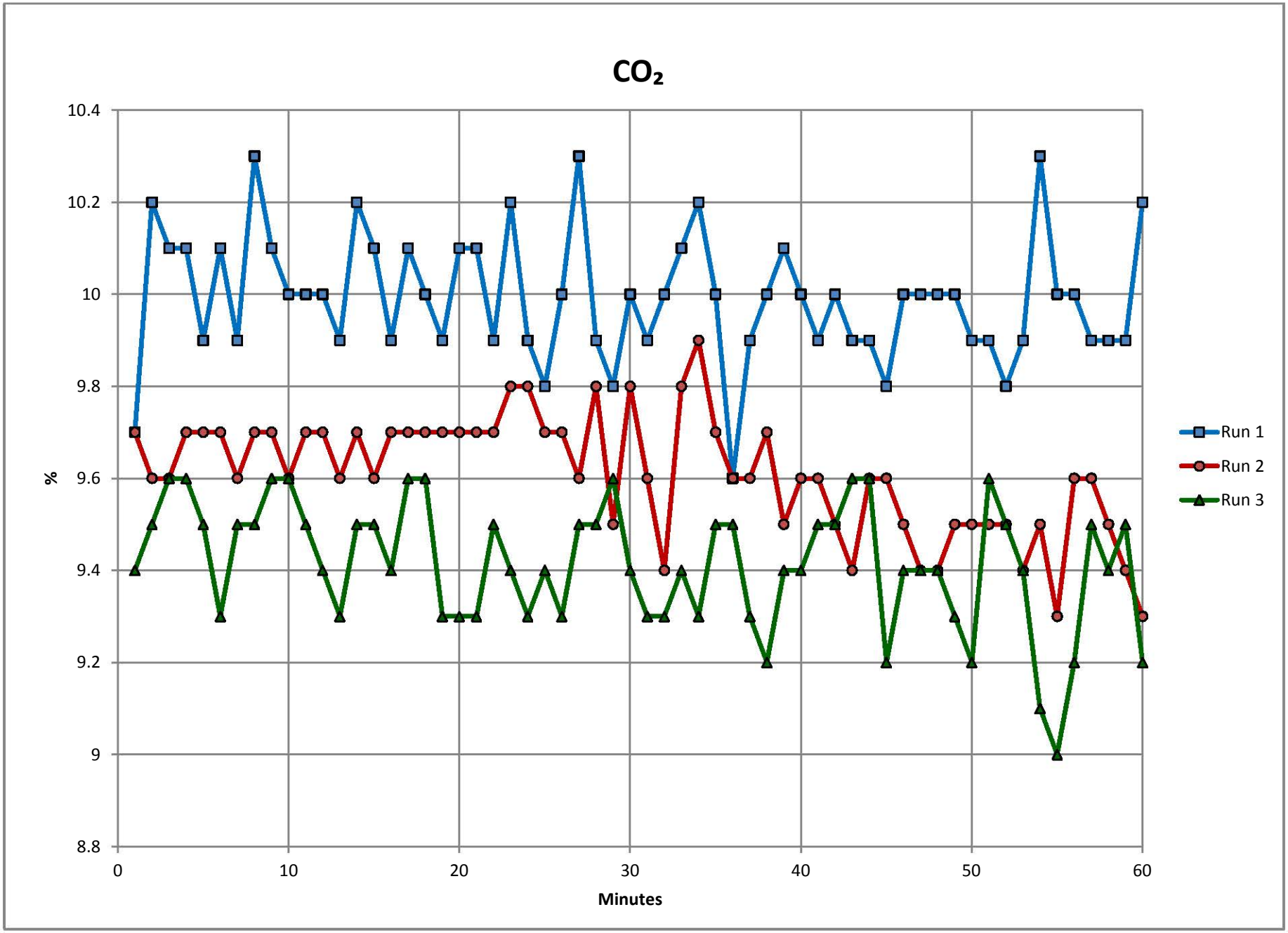
Plant:	Morton Salt	Capacity during Test:	≈ 125kpph steam
Permit #:	MI-ROP-B1824-2008b	Design Capacity:	
SRN:	B1824	SCC Code:	
Tested by:	Network	Date Tested:	August 7, 2013
Reviewed By:	Jeremy Howe	Date Reviewed:	November 13, 2013
Pollutants:	SO2, PM	Purpose of Test:	Compliance
Source:	Boiler #6		

SO_2						
Run #	Corrected ppm	mol wt g/mol	F Factor	O2 %	emission lb/mmBtu	Notes
1	409.58	64	9,780	9.3	1.2	
2	516.89	64	9,780	9.8	1.6	
3	433.54	64	9,780	10.1	1.4	
Avg	**453.34**	**64**	**9,780**	**9.7**	**1.4**	
Limit					**2.5**	


SO2
600
500
400
300
200
100
0
ppm
0
10
20
30
40
50
60
Minutes
Run 1
Run 2
Run 3


SO₂ Over All 3 Runs
600
500
400
300
200
100
0
ppm
0
60
120
180
Minutes
Series1


O2
10.6
10.4
10.2
10
9.8
9.6
9.4
9.2
9
8.8
%
0
10
20
30
40
50
60
Minutes
Run 1
Run 2
Run 3


CO₂
10.4
10.2
10
9.8
9.6
9.4
9.2
9
8.8
%
0
10
20
30
40
50
60
Minutes
Run 1
Run 2
Run 3

Enter Calibration Data						Check Link to RUNSS worksheet								
Note: ACE, SB and D pass if difference is ≤ 0.5 ppmvd														
SO_2	0	848.9	1186	2257	ppm	*Notes: SO2 only 315-550 ppm, but 850 ppm = permit limit of 2.5 lb/mmBtu*								
Direct	1.1	840.0	1176.8	2257.0	ppm									
ACE	**0.0**	**-0.4**	**-0.4**	**0.0**	**%**									
Limit	**2.0**	**2.0**	**2.0**	**2.0**	**%**									
Run	Pre Zero	Post Zero	SBi	SBf	D	Pre Upscale	Post Upscale	SBi	SBf	D	Raw	Co	Cm	*Corrected*
#	ppm	ppm	%S	%S	%S	ppm	ppm	%S	%S	%S	ppm	ppm	ppm	*ppm*
1	4.6	2.5	0.2	0.1	0.1	809.8	820.5	-1.3	-0.9	0.5	395.1	3.6	815.2	*409.6*
2	2.5	2.5	0.1	0.1	0.0	820.5	820.8	-0.9	-0.9	0.0	500.7	2.5	820.7	*516.9*
3	2.5	2.3	0.1	0.1	0.0	820.8	821.9	-0.9	-0.8	0.0	420.6	2.4	821.4	*433.5*
Avg	**3.2**	**2.4**	**0.1**	**0.1**	**0.0**	**817.0**	**821.1**	**-1.0**	**-0.8**	**0.2**	**438.8**	**2.8**	**819.1**	***453.3***
Limit			**5.0**	**5.0**	**3.0**			**5.0**	**5.0**	**3.0**				
O_2	0	5.98	12.11	20.9	%	*Notes*								
Direct	0.0	6.1	12.3	20.9	%									
ACE	**0.0**	**0.6**	**0.9**	**0.0**	**%**									
Limit	**2.0**	**2.0**	**2.0**	**2.0**	**%**									
Run	Pre Zero	Post Zero	SBi	SBf	D	Pre Upscale	Post Upscale	SBi	SBf	D	Raw	Co	Cm	*Corrected*
#	%	%	%S	%S	%S	%	%	%S	%S	%S	%	%	%	*%*
1	0.1	0.1	0.5	0.5	0.0	6.0	6.0	-0.5	-0.5	0.0	9.3	0.1	6.0	*9.3*
2	0.1	0.1	0.5	0.5	0.0	6.0	6.0	-0.5	-0.5	0.0	9.8	0.1	6.0	*9.8*
3	0.1	0.1	0.5	0.5	0.0	6.0	6.0	-0.5	-0.5	0.0	10.0	0.1	6.0	*10.1*
Avg	**0.1**	**0.1**	**0.5**	**0.5**	**0.0**	**6.0**	**6.0**	-0.5	-0.5	**0.0**	**9.7**	**0.1**	**6.0**	***9.7***
Limit			**5.0**	**5.0**	**3.0**			**5.0**	**5.0**	**3.0**				
CO_2	0	6.019	12.04	20.33	%	*Notes*								
Direct	0.0	5.8	11.8	20.3	%									
ACE	**0.0**	**-1.1**	**-1.2**	**0.0**	**%**									
Limit	**2.0**	**2.0**	**2.0**	**2.0**	**%**									
Run	Pre Zero	Post Zero	SBi	SBf	D	Pre Upscale	Post Upscale	SBi	SBf	D	Raw	Co	Cm	*Corrected*
#	%	%	%S	%S	%S	%	%	%S	%S	%S	%	%	%	%
1	0.0	0.0	0.0	0.0	0.0	11.8	11.8	0.0	0.0	0.0	10.0	0.0	11.8	*10.3*
2	0.0	0.0	0.0	0.0	0.0	11.8	11.8	0.0	0.0	0.0	9.6	0.0	11.8	*9.9*
3	0.0	0.0	0.0	0.0	0.0	11.8	11.8	0.0	0.0	0.0	9.4	0.0	11.8	*9.7*
Avg	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**11.8**	**11.8**	**0.0**	**0.0**	**0.0**	**9.7**	**0.0**	**11.8**	**9.9**
Limit			**5.0**	**5.0**	**3.0**			**5.0**	**5.0**	**3.0**				

Minutes	Run 1				Run 2				Run 3			
	Pollutant	SO_2	O_2	CO_2	Pollutant	SO_2	O_2	CO_2	Pollutant	SO_2	O_2	CO_2
	Units	ppm	%	%	Units	ppm	%	%	Units	ppm	%	%
	Avg	395.13	9.28	9.99	Avg	500.67	9.76	9.61	Avg	420.65	10.02	9.41
	Max	487.60	9.70	10.30	Max	528.10	10.10	9.90	Max	477.10	10.40	9.60
	Min	315.30	8.90	9.60	Min	479.30	9.50	9.30	Min	385.70	9.80	9.00
	Count	60	60	60	Count	60	60	60	Count	60	60	60
1	09:01	315.30	9.60	9.70	10:18	485.30	9.60	9.70	11:29	473.00	10.10	9.40
2	09:02	330.40	9.00	10.20	10:19	479.40	9.70	9.60	11:30	472.00	10.00	9.50
3	09:03	334.90	9.10	10.10	10:20	479.60	9.70	9.60	11:31	474.80	9.90	9.60
4	09:04	335.00	9.10	10.10	10:21	480.30	9.70	9.70	11:32	477.10	9.80	9.60
5	09:05	324.70	9.40	9.90	10:22	480.20	9.60	9.70	11:33	468.80	9.90	9.50
6	09:06	323.60	9.20	10.10	10:23	482.30	9.60	9.70	11:34	449.80	10.20	9.30
7	09:07	318.10	9.50	9.90	10:24	479.30	9.80	9.60	11:35	464.60	9.90	9.50
8	09:08	339.50	8.90	10.30	10:25	485.90	9.70	9.70	11:36	458.60	10.00	9.50
9	09:09	334.60	9.10	10.10	10:26	487.20	9.70	9.70	11:37	459.30	9.90	9.60
10	09:10	332.10	9.20	10.00	10:27	486.60	9.70	9.60	11:38	461.40	9.90	9.60
11	09:11	336.20	9.20	10.00	10:28	498.10	9.60	9.70	11:39	454.60	10.00	9.50
12	09:12	333.60	9.20	10.00	10:29	498.40	9.60	9.70	11:40	450.70	10.00	9.40
13	09:13	325.20	9.40	9.90	10:30	493.90	9.70	9.60	11:41	447.30	10.10	9.30
14	09:14	341.80	9.10	10.20	10:31	496.50	9.70	9.70	11:42	447.80	10.00	9.50
15	09:15	341.30	9.20	10.10	10:32	498.90	9.70	9.60	11:43	451.10	9.90	9.50
16	09:16	340.90	9.40	9.90	10:33	501.50	9.70	9.70	11:44	438.30	10.00	9.40
17	09:17	353.10	9.10	10.10	10:34	507.40	9.60	9.70	11:45	440.60	9.80	9.60
18	09:18	355.90	9.30	10.00	10:35	503.90	9.60	9.70	11:46	435.40	9.80	9.60
19	09:19	354.50	9.40	9.90	10:36	499.50	9.60	9.70	11:47	418.70	10.10	9.30
20	09:20	364.40	9.20	10.10	10:37	501.50	9.60	9.70	11:48	422.30	10.10	9.30
21	09:21	364.70	9.10	10.10	10:38	502.70	9.70	9.70	11:49	417.60	10.10	9.30
22	09:22	358.00	9.30	9.90	10:39	498.50	9.70	9.70	11:50	423.10	9.90	9.50
23	09:23	370.60	9.00	10.20	10:40	505.00	9.50	9.80	11:51	416.70	10.10	9.40
24	09:24	364.20	9.40	9.90	10:41	503.40	9.60	9.80	11:52	411.20	10.20	9.30
25	09:25	363.90	9.50	9.80	10:42	497.00	9.70	9.70	11:53	414.60	10.10	9.40
26	09:26	373.70	9.30	10.00	10:43	510.10	9.60	9.70	11:54	398.30	10.20	9.30
27	09:27	386.10	9.00	10.30	10:44	500.10	9.80	9.60	11:55	409.30	10.00	9.50
28	09:28	372.50	9.40	9.90	10:45	515.70	9.50	9.80	11:56	410.70	9.90	9.50
29	09:29	366.80	9.50	9.80	10:46	504.10	9.80	9.50	11:57	411.70	9.90	9.60
30	09:30	380.20	9.30	10.00	10:47	516.80	9.60	9.80	11:58	401.60	10.10	9.40
31	09:31	389.80	9.40	9.90	10:48	507.80	9.80	9.60	11:59	398.10	10.10	9.30
32	09:32	393.30	9.30	10.00	10:49	496.00	10.00	9.40	12:00	398.20	10.10	9.30
33	09:33	408.70	9.20	10.10	10:50	513.60	9.60	9.80	12:01	399.90	10.00	9.40
34	09:34	419.70	9.10	10.20	10:51	528.10	9.50	9.90	12:02	391.70	10.20	9.30
35	09:35	417.80	9.20	10.00	10:52	521.40	9.60	9.70	12:03	403.10	9.90	9.50
36	09:36	404.60	9.70	9.60	10:53	514.00	9.80	9.60	12:04	405.40	9.90	9.50
37	09:37	413.80	9.50	9.90	10:54	512.40	9.70	9.60	12:05	398.70	10.10	9.30
38	09:38	428.50	9.30	10.00	10:55	520.40	9.70	9.70	12:06	392.30	10.30	9.20
39	09:39	437.90	9.10	10.10	10:56	511.10	9.90	9.50	12:07	408.10	10.00	9.40
40	09:40	437.70	9.30	10.00	10:57	512.20	9.80	9.60	12:08	409.60	10.00	9.40
41	09:41	431.80	9.30	9.90	10:58	512.90	9.80	9.60	12:09	409.50	10.00	9.50
42	09:42	434.80	9.20	10.00	10:59	504.70	9.90	9.50	12:10	409.50	9.90	9.50
43	09:43	437.40	9.40	9.90	11:00	499.60	10.00	9.40	12:11	413.00	9.80	9.60
44	09:44	435.70	9.40	9.90	11:01	512.80	9.80	9.60	12:12	411.60	9.80	9.60
45	09:45	435.80	9.50	9.80	11:02	511.40	9.80	9.60	12:13	389.20	10.20	9.20
46	09:46	444.00	9.30	10.00	11:03	507.10	9.90	9.50	12:14	397.50	10.00	9.40
47	09:47	446.70	9.30	10.00	11:04	499.80	10.00	9.40	12:15	397.10	10.00	9.40
48	09:48	450.10	9.30	10.00	11:05	498.20	10.00	9.40	12:16	399.40	10.10	9.40
49	09:49	462.70	9.20	10.00	11:06	501.00	9.90	9.50	12:17	404.30	10.10	9.30
50	09:50	455.60	9.40	9.90	11:07	504.10	9.90	9.50	12:18	401.90	10.20	9.20
51	09:51	454.80	9.40	9.90	11:08	501.70	9.90	9.50	12:19	410.10	9.80	9.60
52	09:52	456.70	9.50	9.80	11:09	508.70	9.90	9.50	12:20	411.20	9.80	9.50
53	09:53	458.40	9.40	9.90	11:10	495.70	10.10	9.40	12:21	401.80	10.00	9.40
54	09:54	481.10	8.90	10.30	11:11	507.40	9.90	9.50	12:22	391.40	10.30	9.10
55	09:55	473.50	9.20	10.00	11:12	489.40	10.10	9.30	12:23	392.40	10.40	9.00
56	09:56	466.90	9.30	10.00	11:13	502.90	9.80	9.60	12:24	398.10	10.20	9.20
57	09:57	461.90	9.40	9.90	11:14	502.90	9.80	9.60	12:25	419.30	9.90	9.50
58	09:58	470.10	9.40	9.90	11:15	490.70	10.00	9.50	12:26	403.30	10.00	9.40
59	09:59	474.80	9.40	9.90	11:16	488.20	10.00	9.40	12:27	406.40	9.90	9.50
60	10:00	487.60	9.10	10.20	11:17	484.60	10.10	9.30	12:28	385.70	10.30	9.20