$PM_{2.5}$, NO_x AND CO EMISSIONS FROM THE BISMARCK LANDFILL KING COLE KEWANEE BOILER BISMARCK, NORTH DAKOTA

Test Date: March 12, 2008

Prepared for:
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Revised Report Date:
April 25, 2008

EXECUTIVE SUMMARY

Bison Engineering, Inc. (Bison) was retained by Bitter Root RC&D to perform emissions testing for particulate matter less than 2.5 microns ($PM_{2.5}$), total particulate matter (TPM), nitrogen oxides (NOx) and carbon monoxide (CO) on the Bismarck Landfill King Cole Kewanee hot water boiler located in Bismarck, North Dakota. The following table presents the results of the low-fire and high fire testing.

Table 1: King Cole Hot Water Boiler Stack Emissions

Bismarck Landfill, Bismarck, ND King Cole Kewanee Hot Water Boiler Stack Emissions			
Emissions	**Units**	**Low-Fire** **Mar. 12, 2008**	**High-Fire** **Mar. 12, 2008**
$PM_{2.5}$	Concentration	0.0535 gr/dscf	0.0494 gr/dscf
	Mass rate	0.168 lbs/hr	0.194 lbs/hr
	Emission factor	0.168 lbs/MMBtu	0.133 lbs/MMBtu
TPM	Concentration	0.064 gr/dscf	0.072 gr/dscf
	Mass rate	0.203 lbs/hr	0.284 lbs/hr
	Emission factor	0.203 lbs/MMBtu	0.195 lbs/MMBtu
NOx	Concentration	111 ppmdv	126 ppmdv
	Mass rate	0.29 lbs/hr	0.42 lbs/hr
	Emission factor	0.291 lbs/MMBtu	0.289 lbs/MMBtu
CO	Concentration	215 ppmdv	138 ppmdv
	Mass rate	0.35 lbs/hr	0.28 lbs/hr
	Emission factor	0.35 lbs/MMBtu	0.20 lbs/MMBtu
Heat Input		1.01 MMBtu/hr	1.44 MMBtu/hr
Percent of 1,500,000 Btu/hr		67%	96%

Table Nomenclature

gr/dscf	grains per dry standard cubic feet (@ 68°F and 1 atm.)
lbs/hr	pounds per hour
lbs/MMBtu	pounds per million British thermal units
ppmdv	parts per million dry volume
MMBtu/hr	million British thermal units per hour
%	percent

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1.0 INTRODUCTION

Bison Engineering, Inc. (Bison) was retained by Bitter Root RC&D to perform air quality emissions testing on the Bismarck Landfill King Cole Kewanee hot water boiler located in Bismarck, North Dakota. The testing was performed according to the details listed in this report. The low-fire and high-fire tests were performed on March 12, 2008.

This report summarizes the results from the testing project and the operating conditions of the process during the testing. The appendices of this report contain the pretest protocol, spreadsheets, testing field data, production data, nomenclature and formulae, equipment/analyzer calibrations and audits, and Protocol 1 gas certifications.

1.1 Program Organization

Bison is a full service air quality consulting company that provides ambient air and meteorological monitoring, air quality permitting, air quality modeling, regulatory negotiations, process-to-emissions optimization and source testing services. Bison's ***Process and Emission Services*** team is led by Calvin Loomis, P.E., Project Engineer and Team Leader. Additional team members are Mike Chovanak, E.I.T., Project Engineer; Bill Shaw, P.E., Project Engineer; Dave Blankenship, Senior Environmental Technician; and Jim Wollenberg, Environmental Technician.

Primary:
Bitter Root RC&D
Address: 1709 N. First Street
Hamilton, Montana 59840
Contact: Tom Coston
Phone: 406/363-1444, ext. 5

Facility Info:
City of Bismarck
Contact: Jeff Heintz
Director, Public Works – Services Operations
Phone: 701/355-1700
Email: jheintz@an.gov

Boiler Contact:
King Coal, Inc
Contact: Vic Carufel
Phone: 701/255-6406
Email: kingcoal@btinet.net

Consultant:
Bison Engineering, Inc.
Address: 1400 11th Avenue
Helena, MT 59601
Contacts: Jim Wollenberg, ext. 225
Mike Chovanak, ext. 276
Cal Loomis, ext. 235
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Email: bison@bison-eng.com

2.0 EMISSION SOURCE INFORMATION

2.1 Facility Description

The boiler is located at the City of Bismarck Landfill.

2.2 Emission Source Description

The Bismarck Landfill operates a King Coal Kewanee hot water boiler. The boiler is specked to be a 1,000,000 But/hr but is manufactured to be a 1,500,000 MMBtu/hr boiler. The boiler has a 35-foot double wall stack with a 12-inch inside diameter.

3.0 TEST RESULTS SUMMARY

3.1 Summary of Emissions Determination

The following tables present the results from the March 12, 2008, emissions testing on the King Cole Kewanee hot water boiler stack. The emission data is presented in grains per dry standard cubic feet (gr/dscf), pounds per hour (lbs/hr), pounds per million British thermal units (lbs/MMBtu) and parts per million dry volume (ppmdv). Additional emissions data and nomenclature can be found in the appendices of this report.

Table 2a: King Cole Boiler Low-Fire Test Results

Bismarck Landfill, Bismarck, ND King Cole Kewanee Boiler Low-Fire Emissions, March 12, 2008					
		Run 1	**Run 2**	**Run 3**	**Avg.**
Stack Flow	acfm	625	634	651	772
	dscfm	378	366	356	367
$PM_{2.5}$	gr/dscf	0.0528	0.0536	0.0540	0.053
	lbs/hr	0.171	0.168	0.165	0.168
	lbs/MMBtu	0.190	0.150	0.165	0.168
TPM	gr/dscf	0.0638	0.0651	0.0646	0.064
	lbs/hr	0.207	0.204	0.197	0.203
	lbs/MMBtu	0.230	0.182	0.198	0.203
Combustion Gases					
NOx	ppmdv	105.3	117.3	111.7	111.5
	lbs/hr	0.285	0.307	0.284	0.292
	lbs/MMBtu	0.316	0.273	0.285	0.291
CO	ppmdv	282.5	159.4	204.2	215.4
	lbs/hr	0.466	0.255	0.317	0.346
	lbs/MMBtu	0.518	0.226	0.318	0.354
Operating Conditions					
Oxygen, % dry		13.2	11.0	11.9	12
Heat Input, MMBtu/hr		0.90	1.13	1.00	1.01
Percent of 1,500,000 Btu/hr		60%	75%	67%	67%

Table 2b: King Cole Kewanee Boiler Low-Fire PM Proportions

Bismarck Landfill, Bismarck, ND King Cole Kewanee Boiler Low-Fire PM Emissions Proportions March 12, 2008	
PM greater than 2.5	17%
Filterable $PM_{2.5}$	46%
Condensable PM	36%

Table 3a: King Cole Boiler High-Fire Test Results

Bismarck Landfill, Bismarck, ND King Cole Kewanee Boiler High-Fire Emissions, March 12, 2008				
		Run 4	**Run 5**	**Avg.**
Stack Flow	acfm	831	830	831
	dscfm	468	454	461
$PM_{2.5}$	gr/dscf	0.0335	0.0653	0.049
	lbs/hr	0.135	0.254	0.194
	lbs/MMBtu	0.098	0.169	0.133
TPM	gr/dscf	0.0531	0.0910	0.072
	lbs/hr	0.213	0.354	0.284
	lbs/MMBtu	0.154	0.236	0.195
Combustion Gases				
NOx	ppmdv	119.7	133.1	126.4
	lbs/hr	0.400	0.431	0.416
	lbs/MMBtu	0.290	0.287	0.289
CO	ppmdv	175.8	100.2	138.0
	lbs/hr	0.359	0.198	0.279
	lbs/MMBtu	0.260	0.132	0.196
Operating Conditions				
Oxygen, % dry		11.4	10.2	11
Heat Input, MMBtu/hr		1.38	1.50	1.44
Percent of 1,500,000 But/hr		92%	100%	96%

Table 3b: King Cole Kewanee Boiler High-Fire PM Proportions

Bismarck Landfill, Bismarck, ND King Cole Kewanee Boiler High-Fire PM Emissions Proportions March 12, 2008	
PM greater than 2.5	33%
Filterable $PM_{2.5}$	26%
Condensable PM	42%

3.2 Production Data

Boiler production data is presented in the test results tables.

3.3 Field Notes

Testing proceeded without interruption. There were no deviations from the methods listed in this report.

4.0 TESTING PROCEDURES

4.1 Sampling Site Locations

Sample site locations were determined by Method 1.

4.2 Test Methods and Procedures

Bison testing personnel performed the following EPA methods as described in Title 40, Code of Federal Regulations (CFR), Part 60, Appendix A:

EPA Reference Method 1, *"Sample and Velocity Traverses for Stationary Sources."* The objective of Method 1 is to determine a suitable location for testing and to determine the velocity measurement points for the source. The distance upstream to atmosphere from the sampling ports (Distance A) is measured and the distance downstream to the nearest disturbance from the sample points (Distance B) is measured. Distances A and B are applied to Method 1, Figure 1-2 for velocity measurement points. These figures give the minimum number of measurement points according to the dimensions of the source. The number of points and the stack diameter are then applied to Method 1, Table 1-2 to determine equal area measurement points within the source. The results of Method 1 location and velocity point measurement locations are included in the report appendices.

EPA Reference Method 2, *"Determination of Stack Gas Velocity and Volumetric Flow Rate (Type-S Pitot Tube)."* The objective of Method 2 is to measure stack gas velocity, collect temperature data, and calculate a volumetric flow. Method 2 velocity measurements are performed using a Type S pitot tube. Differential pressures are measured using an inclined manometer, and temperatures are measured using a k-type thermal indicator. Bison has incorporated 0.84 as the Type S pitot tube coefficient (Cp). The average velocity, temperature, static pressure, and source area are used to calculate volumetric flow within the source. This field data is recorded on field data sheets. Copies of the field data, results from the flow calculations, and calibration data can be found in the appendices to this report.

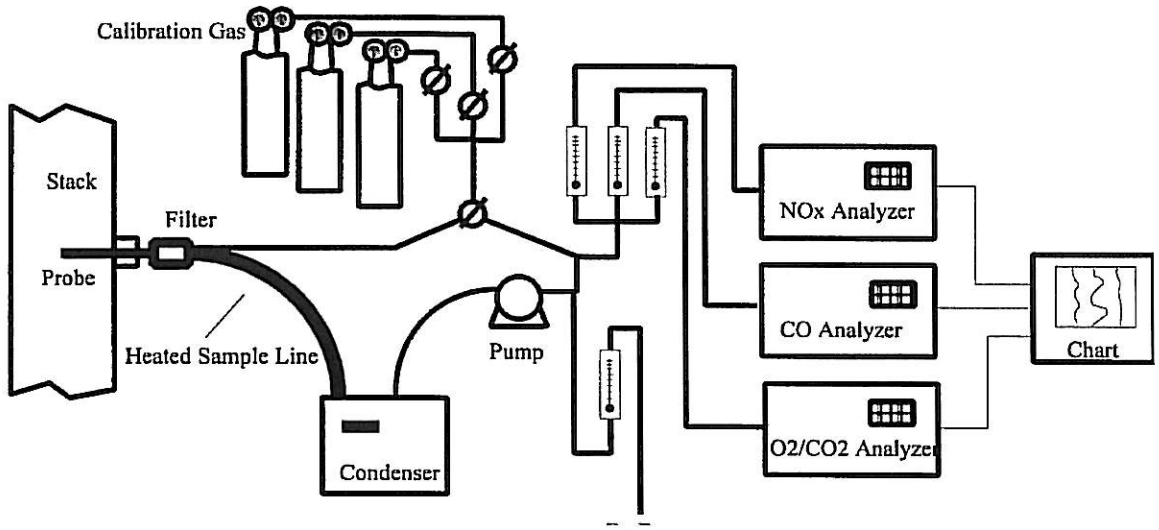
Method 3A, "*Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)."* The objective of Method 3A is to determine the molecular weight of the source stream by determining oxygen (O_2) and carbon dioxide (CO_2) concentrations in the stack gas stream. The principle is to extract a gas sample from a stationary source and route the sample through a conditioning system to a paramagnetic oxygen analyzer and an infrared carbon dioxide analyzer for the measurement of O_2 and CO_2 in percentages (%). The O_2 and CO_2 analyzers calibration adjustments are performed by sending EPA Protocol 1 gas directly to the analyzers. A system calibration is performed by sending calibration gas to the probe and through the system to the analyzers. Bison's CO_2/O_2 analyzer is a Servomex Series 1400 (Serial Numbers 01415/B198 and 014208/901, respectively). The calibration error, system bias and system drift data, and measured concentrations were

recorded on a stripchart or data acquisition system (DAS). A copy of this data is included in a report appendix.

Method 4, *"Determination of Moisture Content in the Stack Gases."* The objective of Method 4 is to determine the moisture content of a gas stream. The principle of the method is to extract a sample from the source at a constant rate and impinge it through chilled water and silica gel. The moisture is removed from the sample stream and the volume (or mass) of water extracted is determined. The sample volume and water volume (or mass) are used to calculate the moisture content of the stack gas. The results of pre- and post-test dry gas meter (DGM) calibrations can be found in the DGM calibrations table. The DGM calibration data can be found in an appendix of this report. The impinger waters are volumetrically measured on-site and the silica gels are transported to Bison's lab and weighed. The test data is hand-recorded on field data sheets and then entered into spreadsheets for moisture determination calculations. This data and the resulting moisture can be found in the appendices of this report.

EPA Reference Method 7E, *"Determination of Nitrogen Oxides Emissions from Stationary Sources."* The objective of Method 7E testing is to determine the NOx concentration from the source. Method 7E entails extraction of a gas sample from a stationary source and routing the sample through a conditioning system to an analyzer for the measurement of NOx (NO and NO_2) in ppmvd. The NO_2 analyzer calibration adjustment is performed by sending EPA Protocol 1 gas directly to the analyzer. A system bias check is performed by sending calibration gas to the probe and through the system to the analyzer. Bison uses a Thermo Environmental 42C (NO-NO_2-NO_x) analyzer, Serial Number 42CHL-56022-306. The calibration error, system bias and system drift data, and measured concentrations are recorded on a stripchart or DAS for permanent record.

Typical Layout of a Method 7E and 10 Sampling System



EPA Reference Method 10, "*Determination of Carbon Monoxide Emissions from Stationary Sources (Instrumental Analyzer Procedure).*" The objective of Method 10 is to determine the CO concentrations from the source. Method 10 entails extraction of a gas sample from a stationary source and routing the sample through a conditioning system to an analyzer for the measurement of CO in ppmvd. The CO analyzer calibration adjustment is performed by sending EPA Protocol 1 gas directly to the analyzer. A system bias check is performed by sending calibration gas to the probe and through the system to the analyzer. Bison uses a Thermo Environmental Instruments 48C CO Analyzer, Serial Number 48C-55909-305. The calibration error, system bias and system drift data, and measured concentrations are recorded on a stripchart or DAS for permanent record.

EPA Reference Method 19, *"Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Oxides Emissions Rates."* Method 19 is employed for the determination of mass rate emissions. Results from Methods 3A, 7E and natural gas dry F factor (F_d) (from Table 19-1) are employed to calculate an NO_X emission rate (E) according to the following steps.

Step 1: Calculate NO_X in pounds per standard cubic feet (lbs/scf). Method 19, Table 19-1, provides factors to convert ppm NO_X to lb/scf.

$$C_d = NO_X \text{ ppm} \times 1.194\times10^{-7} \text{ lbs/scf/ppm} = NO_X \text{ lbs/scf}$$

Step 2: Calculate NO_X results in pounds per hour using Table 19-2 "Factors for Various Fuels," using the F_d factors and measured oxygen (O_2).

$$E = F_d \, {}^{dscf}/_{MMBtu} \; C_d \; \frac{20.9}{(20.9 - \%O_2)} = NOx \text{ lbs/MMBtu}$$

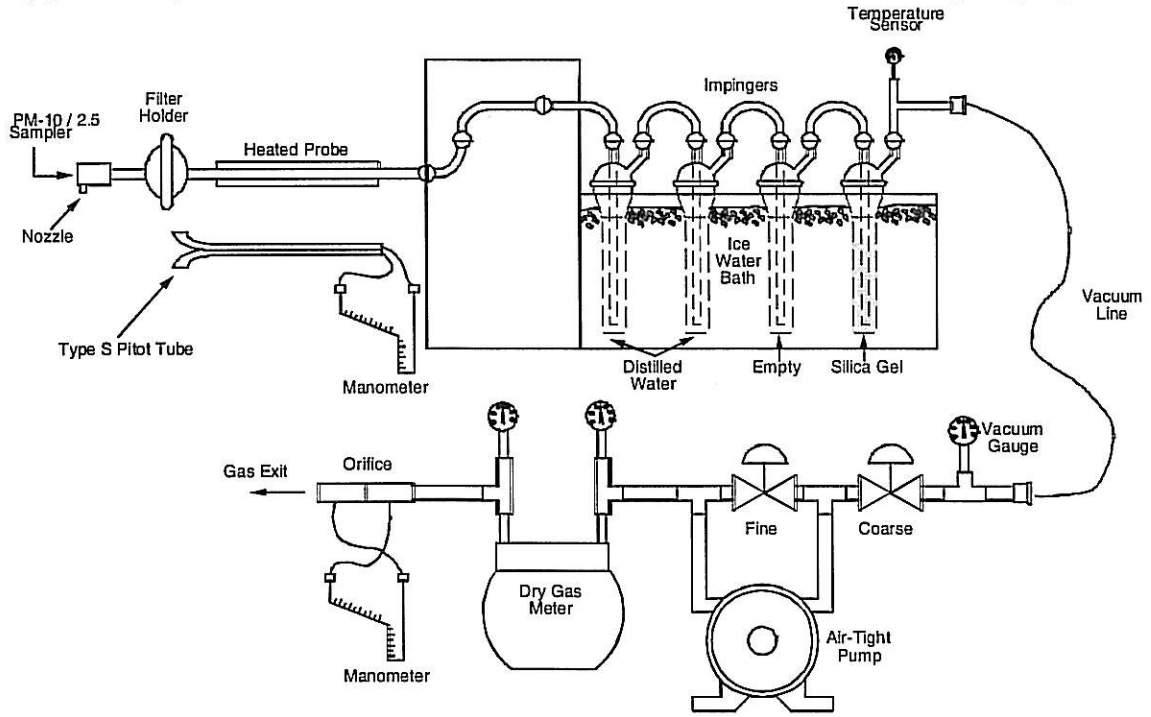
Where: E = pollutant emission rate (lbs/MMBtu)
C_d = pollutant concentration dry basis (lbs/scf)

Step 3: Using the fuel usage measured during the test and the heating factor of 969.2 Btu/scf n.g., calculate the NO_X results in pounds per hour as follows.

$$E \; {}^{lbs}/_{MMBtu} \times 9.692 \times10^{-4} \; {}^{MMBtu}/_{scf\ n.g.} \times \text{fuel} \; {}^{scf\ n.g.}/_{hr} = NOx \text{ lbs/hr}$$

Conditional Test Method 40,*"Determination of $PM_{2.5}$ Emissions (Constant Sampling Rate Procedure)" (Methods 2 & 4 Inclusive).* The objective of Method CT40 is to determine the particulate matter (PM) emissions equal to or less than an aerodynamic diameter of 2.5 microns from stationary sources. The principle is to draw the sample stream through an in-stack cyclone which cuts the PM. The matter less than 2.5 microns proceeds to a 0.3 micron filter. Matter less than 0.3 microns is captured in water impingers. CT40 incorporates Method 2 "velocity measurements" and Method 4 "moisture measurements."

Typical Layout of a Method 201A PM_{10} or CT40 $PM_{2.5}$ Sampling System



4.3 Analytical Methods

Chain of Custody: Bison staff maintained possession of the samples throughout sampling, transport and analysis.

Filter Analysis: Bison weighed filters in an environmentally controlled room. Before field use, the filters were desiccated for a minimum of 24 hours, then weighed and desiccated at 6-hour intervals until a constant pre-test tare was achieved. After the tests, the filters were desiccated for a minimum of 24 hours, then weighed and desiccated at 6-hour intervals until constant post-test weight was achieved. The difference between the average pre-test tare and average post-test weight was the filter mass capture. Sample descriptions are recorded on the field data forms.

Nozzle, Cyclone, Probe and Filter-bell Rinse Analysis: The nozzle, probe and filter-bell were rinsed with acetone. The rinsate was collected in a sample bottle, transferred to a pre-conditioned, tared aluminum sample boat and heated to evaporate the acetone. The boat was again conditioned and weighed to determine "front-half" rinse particulate matter. The rinse mass capture was added to the filter particulate capture to determine "front-half" filterable PM emissions.

Impinger Water: Post-test impinger water description of color and presence of film are recorded on field data sheets. The impinger waters are volumetrically measured after each test run and rinsed with MeCl. The water and rinse is then transferred to uniquely identified sample containers for transport to Bison's lab. At the lab, sample containers are

checked for leakage then the waters are transferred to graduated cylinders where the volumes are checked for leakage.

Impinger Water Organic and Inorganic Matter Analysis: The impinger waters are decanted into a separatory flask and 75 mls of methylene chloride (MeCl) are added and mixed well. The organic fraction is then drained off into a tared beaker and the extraction is performed one more time. The remaining inorganic fraction is drained into a tared beaker. Both beakers are then dried, desiccated and weight gain analysis is performed.

Organic CPM, Methylene Chloride (MeCl) Extractable Matter (MCEM): The impinger waters are transferred to a separatory flask where MeCl is added. The flask is shaken and allowed to settle. The solution separates into two distinct aqueous solutions, and the lower solution is separated off into a tared beaker. This process is repeated. Once the solution has evaporated to less than 50 mls, the solution is transferred to a pre-conditioned, tared boat and allowed to air dry until completely evaporated. After evaporation, the boats are then placed in a desiccator for a minimum of 6 hours after which they are weighed in 6-hour intervals until a constant weight is achieved. This weight gain results in the MCEM.

Inorganic CPM: The remaining water in the flask is drained into another tared beaker and placed on a warming plate to evaporate. Once the water has evaporated to less than 50 mls, the water is transferred to a pre-conditioned, tared boat and allowed to air dry until completely evaporated. After evaporation, the boats are then placed in a desiccator for a minimum of 6 hours after which they are weighed in 6-hour intervals until a constant weight is achieved.

Silica Gel: Bison transports pre-dried silica gel in airtight containers holding approximately 250 grams. Each container is weighed prior to use in a sampling train. After testing, the gel is placed back into the container and reweighed for moisture gain. Pre- and post-test silica gel weights are recorded in the lab, entered into the spreadsheets and may be recorded on field data sheets.

Fuel samples were taken during the testing project and sent to the following lab for ultimate analysis and Btu determination. The lab results are presented in an appendix to this report.

Hazen Research Inc.
4601 Indiana Street
Golden, Colorado 80403
Tel. 303 279-4501
Fax 303 278-1528
Contact: Gerard H. Cunningham, Fuel Laboratory Manager

5.0 QUALITY ASSURANCE AND QUALITY CONTROL

5.1 Documentation and Tracking

Bison uses a project number for document control and tracking for all projects. Each project that Bison works on is assigned a project number. All documentation pertaining to that project is filed in the same place under that project number. This assures all pertinent information can be found easily at a later date.

The tracking number for this project is **BRR208862.**

5.2 Sampling Protocol

Bison's test, laboratory, reporting, and quality assurance procedures conform to the requirements specified in the *Quality Assurance Handbook for Air Pollution Measurement Systems, Vol. III, Stationary Source Specific Methods,* published by the U.S. Environmental Protection Agency in August, 1977, as revised and amended (cat. #EPA-600/4-77-027b).

The individual test methods specify handling procedures for physical samples (liquids, traps, etc.). Bison follows the procedures outlined in the appropriate methods as described in EPA 40 CFR Part 60, Appendix A and Appendix B.

5.3 Quality Assurance

Bison's quality assurance program is designed to ensure that all source testing methods are followed and are performed by competent, experienced personnel. Bison's equipment is properly calibrated and maintained in good working order. Procedures for sample collection, recovery, and analysis are performed according to applicable EPA methods. Bison's practices conform to the procedures in the Environmental Protection Agency (EPA) *Quality Assurance Handbook for Air Pollution Measurement Systems*, Volume 3, EPA-600/4-77-0276, 1977, as amended.

Bison personnel calibrate equipment and instruments using standards when applicable or per the procedures of National Institute of Standards and Technology (NIST). Bison's equipment is manufactured to meet all applicable EPA criteria and parameters. Bison defines a calibration as the procedure of changing a measurement system or device to match a constant or standard measurement system or device; an "audit" checks the variance between the value and a standard or a precalibration.

Emission testing quality assurance checks and quality controls (QA/QC) require three steps: before, during, and after field testing. "Before" QA/QC procedures are performed in Bison's lab, "during" QA/QC checks are recorded on the field data sheets, and "after" QA/QC procedures are performed at Bison's lab. These data can be found in the

appendices. The following table describes Bison's QA/QC, calibration and audit procedures and schedule.

Table 4: Equipment Calibration and Audit Procedures

Parameter or Unit	Schedule and Requirement	Method Reference
Acetone / DI water	Blank analysis on the rinse solution.	Method 5, 3.2
Probe nozzle	Calibration according to reference.	Method 5, 5.1
Isolated Type S pitot tubes	Calibration prior to initial field use.	Method 2, 10.1
	Re-examined after each field use.	Method 2, 10.1.5.2.1
Temperature gauges	Audited on-site and/or after each field use.	Method 2, 10.3.1
Probe heater	Calibration prior to initial field use.	Method 5, 5.4
Barometer	Calibrated against Hg barometer.	Method 2, 10.4
Metering system	Calibration prior to use.	Method 5, 10.3.1
	Calibration after use.	Method 5, 10.3.2
Analytical balance	Calibrated and/or audited each year by independent auditor.	N/A
	Audited during sample weighing.	N/A
Analyzers	Analyzer calibration error, ACE.	Method 7E, 8.5
	NO_2 to NO conversion test.	Method 7E, 8.2.4
Sample system	Sample system bias check, SB.	Method 7E, 8.5
	Zero and calibration drift tests.	Method , 7E.8.5

5.4 Volumetric Sampling Equipment Calibrations

Volumetric Sampling by Dry Gas Meter (DGM)

Volumetric sampling by DGM must be initially calibrated across its full operating range then audited after each testing project. The post-test audit must be within 5% of its initial calibration. Should the DGM not be within the 5% criteria, the DGM factors must be used that will give the lowest sample volume. Calibration data can be found in an appendix to this report. The following table presents the results of the pre- and post-test DGM calibrations and audits.

Table 5: Meter Box Calibration Results

Bison Engineering Equipment Calibration Record				
Unit	Pre-Calibration	Post-Calibration	Results	Required
Meter Box 4, "Y"	1.049	1.041	0.01%	±5% from pre-calibration

Method 5, Section 5.3.3, states that, should the pre- and post-"Y" factor calibrations differ more than 5%, the lesser "Y" value shall be used in the calculations.

5.5 Instrument Calibration, Maintenance and Standards

Bison uses a field barometric pressure gauge that is calibrated prior to each field deployment against a mercury-in-glass standard barometer. Temperature calibrations are performed using a mercury-in-glass NIST-traceable thermometers.

Bison uses RATA-class calibration gases for all emission testing projects which are certified as EPA Protocol 1 gases and are purchased from Scott Specialty Gases. The calibration gas certifications are included in the appendix of this report.

Calibration adjustments of the analyzers are performed by sending the Protocol 1 gas directly to the analyzers. A system audit is performed before and after each test run by sending calibration gas to the probe and through the system to the analyzers. The results of these calibrations and audits can be found in the spreadsheets located in the appendices.

5.6 Data Acquisition, Reduction and Validation

Test data such as velocities, temperatures and isokinetic sampling are hand-recorded on field data sheets. The data is then entered into computer spreadsheets where QC/QA and emission calculations are performed according to the methods. An appendix of this report contains nomenclature and formulae for reference. All raw field data is supplied in an appendix to this report. The appendix contains some example calculations; additional examples will be supplied upon request.

Rounding of Significant Figures

If the first digit to be discarded is less than five, the last digit retained should not be changed. When the first digit discarded is greater than five, or if it is a five followed by at least one digit other than 0, the last figure retained should be increased by one unit. When the first digit discarded is exactly five, followed only by zeros, the last digit retained should be rounded upward if it is an odd number, but no adjustment made if it is an even number.

For example, if the emission standard is 90, than 90.357 would be rounded to 90, 90.639 would be rounded to 91, 90.500 would be rounded to 90, and 91.500 would be rounded to 92.

Standard	Number	Rounded To
90	90.357	90
90	90.639	91
90	91.500	92

APPENDIX A:
LOW-FIRE PM TEST DATA

Bison Engineering
Method 201A Spreadsheet
Method 201A PM_{10} & CT40 $PM_{2.5}$ Test

COMPANY	**Bitter Root**
FACILITY	**Bismarck Landfill**
LOCATION	**Bismarck N.D.**
SOURCE	**Boiler, Low Fire**
DATE	**Mar 12, 08**

Method 201A PM10 & CT Method 40 PM2.5

Client	Bitter Root				Number
Facility	Bismarck Landfill				of Runs
Location	Bismarck N.D.				3
Source	Boiler, Low Fire				
Test date		Mar 12, 08	Mar 12, 08	Mar 12, 08	
Start time		9:21	10:40	11:56	
Test run		One	Two	Three	
Preliminary info					
Barometric pressure [Bp]	"Hg	27.88	27.88	25.87	
Stack Diameter	inch	12	12	12	
stack exit area	sqft	0.79	0.79	0.79	
Meter box ID		3	3	3	
meter box Yi		1.003	1.003	1.003	
meter box delta H@		1.76	1.76	1.76	
Pitot tube coefficient Cp		0.84	0.84	0.84	
Test Information					
nozzle size [nz]	inch	0.35	0.35	0.35	
filter number		2982	2983	2984	
Sample points		12	12	12	
Test duration	min	48	48	48	
Isokinetics [i]	%	136	137	116	
D50 cut rate		10.22	10.21	10.16	
Sample volume, eq 4.3	dscf	20.94	19.53	18.23	
avg delta P	"H2O	0.036	0.036	0.036	
avg sqrt delta P	"H2O	0.190	0.191	0.191	
201A Constant sample rate delta H	"H2O	0.56	0.57	0.59	
CT40 Constant sample rate delta H	"H2O	0.51	0.51	0.54	
avg meter temp [Tm]	deg F	58.7	63.5	65.8	
Stack Information					AVERAGES
avg stack temp [ts]	deg F	313	321	301	312
avg ABS stack temp [Ts]	deg R	773	781	761	772
actual stack flow	acfm	625	634	651	637
actual stack velocity [Vs]	ft/sec	13.3	13.4	13.8	14
Standard stack flow	dscfm	378	366	356	367
Standard stack flow	dscf/hr	22710	21981	21343	22011
stack moisture [bws], eq 4.4	% v/v	4.96	8.19	8.98	7
measured static pressure	"H2O	0	0	0	0
stack static pressure [ps]	"Hg	27.88	27.88	25.87	27.21
Oxygen content	%O2	13.25	11.01	11.89	12
Carbon dioxide content	%CO2	7.75	9.99	9.11	9
Wet (Actual) Molecular Weight, Ms	lb/lb.mole	29.2	29.1	28.9	29.0
Dry Molecular Weight, Md	lb/lb.mole	29.8	30.0	29.9	29.9
Lab Information					
Impinger H2O Gain	mls	20	35	35	
Impinger H2O volume [Vwc(STD)], eq 4.1	scf	0.94	1.65	1.65	
Silica Gel H2O Gain	grams (g)	3.2	2	3.2	
Silica Gel volume [Vsg(STD)], eq 4.2	scf	0.15	0.09	0.15	
Lab Data, cyclone > PM2.5 weight gain	g	0.0150	0.0145	0.0125	
Lab Data, cyclone PM2.5 weight gain	g	0.0009	0.0024	0.0009	
Lab Data, Filter PM2.5 weight gain	g	0.0375	0.0373	0.0345	
Lab data condensible PM (CPM)	g	0.0319	0.0270	0.0273	
Lab data MeCl Matter (MCEM)	g	0.0013	0.0012	0.0011	
cyclone > PM2.5 weight gain	grains (gr)	0.2315	0.2238	0.1929	
cyclone PM2.5 weight gain	gr	0.0139	0.0370	0.0139	
Filter PM2.5 weight gain	gr	0.5787	0.5756	0.5324	
condensible PM (CPM)	gr	0.4923	0.4167	0.4213	
MeCl Matter (MCEM)	gr	0.0201	0.0185	0.0170	
Grain loading Emissions					AVERAGES
> PM2.5 cut	gr/dscf	0.0111	0.0115	0.0106	0.0110
PM 2.5 cyclone & filter	gr/dscf	0.0283	0.0314	0.0300	0.0299
condensible PM (CPM)	gr/dscf	0.0235	0.0213	0.0231	0.0227
MeCl Matter (MCEM-CPM))	gr/dscf	0.0010	0.0009	0.0009	0.0009
EPA PM2.5 + CPM	gr/dscf	0.0528	0.0536	0.0540	0.0535
Total PM	gr/dscf	0.0638	0.0651	0.0646	0.0645
Mass Rate Emissions					AVERAGES
> PM2.5 cut	lbs/hr	0.036	0.036	0.032	0.0347
PM 2.5 cyclone & filter	lbs/hr	0.092	0.098	0.091	0.0939
condensible PM (CPM)	lbs/hr	0.076	0.067	0.070	0.0712
MeCl Matter (MCEM-CPM))	lbs/hr	0.003	0.003	0.003	0.0030
EPA PM2.5 + CPM	lbs/hr	0.171	0.168	0.165	0.1681
Total PM	lbs/hr	0.207	0.204	0.197	0.2028
Emission Factor					AVERAGES
lab analysis Fd @ 0% oxygen	dscf/MMBtu @ 0%	9242	9242	9242	9242
lab analysis Fd @ stack conditions	dscf/MMBtu @ SK	25249	19531	21438	22073
EPA PM2.5 + CPM	lbs/MMBtu	0.190	0.150	0.165	0.1685
TPM	lbs/MMBtu	0.230	0.182	0.198	0.2032
Boiler operating rate	MMBtu/hr	0.90	1.13	1.00	1.01

Test Run 1 **Bison Engineering, Method 201A PM_{10} & CT40 $PM_{2.5}$ Spreadsheet**

Data by	jw, mc	Checked by	cwl

Facility:	Bitter Root	**Location:**	Bismarck N.D.	**Date:**	Mar 12, 08
Operators:	**Filter #** 2982	**Source:**	Boiler, Low Fire	**Start time:** 9:21	**End time:**

PRELIMINARY INFO.

Pm	Bp			27.88	("Hg)
	Diam	Lngth	Wdth	Rnd sqft	Rect. sqft
(inches)	12			0.79	0
	Stack AREA			0.79	(sqft)
	Yi			1.003	
	Delta H@			1.76	

PRE TEST INFO

	Assumed moisture	5.0	(%)
	Assumed Meter Temp	65.0	(deg F)
	Target Run Time	48.0	(min)
	Total Number of Points	12	

TRAVERSE INFO

Pg	Static, gage pressure	0.00	("H2O)
	Stack Temp, ts	330.0	(deg F)
O_2	Abs stack Temp, Ts	790	(deg R)
CO_2	Oxygen, dry	13.3	(% v/v d)
	Oxygen, wet	12.5875	(% v/v w)
	Carbon Dioxide, dry	7.8	(% v/v d)
	Molecular weight, dry	29.77	(lb/lb.mole)
	Molecular weight, wet	29.1815	(lb/lb.mole)

201A Calculations

us	201A stack viscosity			243.49	(micropoise)
Qs	201A Cylone flow rate			0.685	(ft^3/min)
ΔH	**201A Delta H ==>**			**0.56**	("H20)
	RANGE	0.50	- 50 °F	0.64	+ 50 °F

CT40 Calculations

us	CT40 stack viscosity			237.57	(micropoise)
C	Cunningham Corr. Factor			1.11	
D_{50LL}	Lower limit cut diameter			9.41	(micrometers
D_{50T}	Cut diam for cyclone			10.20	(micrometers
Qs	CT40 Cylone flow rate			0.649	(ft^3/min)
Nre	Reynolds number			2432	Nre < 3162 *
ΔH	**CT40 Delta H ==>**			**0.51**	("H20)
	RANGE	0.45	- 50 °F	0.58	+ 50 °F

NOZZLE SELECTION

Nd					
201A	•136 •15 •164 •182 •197 •215 •233 •264 •3 •342 •39				
CT40	N1•125 N2•138 N3•156 N4•172 N5•188 N6•20 N7•22 N8•25				
H_2O	Nozzle Diameter estamate	0.385	Selected >	0.35	
H_2O	delta P (min)	ERR	AVG	ERR	AVG
H_2O	delta P (max)	NA	ERR	NA	ERR
H_2O	Alt - delta P (min)	ERR	ERR	ERR	ERR
H_2O	Alt - delta P (max)	0.131	ERR	0.118	ERR

POST TEST INFO

Impinger water	20	Silica gel	3.2 (g)

CALCULATED RESULTS

Ps	Stack pressure, Ps	27.88	(" Hg)
Bws	% H2O in Stack	4.96	(Bws)
Mw	Actual Wet Molecular Weight	29.19	(lb/lb.mole)
Vs	Dry STD sample Volume	20.94	(dscf)
	Final Sampling Time	47.9	(min)
us	Post test stack viscosity	238.74	(micropoise)
C	Post test Cunningham corr. factor	1.11	
D_{50LL}	Post test lower limit cut diameter	9.45	(micrometers)
D_{50T}	Post test cut diam for cyclone	10.22	(micrometers)
Qs std	Post test cyclone flow rate	0.65	(ft^3/min)
I	Isokinetic Avg, { 80 < I < 120 }	136	(%)
D50	D50 Cut Rate, { 9 < d50 < 11 }	10.2	(um)

Revised Sept 08/01 by CWL

Test	Pre traverse		Point	Run	MetrVol	Vel head		201A CT40	Stack	Meter Temp			Assumed	Actual	Rolling	STACK Vel.	STACK Flow	STACK Flow
No	dP	sqrt dP	Time	Time	32.05	delta P	sqrt dP	delta H	Temp	In	Out	Avg	% I	%I	%I	ft/sec	acfm	dscfm
1	0.036	0.19	4.0	4.0	33.86	0.036	0.19	0.56	255	57	55	56	129.58	130	130	12.77	602	394
2	0.036	0.19	4.0	8.0	35.64	0.036	0.19	0.56	322	58	55	56.5	133.14	133	131	13.36	629	376
3	0.036	0.19	4.0	12.0	37.28	0.036	0.19	0.56	325	59	56	57.5	122.67	123	128	13.38	631	376
4	0.038	0.19	4.1	16.1	39.12	0.038	0.19	0.56	325	59	56	57.5	130.69	131	129	13.75	648	386
5	0.040	0.20	4.2	20.3	41.09	0.040	0.20	0.56	326	59	56	57.5	133.22	133	130	14.12	665	396
6	0.042	0.20	4.3	24.6	42.85	0.042	0.20	0.56	327	60	57	58.5	113.30	113	127	14.47	682	405
7	0.042	0.20	4.3	28.9	44.85	0.042	0.20	0.56	325	61	58	59.5	128.34	128	127	14.45	681	406
8	0.028	0.17	3.5	32.4	46.80	0.028	0.17	0.56	316	61	58	59.5	187.20	187	135	11.73	553	333
9	0.035	0.19	3.9	36.3	48.00	0.035	0.19	0.56	307	62	58	60	91.84	92	130	13.04	615	375
10	0.036	0.19	4.0	40.3	50.46	0.036	0.19	0.56	308	62	59	60.5	180.95	181	135	13.24	624	380
11	0.032	0.18	3.8	44.1	51.90	0.032	0.18	0.56	308	62	59	60.5	118.26	118	134	12.48	588	358
12	0.032	0.18	3.8	47.9	54.02	0.032	0.18	0.56	308	62	59	60.5	174.11	174	137	12.48	588	358
	avg dP	avg. ⌈dP	sample volume		21.970	avg. dP	avg. ⌈dP	dH	Ts		Tm					ft/sec	acfm	dscfm
	0.036	0.190				0.036	0.190	0.56	312.67	ts °F	58.67	tm °F				13.27	625	379
avg sqrt dP squared		0.036							772.67	Ts °R	518.67	Tm °R						

CT040 TEST METHOD CALCULATIONS
Test Run 1

ts	Ts	O2 dry	O2 wet	Bws	Ps	Mw	Md	Pbar	Tm	ΔH@
330	790	13.25	12.59	0.05	27.88	29.1815	29.77	27.88	525	1.76

Eq. 3 **CT040 viscosity**

C1	C2	C3	C4	C5	C6
-150.3162	13.4622	3.86E+06	0.591123	91.9723	1.52E-05

$u = C1 + C2 (\text{sqrt } Ts) + C3\ Ts^{-2} + C4\ (\%O_{2\ wet}) - C5\ Bws + C6\ Bws\ Ts^2$

	C1	C2	sqrt Ts	C3	Ts ^-2	C4	%O2 wet	C5	Bws	C6	Bws	Ts^2
u =	-150.3162	13.4622	28.10694	3861530	1.6E-06	0.591123	12.5875	91.9723	0.05	1.52E-05	0.05	624100

u = 237.57 micropoise

Eq. 4 **Cunningham Correction Factor**

$C = 1 + 0.0057193\ (u/Ps/Dp)\ (Ts/Mw)^{0.5}$

u	Ps	Dp	Ts	Mw
237.5681	27.88	2.25	790	29.1815

C = 1 0.005719 3.787153 5.203071

C = 1.11

Eq. 5 **Lower Limit Cut Diameter**

$D_{50LL} = 9.057\ C^{0.3007}\ (Mw*Ps/Ts)^{0.1993}$

$D_{50LL} = \frac{9.057 \mid 1.112698 \mid 0.3007 \mid 29.1815 \mid 27.88}{790}^{0.1993}$

D_{50LL} = 9.408

Eq. 6 **Cut Diameter for Cyclone I for the Middle of the Overlap Zone**

$D_{50T} = (11 + D_{50LL}) / 2$

Qs = 0.649 ft^3/min

Eq. 8 **Reynolds Number**

$Nre = 8.64x10^5\ (Ps*Mw/Ts)\ (Qs/u)$

$\frac{8.64E+05 \mid 27.88 \mid 29.1815 \mid 0.649438}{790 \mid 237.5681}$

Nre = 864000 1.029848 0.002734

Nre = 2432

If Nre < 3162 use eq.9 to calculate ΔH
If Nre > 3162 recalculate D_{50LL} using Eq.10

Eq. 9 **Meter Box Orifice Pressure Drop SAME AS 201A**

$\Delta H = (Qs\ (1 - Bws)\ Ps / Ts)^2\ (1.083\ Tm\ Md\ \Delta H@ / Pbar)$

$\Delta H = \frac{0.649438 \mid 0.95 \mid 27.88 \mid 2 \mid 1.083 \mid 525 \mid 29.77 \mid 1.76}{790 \mid 27.88}$

ΔH = 0.000474 1068.529

ΔH = 0.51 +50 °F ΔH = 0.45 0.000419
-50 °F ΔH = 0.58 0.00054

Eq. 10 **Recalculated Lower Limit Cut Diameter @ Nre >3162**

$D_{50LL} = 10.0959\ C^{0.44}\ (Mw*Ps/Ts)^{0.06}$

$D_{50LL} = \frac{10.0959 \mid 1.112698 \mid 0.44 \mid 29.1815 \mid 27.88}{790}^{0.06}$

D_{50LL} = 10.6

Re Eq. 6 **Recalculated Cut Diameter for Cyclone I for the Middle of the Overlap Zone @ Nre >3162**

$D_{50T} = (11 + D_{50LL}) / 2$

$\frac{11 \mid 10.6 \mid / \mid 2}{}$

D_{50T} = 10.80

Re Eq. 7 **Recalculated Cyclone Sampling Rate @ Nre >3162**

$Qs = 0.07296\ u\ (Ts/Mw/Ps)^{0.2949}\ (1/D\ 50T)^{1.4102}$

$Qs = \frac{0.07296 \mid 237.5681 \mid 790 \mid 0.2949 \mid 1}{29.1815 \mid 27.88 \mid 10.8}^{1.4102}$

Qs = 0.07296 237.5681 0.991364 0.034887

Re Qs = 0.60 ft^3/min

Test Run 2 **Bison Engineering, Method 201A PM_{10} & CT40 $PM_{2.5}$ Spreadsheet**

Data by	jw, mc	Checked by	cwl

Facility:	Bitter Root			**Location:**	Bismarck N.D.	**Date:**	Mar 12, 08
Operators:		**Filter #**	2983	**Source:**	Boiler, Low Fire	**Start time:** 10:40	**End time:**

PRELIMINARY INFO.

Pm	Bp			27.88	("Hg)
	Diam	Lngth	Wdth	Rnd sqft	Rect. sqft
(inches)	12	0	0	0.79	0
	Stack AREA			0.79	(sqft)
	Yi			1.003	
	Delta H@			1.76	

PRE TEST INFO

	Assumed moisture	5.0	(%)
	Assumed Meter Temp	63.0	(deg F)
	Target Run Time	48.0	(min)
	Total Number of Points	12	

TRAVERSE INFO

Pg	Static, gage pressure	0.00	("H2O)
	Stack Temp, ts	380.0	(deg F)
O_2	Abs stack Temp, Ts	840	(deg R)
CO_2	Oxygen, dry	11.0	(% v/v d)
	Oxygen, wet	10.4595	(% v/v w)
	Carbon Dioxide, dry	10.0	(% v/v d)
	Molecular weight, dry	30.0388	(lb/lb.mole)
	Molecular weight, wet	29.43686	(lb/lb.mole)

201A Calculations

us	201A stack viscosity	256.21	(micropoise)
Qs	201A Cylone flow rate	0.732	(ft^3/min)
ΔH	**201A Delta H ==>**	**0.57**	("H20)
	RANGE 0.51 - 50 °F	0.65	+ 50 °F

CT40 Calculations

us	CT40 stack viscosity	247.45	(micropoise)
C	Cunningham Corr. Factor	1.12	
D_{50LL}	Lower limit cut diameter	9.33	(micrometers
D_{50T}	Cut diam for cyclone	10.16	(micrometers
Qs	CT40 Cylone flow rate	0.691	(ft^3/min)
Nre	Reynolds number	2357	Nre < 3162 *
ΔH	**CT40 Delta H ==>**	**0.51**	("H20)
	RANGE 0.45 - 50 °F	0.58	+ 50 °F

NOZZLE SELECTION

Nd					
201A	•136 •15 •164 •182 •197 •215 •233 •264 •3 •342 •39				
CT40	N1•125 N2•138 N3•156 N4•172 N5•188 N6•20 N7•22 N8•25				
H_2O	Nozzle Diameter estamate	0.391	Selected >	0.35	
H_2O	delta P (min)	ERR	AVG	ERR	AVG
H_2O	delta P (max)	NA	ERR	NA	ERR
H_2O	Alt - delta P (min)	ERR	ERR	ERR	ERR
H_2O	Alt - delta P (max)	0.142	ERR	0.127	ERR

POST TEST INFO

Impinger water	35	Silica gel	2 (g)

CALCULATED RESULTS

Ps	Stack pressure, Ps	27.88	(" Hg)
Bws	% H2O in Stack	8.19	(Bws)
Mw	Actual Wet Molecular Weight	29.05	(lb/lb.mole)
Vs	Dry STD sample Volume	19.53	(dscf)
	Final Sampling Time	45.7	(min)
us	Post test stack viscosity	237.50	(micropoise)
C	Post test Cunningham corr. factor	1.11	
D_{50LL}	Post test lower limit cut diameter	9.42	(micrometers)
D_{50T}	Post test cut diam for cyclone	10.21	(micrometers)
Qs std	Post test cyclone flow rate	0.65	(ft^3/min)
I	Isokinetic Avg, { 80 < I < 120 }	137	(%)
D50	D50 Cut Rate, { 9 < d50 < 11 }	10.2	(um)

Revised Sept 08/01 by CWL

Test No	Pre traverse dP	Pre traverse sqrt dP	Point Time	Run Time	MetrVol 54.13	Vel head delta P	Vel head sqrt dP	201A CT40 delta H	Stack Temp	Meter Temp In	Meter Temp Out	Meter Temp Avg	Assumed % I	Actual %I	Rolling %I	STACK Vel. ft/sec	STACK Flow acfm	STACK Flow dscfm
1	0.036	0.19	4.0	4.0	55.79	0.040	0.20	0.57	295	63	61	62	114.27	118	118	13.87	653	391
2	0.036	0.19	3.9	7.9	57.60	0.038	0.19	0.57	300	63	61	62	131.54	136	127	13.56	639	380
3	0.036	0.19	3.8	11.7	59.23	0.037	0.19	0.57	305	63	61	62	123.61	128	127	13.42	633	374
4	0.038	0.19	3.8	15.5	61.03	0.037	0.19	0.57	317	63	62	62.5	137.44	142	131	13.53	638	371
5	0.040	0.20	3.9	19.4	62.84	0.038	0.19	0.57	323	64	62	63	133.26	138	132	13.76	649	374
6	0.042	0.20	4.0	23.4	64.67	0.040	0.20	0.57	323	64	62	63	128.04	132	132	14.12	665	384
7	0.042	0.20	4.0	27.4	66.13	0.040	0.20	0.57	327	65	62	63.5	102.31	106	129	14.16	667	383
8	0.028	0.17	3.9	31.3	67.81	0.038	0.19	0.57	330	65	63	64	124.00	128	129	13.82	651	373
9	0.035	0.19	3.6	34.9	69.76	0.033	0.18	0.57	334	66	63	64.5	167.58	173	134	12.92	609	346
10	0.036	0.19	3.7	38.6	71.58	0.034	0.18	0.57	338	67	63	65	150.16	155	136	13.14	619	351
11	0.032	0.18	3.6	42.2	73.08	0.032	0.18	0.57	335	67	63	65	130.87	135	136	12.73	600	341
12	0.032	0.18	3.5	45.7	74.82	0.030	0.17	0.57	327	68	64	66	160.15	166	138	12.26	578	332
	avg dP	avg. √dP	sample volume		20.690	avg. dP	avg. √dP	dH	Ts		Tm					ft/sec	acfm	dscfm
	0.036	0.190				0.036	0.191	0.56	321.17	ts °F	63.54	tm °F				13.44	633	366
avg sqrt dP squared		0.036							781.17	Ts °R	523.54	Tm °R						

Test Run 3 **Bison Engineering, Method 201A PM_{10} & CT40 $PM_{2.5}$ Spreadsheet**

Data by	jw, mc	Checked by	cwl

Facility:	Bitter Root	Location:	Bismarck N.D.	Date:	Mar 12, 08
Operators:	Filter # 2984	Source:	Boiler, Low Fire	Start time: 11:56	End time:

PRELIMINARY INFO.

Pm	Bp			25.87	("Hg)
	Diam	Lngth	Wdth	Rnd sqft	Rect. sqft
(inches)	12	0	0	0.79	0
	Stack AREA			0.79	(sqft)
	Yi			1.003	
	Delta H@			1.76	

PRE TEST INFO

	Assumed moisture	3.0	(%)
	Assumed Meter Temp	78.0	(deg F)
	Target Run Time	48.0	(min)
	Total Number of Points	12	

TRAVERSE INFO

Pg	Static, gage pressure	0.00	("H2O)
	Stack Temp, ts	335.0	(deg F)
O_2	Abs stack Temp, Ts	795	(deg R)
CO_2	Oxygen, dry	11.9	(% v/v d)
	Oxygen, wet	11.5333	(% v/v w)
	Carbon Dioxide, dry	9.1	(% v/v d)
	Molecular weight, dry	29.9332	(lb/lb.mole)
	Molecular weight, wet	29.575204	(lb/lb.mole)

201A Calculations

us	201A stack viscosity		245.64	(micropoise)
Qs	201A Cylone flow rate		0.705	(ft^3/min)
ΔH	**201A Delta H ==>**		**0.59**	("H20)
	RANGE	0.52 - 50 °F	0.67	+ 50 °F

CT40 Calculations

us	CT40 stack viscosity	239.72	(micropoise)
C	Cunningham Corr. Factor	1.12	
D_{50LL}	Lower limit cut diameter	9.30	(micrometers
D_{50T}	Cut diam for cyclone	10.15	(micrometers
Qs	CT40 Cylone flow rate	0.673	(ft^3/min)
Nre	Reynolds number	2336	Nre < 3162 *
ΔH	**CT40 Delta H ==>**	**0.54**	("H20)
	RANGE	0.47 - 50 °F	0.61 + 50 °F

NOZZLE SELECTION

Nd					
201A	•136 •15 •164 •182 •197 •215 •233 •264 •3 •342 •39				
CT40	N1•125 N2•138 N3•156 N4•172 N5•188 N6•20 N7•22 N8•25				
H_2O	Nozzle Diameter estamate	0.384	Selected >	0.35	
H_2O	delta P (min)	ERR	AVG	ERR	AVG
H_2O	delta P (max)	NA	ERR	NA	ERR
H_2O	Alt - delta P (min)	ERR	ERR	ERR	ERR
H_2O	Alt - delta P (max)	0.130	ERR	0.119	ERR

POST TEST INFO

Impinger water	35	Silica gel	3.2 (g)

CALCULATED RESULTS

Ps	Stack pressure, Ps	25.87	(" Hg)
Bws	% H2O in Stack	8.98	(Bws)
Mw	Actual Wet Molecular Weight	28.86	(lb/lb.mole)
Vs	Dry STD sample Volume	18.23	(dscf)
	Final Sampling Time	52.1	(min)
us	Post test stack viscosity	231.80	(micropoise)
C	Post test Cunningham corr. factor	1.12	
D_{50LL}	Post test lower limit cut diameter	9.33	(micrometers)
D_{50T}	Post test cut diam for cyclone	10.16	(micrometers)
Qs std	Post test cyclone flow rate	0.65	(ft^3/min)
I	Isokinetic Avg, { 80 < I < 120 }	116	(%)
D50	D50 Cut Rate, { 9 < d50 < 11 }	10.2	(um)

Revised Sept 08/01 by CWL

Test No	Pre traverse dP	sqrt dP	Point Time	Run Time	MetrVol 74.95	Vel head delta P	sqrt dP	201A CT40 delta H	Stack Temp	Meter Temp In	Out	Avg	Assumed % I	Actual %I	Rolling %I	STACK Vel. ft/sec	Flow acfm	Flow dscfm
1	0.040	0.20	4.2	4.2	76.66	0.034	0.18	0.59	272	65	64	64.5	112.06	119	119	13.11	618	351
2	0.038	0.19	4.4	8.6	78.32	0.038	0.19	0.59	279	66	64	65	98.60	105	112	13.93	656	369
3	0.037	0.19	4.5	13.1	80.06	0.039	0.20	0.59	282	66	64	65	99.95	107	110	14.14	666	373
4	0.037	0.19	4.6	17.7	81.87	0.040	0.20	0.59	289	66	64	65	100.90	108	110	14.38	678	376
5	0.038	0.19	4.6	22.3	83.69	0.040	0.20	0.59	284	67	65	66	100.93	108	109	14.34	676	377
6	0.040	0.20	4.4	26.7	85.45	0.038	0.19	0.59	305	67	65	66	106.16	113	110	14.17	668	363
7	0.040	0.20	4.5	31.2	87.10	0.039	0.20	0.59	301	67	65	66	95.80	102	109	14.32	675	368
8	0.038	0.19	4.4	35.6	88.83	0.038	0.19	0.59	311	68	65	66.5	104.66	112	109	14.23	670	361
9	0.033	0.18	4.1	39.7	90.62	0.032	0.18	0.59	320	68	65	66.5	127.37	136	112	13.13	619	330
10	0.034	0.18	4.2	43.9	92.47	0.034	0.18	0.59	322	68	65	66.5	124.83	133	114	13.55	639	339
11	0.032	0.18	4.1	48.0	94.08	0.033	0.18	0.59	326	68	65	66.5	113.25	121	115	13.38	631	333
12	0.030	0.17	4.1	52.1	95.85	0.032	0.18	0.59	320	68	65	66.5	125.95	134	116	13.13	619	330
	avg dP	avg. √dP	sample volume		20.900	avg. dP	avg. √dP	dH	Ts		Tm					ft/sec	acfm	dscfm
	0.036	0.191				0.036	0.191	0.56	300.92	ts °F	65.83	tm °F				13.82	651	356
avg sqrt dP squared		0.036							760.92	Ts °R	525.83	Tm °R						

Sample Identification	Filter #	Date	Tare 1 (g)	Date	Tare 2 (g)	CHECK	Average	Filter #	Date	Final 1 (g)	Date	Final 2 (g)	CHECK	Average	Gain
Bismarck Run 1	2982	2/8/2008	0.3483	2/11/2008	0.3484	0.0001	0.3484	2982	3/14/2008	0.3857	3/17/2008	0.3860	0.0003	0.3859	0.0375
Bismarck Run 2	2983	2/8/2008	0.3491	2/11/2008	0.3493	0.0002	0.3492	2983	3/14/2008	0.3864	3/17/2008	0.3867	0.0003	0.3866	0.0374
Bismarck Run 3	2984	2/8/2008	0.3463	2/11/2008	0.3463	0.0000	0.3463	2984	3/14/2008	0.3810	3/17/2008	0.3806	-0.0004	0.3808	0.0345
Bismarck Run 4	2976	2/8/2008	0.3480	2/11/2008	0.3480	0.0000	0.3480	2976	3/14/2008	0.3854	3/17/2008	0.3853	-0.0001	0.3854	0.0374
Bismarck Run 5	2977	2/8/2008	0.3460	2/11/2008	0.3464	0.0004	0.3462	2977	3/14/2008	0.3873	3/17/2008	0.3875	0.0002	0.3874	0.0412

Vol (ml)	Sample Identification	Pan #	Date	Tare 1 (g)	Date	Tare 2 (g)	CHECK	Average	Pan #	Date	Final 1 (g)	Date	Final 2 (g)	CHECK	Average	Gain
26.3	Bismarck Boiler plus 2.5 Run - 1	1451	3/14/2008	2.5467	3/17/2008	2.5467	0.0000	2.5467	1451	3/17/2008	2.5567	3/18/2008	2.5647	0.0080	2.5607	0.01400
33.5	Bismarck Boiler plus 2.5 Run - 2	1452	3/14/2008	2.5192	3/17/2008	2.5191	-0.0001	2.5192	1452	3/17/2008	2.5340	3/18/2008	2.5336	-0.0004	2.5338	0.01465
37.2	Bismarck Boiler plus 2.5 Run - 3	1453	3/14/2008	2.5346	3/17/2008	2.5344	-0.0002	2.5345	1453	3/17/2008	2.5473	3/18/2008	2.5469	-0.0004	2.5471	0.01260
35.1	Bismarck Boiler plus 2.5 Run - 4	1454	3/14/2008	2.5319	3/17/2008	2.5321	0.0002	2.5320	1454	3/17/2008	2.5562	3/18/2008	2.5558	-0.0004	2.5560	0.02400
46.8	Bismarck Boiler plus 2.5 Run - 5	1455	3/14/2008	2.5315	3/17/2008	2.5315	0.0000	2.5315	1455	3/17/2008	2.5620	3/18/2008	2.5616	-0.0004	2.5618	0.03030
79	Bismarck Boiler Probe Rinse Run 1	1456	3/14/2008	2.5352	3/17/2008	2.5350	-0.0002	2.5351	1456	3/17/2008	2.5361	3/18/2008	2.5361	0.0000	2.5361	0.00100
85.8	Bismarck Boiler Probe Rinse Run 2	1457	3/14/2008	2.5368	3/17/2008	2.5368	0.0000	2.5368	1457	3/17/2008	2.5394	3/18/2008	2.5392	-0.0002	2.5393	0.00250
48.7	Bismarck Boiler Probe Rinse Run 3	1458	3/14/2008	2.5298	3/17/2008	2.5295	-0.0003	2.5297	1458	3/17/2008	2.5307	3/18/2008	2.5306	-0.0001	2.5307	0.00100
56.5	Bismarck Boiler Probe Rinse Run 4	1459	3/14/2008	2.5407	3/17/2008	2.5406	-0.0001	2.5407	1459	3/17/2008	2.5415	3/18/2008	2.5414	-0.0001	2.5415	0.00080
44.5	Bismarck Boiler Probe Rinse Run 5	1460	3/14/2008	2.5345	3/17/2008	2.5346	0.0001	2.5346	1460	3/17/2008	2.5347	3/18/2008	2.5347	0.0000	2.5347	0.00015
50	Bismarck Boiler MeCl Extraction Run 1	1461	3/14/2008	2.5410	3/17/2008	2.5410	0.0000	2.5410	1461	3/17/2008	2.5423	3/18/2008	2.5422	-0.0001	2.5423	0.00125
50	Bismarck Boiler MeCl Extraction Run 2	1462	3/14/2008	2.5424	3/17/2008	2.5423	-0.0001	2.5424	1462	3/17/2008	2.5438	3/18/2008	2.5436	-0.0002	2.5437	0.00135
50	Bismarck Boiler MeCl Extraction Run 3	1463	3/14/2008	2.5214	3/17/2008	2.5215	0.0001	2.5215	1463	3/17/2008	2.5228	3/18/2008	2.5226	-0.0002	2.5227	0.00125
50	Bismarck Boiler MeCl Extraction Run 4	1464	3/14/2008	2.5590	3/17/2008	2.5589	-0.0001	2.5590	1464	3/17/2008	2.5605	3/18/2008	2.5601	-0.0004	2.5603	0.00135
50	Bismarck Boiler MeCl Extraction Run 5	1465	3/14/2008	2.5358	3/17/2008	2.5360	0.0002	2.5359	1465	3/17/2008	2.5375	3/18/2008	2.5373	-0.0002	2.5374	0.00150
200	Bismarck Boiler Impinger Run 1	1466	3/14/2008	2.5466	3/17/2008	2.5466	0.0000	2.5466	1466	3/17/2008	2.5784	3/18/2008	2.5787	0.0003	2.5786	0.03195
200	Bismarck Boiler Impinger Run 2	1467	3/14/2008	2.5339	3/17/2008	2.5338	-0.0001	2.5339	1467	3/17/2008	2.5608	3/18/2008	2.5611	0.0003	2.5610	0.02710
200	Bismarck Boiler Impinger Run 3	1468	3/14/2008	2.5340	3/17/2008	2.5340	0.0000	2.5340	1468	3/17/2008	2.5611	3/18/2008	2.5615	0.0004	2.5613	0.02730
200	Bismarck Boiler Impinger Run 4	1469	3/14/2008	2.5373	3/17/2008	2.5374	0.0001	2.5374	1469	3/17/2008	2.5691	3/18/2008	2.5693	0.0002	2.5692	0.03185
200	Bismarck Boiler Impinger Run 5	1470	3/14/2008	2.5356	3/17/2008	2.5356	0.0000	2.5356	1470	3/17/2008	2.5695	3/18/2008	2.5699	0.0004	2.5697	0.03410
100	MECl Blank	1471	3/14/2008	2.5305	3/17/2008	2.5306	0.0001	2.5306	1471	3/17/2008	2.5305	3/18/2008	2.5306	0.0001	2.5306	0.00000
100	Acetone Blank	1472	3/14/2008	2.5405	3/17/2008	2.5403	-0.0002	2.5404	1472	3/17/2008	2.5406	3/18/2008	2.5404	-0.0002	2.5405	0.00010
100	Water Blank	1473	3/14/2008	2.5340	3/17/2008	2.5336	-0.0004	2.5338	1473	3/17/2008	2.5342	3/18/2008	2.5343	0.0001	2.5343	0.00045

APPENDIX B:
LOW-FIRE NOx AND CO TEST DATA

Bismarck Low Fire NOx CO test data

		Run 1	Run 2	Run 3	Avg.
Stack Flow	dscfh	22710	21981	21343	**22346**
Heat input	MMBtu/hr	0.90	1.13	1.00	**1.0**
NOx source concentration	ppmvd	105.3	117.3	111.7	**111.5**
NOx concentration, M19 conversion	lbs/dscf	1.253E-05	1.396E-05	1.329E-05	**1.326E-05**
NOx mass rate	lbs/hr	0.285	0.307	0.284	**0.292**
NOx emission factor	lbs/MMBtu	0.316	0.273	0.285	**0.291**
CO source concentration	ppmvd	282.5	159.4	204.2	**215.4**
CO concentration, M19 conversion	lbs/dscf	2.053E-05	1.159E-05	1.484E-05	**1.565E-05**
CO mass rate	lbs/hr	0.466	0.255	0.317	**0.346**
NOx emission factor	lbs/MMBtu	0.518	0.226	0.318	**0.354**

Bismarck Run 1

Date/Time mm/dd/yy hh:mm:ss	CO ppm	NOx ppm	O2 %
03/12/08 09:21:27	160.04	122.63	10.69
03/12/08 09:21:37	137.31	127.26	10.57
03/12/08 09:21:47	117.06	131.82	10.47
03/12/08 09:21:57	103.44	132.43	10.30
03/12/08 09:22:07	94.75	133.02	10.41
03/12/08 09:22:17	97.76	132.97	10.73
03/12/08 09:22:27	104.88	132.68	10.64
03/12/08 09:22:37	106.34	130.93	10.73
03/12/08 09:22:47	101.38	128.81	10.92
03/12/08 09:22:57	96.01	128.79	10.71
03/12/08 09:23:07	94.16	129.10	11.09
03/12/08 09:23:17	94.43	129.99	11.44
03/12/08 09:23:27	97.80	130.93	11.49
03/12/08 09:23:37	102.56	127.04	12.09
03/12/08 09:23:47	109.73	123.52	11.93
03/12/08 09:23:57	121.39	118.49	11.87
03/12/08 09:24:07	124.71	113.68	11.91
03/12/08 09:24:17	123.47	115.18	11.64
03/12/08 09:24:27	123.54	116.35	11.33
03/12/08 09:24:37	121.72	120.43	11.03
03/12/08 09:24:47	123.84	124.30	11.07
03/12/08 09:24:57	124.70	127.52	11.30
03/12/08 09:25:07	124.15	130.55	11.41
03/12/08 09:25:17	124.12	130.30	11.53
03/12/08 09:25:27	123.58	129.92	11.98
03/12/08 09:25:37	126.80	127.49	12.52
03/12/08 09:25:47	132.88	124.84	13.14
03/12/08 09:25:57	138.73	117.84	13.32
03/12/08 09:26:07	144.50	111.00	12.98
03/12/08 09:26:17	140.85	110.97	12.77
03/12/08 09:26:27	133.17	111.29	12.23
03/12/08 09:26:37	124.74	115.14	11.50
03/12/08 09:26:47	117.94	119.03	11.62
03/12/08 09:26:57	111.83	120.79	11.54
03/12/08 09:27:07	109.36	122.62	11.85
03/12/08 09:27:17	111.24	121.04	11.73
03/12/08 09:27:27	114.44	119.92	11.81
03/12/08 09:27:37	115.63	119.87	11.81
03/12/08 09:27:47	112.41	120.21	11.46
03/12/08 09:27:57	105.51	123.53	11.32
03/12/08 09:28:07	96.68	126.71	11.29
03/12/08 09:28:17	87.10	131.18	11.47
03/12/08 09:28:27	83.79	135.67	11.95
03/12/08 09:28:37	89.11	131.78	12.47
03/12/08 09:28:47	102.20	127.84	12.90
03/12/08 09:28:57	118.28	121.71	13.05
03/12/08 09:29:07	135.81	115.41	12.96
03/12/08 09:29:17	145.29	112.82	12.58
03/12/08 09:29:27	141.50	110.09	12.68
03/12/08 09:29:37	126.81	112.85	12.76
03/12/08 09:29:47	220.11	115.44	12.43
03/12/08 09:29:57	195.30	117.30	12.25
03/12/08 09:30:07	179.75	119.01	12.31
03/12/08 09:30:17	172.04	120.16	12.45
03/12/08 09:30:27	179.17	121.68	12.27
03/12/08 09:30:37	202.78	119.58	12.40

03/12/08 09:30:47	228.79	117.81	12.70
03/12/08 09:30:57	242.28	114.57	12.80
03/12/08 09:31:07	242.61	111.58	12.50
03/12/08 09:31:17	240.80	112.50	12.31
03/12/08 09:31:27	232.95	113.40	12.31
03/12/08 09:31:37	217.68	116.69	11.85
03/12/08 09:31:47	201.02	119.64	11.39
03/12/08 09:31:57	182.45	124.90	11.38
03/12/08 09:32:07	165.61	130.28	11.49
03/12/08 09:32:17	158.87	131.50	11.51
03/12/08 09:32:27	154.35	132.72	11.34
03/12/08 09:32:37	152.85	131.74	10.96
03/12/08 09:32:47	154.05	130.89	10.86
03/12/08 09:32:57	149.81	131.50	10.88
03/12/08 09:33:07	147.44	132.09	10.90
03/12/08 09:33:17	150.74	130.88	10.92
03/12/08 09:33:27	154.05	129.71	10.91
03/12/08 09:33:37	154.65	130.91	11.14
03/12/08 09:33:47	154.66	131.77	11.50
03/12/08 09:33:57	159.77	128.79	11.70
03/12/08 09:34:07	174.78	125.44	11.69
03/12/08 09:34:17	191.71	122.04	11.86
03/12/08 09:34:27	195.56	118.46	11.90
03/12/08 09:34:37	187.51	116.71	11.80
03/12/08 09:34:47	180.05	115.21	11.83
03/12/08 09:34:57	179.14	116.03	11.90
03/12/08 09:35:07	186.34	116.63	11.93
03/12/08 09:35:17	201.91	115.46	11.73
03/12/08 09:35:27	229.35	114.01	11.30
03/12/08 09:35:37	266.21	115.18	11.09
03/12/08 09:35:47	306.11	116.63	11.19
03/12/08 09:35:57	317.04	118.42	11.43
03/12/08 09:36:07	312.60	120.20	11.31
03/12/08 09:36:17	303.44	118.76	11.49
03/12/08 09:36:27	283.96	117.59	11.72
03/12/08 09:36:37	272.50	116.76	11.55
03/12/08 09:36:47	269.68	115.49	11.38
03/12/08 09:36:57	265.32	118.17	11.77
03/12/08 09:37:07	256.83	121.09	12.07
03/12/08 09:37:17	246.88	118.46	12.09
03/12/08 09:37:27	233.92	116.08	12.50
03/12/08 09:37:37	225.80	115.14	12.44
03/12/08 09:37:47	224.60	114.58	12.57
03/12/08 09:37:57	229.37	113.71	12.71
03/12/08 09:38:07	235.38	112.83	12.77
03/12/08 09:38:17	247.16	111.90	12.75
03/12/08 09:38:27	249.88	111.29	12.63
03/12/08 09:38:37	247.43	112.55	12.66
03/12/08 09:38:47	246.86	114.03	12.59
03/12/08 09:38:57	235.65	113.71	12.45
03/12/08 09:39:07	225.79	113.42	12.38
03/12/08 09:39:17	222.17	113.42	12.10
03/12/08 09:39:27	219.20	113.76	11.78
03/12/08 09:39:37	206.08	117.88	11.67
03/12/08 09:39:47	187.83	122.63	11.66
03/12/08 09:39:57	176.21	125.78	11.90
03/12/08 09:40:07	174.71	128.79	12.00
03/12/08 09:40:17	179.78	126.38	11.76
03/12/08 09:40:27	189.59	124.02	11.68
03/12/08 09:40:37	191.99	124.89	11.84

03/12/08 09:40:47	183.98	126.13	12.04
03/12/08 09:40:57	178.88	125.49	12.25
03/12/08 09:41:07	178.91	124.60	12.36
03/12/08 09:41:17	185.43	121.42	12.32
03/12/08 09:41:27	197.37	118.16	12.49
03/12/08 09:41:37	209.40	117.01	12.78
03/12/08 09:41:47	222.84	115.43	13.25
03/12/08 09:41:57	224.66	113.15	13.70
03/12/08 09:42:07	219.84	110.42	13.99
03/12/08 09:42:17	223.38	106.34	14.25
03/12/08 09:42:27	241.13	102.48	13.39
03/12/08 09:42:37	257.81	103.33	12.48
03/12/08 09:42:47	251.98	104.57	12.47
03/12/08 09:42:57	233.24	111.93	12.62
03/12/08 09:43:07	224.05	119.60	12.50
03/12/08 09:43:17	221.01	118.79	12.58
03/12/08 09:43:27	212.97	117.89	12.46
03/12/08 09:43:37	201.66	116.68	12.22
03/12/08 09:43:47	195.88	115.53	12.01
03/12/08 09:43:57	193.53	115.80	12.05
03/12/08 09:44:07	195.89	116.37	12.34
03/12/08 09:44:17	199.80	113.71	12.56
03/12/08 09:44:27	197.10	110.73	12.72
03/12/08 09:44:37	193.18	109.28	12.53
03/12/08 09:44:47	200.42	107.79	12.29
03/12/08 09:44:57	204.56	109.55	11.96
03/12/08 09:45:07	205.46	111.60	11.99
03/12/08 09:45:17	201.65	113.97	11.89
03/12/08 09:45:27	200.73	116.38	12.15
03/12/08 09:45:37	204.27	116.68	12.44
03/12/08 09:45:47	209.41	116.40	12.35
03/12/08 09:45:57	219.55	114.88	12.09
03/12/08 09:46:07	233.89	113.43	12.18
03/12/08 09:46:17	248.07	114.01	12.29
03/12/08 09:46:27	255.04	114.33	12.34
03/12/08 09:46:37	249.29	113.46	12.62
03/12/08 09:46:47	240.82	112.83	12.97
03/12/08 09:46:57	242.66	110.39	13.04
03/12/08 09:47:07	272.23	108.07	13.13
03/12/08 09:47:17	300.86	105.80	13.35
03/12/08 09:47:27	315.91	103.08	13.42
03/12/08 09:47:37	330.35	101.98	13.34
03/12/08 09:47:47	330.63	100.80	13.50
03/12/08 09:47:57	320.13	103.61	13.84
03/12/08 09:48:07	305.20	106.27	13.99
03/12/08 09:48:17	295.86	103.66	13.98
03/12/08 09:48:27	288.93	101.36	14.05
03/12/08 09:48:37	280.59	101.43	14.28
03/12/08 09:48:47	271.71	101.36	14.43
03/12/08 09:48:57	274.35	98.67	14.37
03/12/08 09:49:07	283.33	95.98	14.19
03/12/08 09:49:17	286.92	97.44	14.31
03/12/08 09:49:27	285.73	98.96	14.47
03/12/08 09:49:37	282.44	97.80	14.18
03/12/08 09:49:47	273.70	96.78	14.30
03/12/08 09:49:57	257.84	98.05	14.37
03/12/08 09:50:07	252.34	99.54	14.27
03/12/08 09:50:17	251.96	98.07	14.46
03/12/08 09:50:27	262.66	96.55	14.67
03/12/08 09:50:37	281.18	93.90	14.69

03/12/08 09:50:47	302.27	90.88	14.59
03/12/08 09:50:57	301.08	91.83	14.75
03/12/08 09:51:07	292.25	92.72	14.61
03/12/08 09:51:17	290.12	93.81	14.59
03/12/08 09:51:27	303.42	95.09	14.72
03/12/08 09:51:37	321.60	95.04	14.83
03/12/08 09:51:47	329.50	95.05	14.70
03/12/08 09:51:57	337.16	94.74	14.80
03/12/08 09:52:07	330.40	94.70	15.04
03/12/08 09:52:17	319.86	92.66	15.17
03/12/08 09:52:27	323.58	90.28	15.23
03/12/08 09:52:37	363.07	87.74	15.30
03/12/08 09:52:47	423.38	85.05	15.44
03/12/08 09:52:57	468.18	82.98	15.59
03/12/08 09:53:07	484.20	80.96	15.74
03/12/08 09:53:17	478.11	77.63	15.97
03/12/08 09:53:27	455.77	74.05	16.38
03/12/08 09:53:37	449.03	69.29	16.41
03/12/08 09:53:47	454.87	64.92	16.42
03/12/08 09:53:57	465.70	63.20	16.52
03/12/08 09:54:07	476.03	61.38	16.50
03/12/08 09:54:17	476.27	60.79	16.51
03/12/08 09:54:27	476.66	60.19	16.54
03/12/08 09:54:37	469.68	58.91	16.57
03/12/08 09:54:47	451.95	57.95	16.46
03/12/08 09:54:57	447.52	58.24	16.51
03/12/08 09:55:07	437.68	58.23	16.43
03/12/08 09:55:17	438.62	57.92	16.27
03/12/08 09:55:27	451.98	57.37	16.38
03/12/08 09:55:37	473.88	58.22	16.43
03/12/08 09:55:47	491.90	58.89	16.39
03/12/08 09:55:57	497.76	57.35	16.32
03/12/08 09:56:07	482.23	56.20	16.31
03/12/08 09:56:17	465.95	57.65	16.34
03/12/08 09:56:27	457.51	59.40	16.16
03/12/08 09:56:37	465.36	60.48	16.38
03/12/08 09:56:47	481.65	61.62	16.06
03/12/08 09:56:57	484.53	63.41	15.98
03/12/08 09:57:07	497.48	64.90	15.96
03/12/08 09:57:17	502.57	66.40	16.03
03/12/08 09:57:27	493.13	67.86	16.11
03/12/08 09:57:37	484.85	66.36	16.11
03/12/08 09:57:47	491.91	65.14	15.80
03/12/08 09:57:57	510.00	66.93	15.57
03/12/08 09:58:07	551.31	69.07	15.62
03/12/08 09:58:17	566.67	72.27	15.68
03/12/08 09:58:27	565.64	75.32	15.64
03/12/08 09:58:37	586.14	74.65	15.56
03/12/08 09:58:47	607.31	74.04	15.65
03/12/08 09:58:57	606.81	75.49	15.80
03/12/08 09:59:07	579.19	76.81	15.79
03/12/08 09:59:17	536.97	75.91	15.75
03/12/08 09:59:27	509.98	74.68	15.90
03/12/08 09:59:37	494.48	73.73	16.04
03/12/08 09:59:47	489.01	72.55	15.91
03/12/08 09:59:57	507.90	72.25	15.78
03/12/08 10:00:07	528.05	71.69	15.99
03/12/08 10:00:17	540.45	72.53	16.20
03/12/08 10:00:27	539.61	72.83	16.23
03/12/08 10:00:37	536.06	70.23	15.88

03/12/08 10:00:47	545.13	67.84	15.45
03/12/08 10:00:57	560.34	73.18	15.28
03/12/08 10:01:07	573.88	78.91	15.18
03/12/08 10:01:17	586.41	83.01	14.12
03/12/08 10:01:27	561.88	87.14	13.26
03/12/08 10:01:37	487.50	102.45	13.53
03/12/08 10:01:47	415.09	117.86	13.84
03/12/08 10:01:57	396.27	116.10	13.99
03/12/08 10:02:07	422.50	114.31	14.16
03/12/08 10:02:17	455.69	110.66	14.21
03/12/08 10:02:27	483.66	107.15	14.30
03/12/08 10:02:37	504.35	106.08	14.48
03/12/08 10:02:47	539.64	104.56	14.51
03/12/08 10:02:57	589.53	101.39	14.28
03/12/08 10:03:07	614.17	98.37	14.44
03/12/08 10:03:17	598.14	99.87	14.84
03/12/08 10:03:27	586.77	101.38	14.94
03/12/08 10:03:37	601.20	95.28	14.60
03/12/08 10:03:47	617.63	89.40	13.84
Run 1 Average >	**282.51**	**105.31**	**13.25**

Bismarck Run 2

Date/Time mm/dd/yy hh:mm:ss	CO ppm	NOx ppm	O2 %
03/12/08 10:40:37	379.37	69.64	14.56
03/12/08 10:40:47	387.03	69.32	13.97
03/12/08 10:40:57	396.93	74.09	13.60
03/12/08 10:41:07	392.86	78.89	13.28
03/12/08 10:41:17	375.13	84.76	13.19
03/12/08 10:41:27	350.20	90.63	13.00
03/12/08 10:41:37	318.32	93.89	12.73
03/12/08 10:41:47	294.41	97.42	12.48
03/12/08 10:41:57	278.91	99.28	12.20
03/12/08 10:42:07	257.16	101.39	12.13
03/12/08 10:42:17	234.81	104.59	12.32
03/12/08 10:42:27	215.97	107.53	12.29
03/12/08 10:42:37	206.65	107.26	12.41
03/12/08 10:42:47	201.65	106.64	12.73
03/12/08 10:42:57	204.41	105.77	12.68
03/12/08 10:43:07	212.70	104.90	12.46
03/12/08 10:43:17	220.13	103.38	11.97
03/12/08 10:43:27	216.89	102.06	11.33
03/12/08 10:43:37	191.41	108.05	10.99
03/12/08 10:43:47	167.70	114.30	10.71
03/12/08 10:43:57	151.37	117.88	10.50
03/12/08 10:44:07	141.54	121.13	10.55
03/12/08 10:44:17	142.71	121.46	10.54
03/12/08 10:44:27	149.02	121.48	10.52
03/12/08 10:44:37	153.18	120.20	10.50
03/12/08 10:44:47	147.41	119.04	10.53
03/12/08 10:44:57	138.77	120.52	10.31
03/12/08 10:45:07	134.07	122.34	10.45
03/12/08 10:45:17	134.67	122.34	10.88
03/12/08 10:45:27	140.59	122.38	11.31
03/12/08 10:45:37	143.08	117.93	11.48
03/12/08 10:45:47	146.56	113.11	11.66
03/12/08 10:45:57	155.90	110.72	11.82
03/12/08 10:46:07	168.56	108.14	11.97
03/12/08 10:46:17	182.50	106.08	11.88
03/12/08 10:46:27	190.25	104.28	11.74
03/12/08 10:46:37	185.21	106.70	11.76
03/12/08 10:46:47	181.61	109.31	11.65
03/12/08 10:46:57	180.09	111.00	11.62
03/12/08 10:47:07	171.48	113.10	11.27
03/12/08 10:47:17	165.01	114.28	11.15
03/12/08 10:47:27	162.71	115.49	11.12
03/12/08 10:47:37	161.91	114.30	10.95
03/12/08 10:47:47	161.00	112.84	10.93
03/12/08 10:47:57	156.81	113.17	11.08
03/12/08 10:48:07	152.23	113.14	11.04
03/12/08 10:48:17	153.78	111.95	11.01
03/12/08 10:48:27	160.98	110.38	10.82
03/12/08 10:48:37	161.03	110.75	10.64
03/12/08 10:48:47	151.93	110.67	10.80
03/12/08 10:48:57	139.04	113.17	10.85
03/12/08 10:49:07	128.05	115.53	11.06
03/12/08 10:49:17	122.39	116.37	11.40
03/12/08 10:49:27	125.65	117.05	11.88

03/12/08 10:49:37	130.75	113.13	12.14
03/12/08 10:49:47	140.96	109.56	12.48
03/12/08 10:49:57	159.16	105.82	12.83
03/12/08 10:50:07	184.29	102.32	13.10
03/12/08 10:50:17	204.32	98.74	12.99
03/12/08 10:50:27	219.89	95.41	12.68
03/12/08 10:50:37	224.39	97.45	12.04
03/12/08 10:50:47	208.81	99.88	11.41
03/12/08 10:50:57	181.36	106.36	10.61
03/12/08 10:51:07	157.11	112.84	10.55
03/12/08 10:51:17	142.72	117.29	10.97
03/12/08 10:51:27	139.34	121.48	11.27
03/12/08 10:51:37	138.77	119.08	11.37
03/12/08 10:51:47	137.04	117.00	11.56
03/12/08 10:51:57	139.92	115.50	11.67
03/12/08 10:52:07	151.64	114.33	11.80
03/12/08 10:52:17	165.00	111.01	12.09
03/12/08 10:52:27	172.11	107.78	12.18
03/12/08 10:52:37	175.97	105.79	12.11
03/12/08 10:52:47	182.86	103.98	12.11
03/12/08 10:52:57	201.45	102.36	11.95
03/12/08 10:53:07	227.96	100.82	11.74
03/12/08 10:53:17	234.26	102.32	11.70
03/12/08 10:53:27	221.59	103.37	11.27
03/12/08 10:53:37	208.25	107.52	10.52
03/12/08 10:53:47	198.33	111.32	10.11
03/12/08 10:53:57	188.73	116.45	9.71
03/12/08 10:54:07	180.40	121.46	9.77
03/12/08 10:54:17	175.68	123.74	10.08
03/12/08 10:54:27	189.95	125.82	10.32
03/12/08 10:54:37	215.01	121.48	10.66
03/12/08 10:54:47	220.18	116.72	10.80
03/12/08 10:54:57	205.84	116.13	10.93
03/12/08 10:55:07	178.10	115.86	11.02
03/12/08 10:55:17	153.56	117.92	10.87
03/12/08 10:55:27	136.43	119.90	10.90
03/12/08 10:55:37	123.94	122.30	11.14
03/12/08 10:55:47	120.03	124.30	10.87
03/12/08 10:55:57	123.02	122.63	10.78
03/12/08 10:56:07	121.54	120.49	10.80
03/12/08 10:56:17	112.68	120.86	10.57
03/12/08 10:56:27	101.99	121.44	10.36
03/12/08 10:56:37	92.69	123.95	10.32
03/12/08 10:56:47	90.64	126.73	10.09
03/12/08 10:56:57	96.36	126.11	10.16
03/12/08 10:57:07	104.90	125.52	10.47
03/12/08 10:57:17	117.13	123.98	11.05
03/12/08 10:57:27	123.58	122.65	11.42
03/12/08 10:57:37	129.30	119.66	11.54
03/12/08 10:57:47	139.64	116.41	11.66
03/12/08 10:57:57	148.71	115.27	11.65
03/12/08 10:58:07	156.53	114.08	11.76
03/12/08 10:58:17	156.46	114.35	11.68
03/12/08 10:58:27	150.72	114.66	11.52
03/12/08 10:58:37	142.38	116.13	11.35
03/12/08 10:58:47	134.08	117.62	11.04
03/12/08 10:58:57	132.88	120.51	10.84
03/12/08 10:59:07	135.90	123.30	10.81

03/12/08 10:59:17	141.57	123.23	10.69
03/12/08 10:59:27	141.49	122.99	10.64
03/12/08 10:59:37	136.75	124.89	10.41
03/12/08 10:59:47	125.06	127.05	10.18
03/12/08 10:59:57	116.27	130.00	10.12
03/12/08 11:00:07	118.27	133.04	10.13
03/12/08 11:00:17	141.82	130.61	10.12
03/12/08 11:00:27	194.14	128.20	9.92
03/12/08 11:00:37	228.27	126.12	10.01
03/12/08 11:00:47	222.83	123.97	10.14
03/12/08 11:00:57	201.42	123.53	10.11
03/12/08 11:01:07	183.97	123.27	10.34
03/12/08 11:01:17	172.05	122.65	10.46
03/12/08 11:01:27	159.48	122.36	10.35
03/12/08 11:01:37	143.67	123.54	10.50
03/12/08 11:01:47	129.58	124.96	10.98
03/12/08 11:01:57	120.27	122.98	11.48
03/12/08 11:02:07	117.10	120.52	11.56
03/12/08 11:02:17	117.08	118.21	11.61
03/12/08 11:02:27	119.97	116.14	11.59
03/12/08 11:02:37	130.46	116.16	11.52
03/12/08 11:02:47	138.74	116.13	11.60
03/12/08 11:02:57	145.68	116.42	11.49
03/12/08 11:03:07	151.97	117.05	11.52
03/12/08 11:03:17	158.05	116.12	11.44
03/12/08 11:03:27	169.19	115.24	11.18
03/12/08 11:03:37	183.12	114.89	11.03
03/12/08 11:03:47	195.32	114.33	10.92
03/12/08 11:03:57	204.65	115.51	10.74
03/12/08 11:04:07	222.57	116.45	10.73
03/12/08 11:04:17	224.37	115.82	10.80
03/12/08 11:04:27	212.72	115.51	11.06
03/12/08 11:04:37	194.11	116.40	11.12
03/12/08 11:04:47	183.34	117.35	11.02
03/12/08 11:04:57	173.88	118.54	10.84
03/12/08 11:05:07	161.93	119.97	10.62
03/12/08 11:05:17	144.26	124.32	10.45
03/12/08 11:05:27	125.07	129.14	10.24
03/12/08 11:05:37	109.80	130.30	10.30
03/12/08 11:05:47	99.00	131.54	9.98
03/12/08 11:05:57	92.10	133.29	9.90
03/12/08 11:06:07	87.15	135.08	9.49
03/12/08 11:06:17	90.00	136.34	9.58
03/12/08 11:06:27	95.14	137.21	9.97
03/12/08 11:06:37	101.10	132.77	10.14
03/12/08 11:06:47	118.27	127.92	9.73
03/12/08 11:06:57	204.04	123.76	9.86
03/12/08 11:07:07	276.81	119.98	9.77
03/12/08 11:07:17	343.46	119.05	9.89
03/12/08 11:07:27	350.23	118.52	9.64
03/12/08 11:07:37	320.84	120.84	9.68
03/12/08 11:07:47	280.70	123.27	9.66
03/12/08 11:07:57	248.77	124.93	9.61
03/12/08 11:08:07	218.42	126.74	9.60
03/12/08 11:08:17	199.22	127.92	10.18
03/12/08 11:08:27	163.62	128.82	10.60
03/12/08 11:08:37	127.21	127.60	10.70
03/12/08 11:08:47	99.02	126.10	10.50

03/12/08 11:08:57	85.04	126.70	10.34
03/12/08 11:09:07	80.01	127.34	10.14
03/12/08 11:09:17	77.33	130.30	10.14
03/12/08 11:09:27	76.45	133.33	10.53
03/12/08 11:09:37	75.54	133.91	10.90
03/12/08 11:09:47	74.63	134.16	11.07
03/12/08 11:09:57	73.09	131.55	11.13
03/12/08 11:10:07	75.22	129.14	11.45
03/12/08 11:10:17	85.61	126.67	11.64
03/12/08 11:10:27	101.08	124.34	11.61
03/12/08 11:10:37	115.96	122.37	11.71
03/12/08 11:10:47	125.11	120.53	11.65
03/12/08 11:10:57	126.31	118.51	11.07
03/12/08 11:11:07	118.57	116.45	10.36
03/12/08 11:11:17	106.42	121.80	9.97
03/12/08 11:11:27	91.49	126.98	9.77
03/12/08 11:11:37	78.77	130.93	9.37
03/12/08 11:11:47	71.13	134.80	9.37
03/12/08 11:11:57	65.77	135.75	9.46
03/12/08 11:12:07	64.52	136.61	9.39
03/12/08 11:12:17	63.05	136.93	9.40
03/12/08 11:12:27	62.38	136.98	9.19
03/12/08 11:12:37	66.29	136.66	9.22
03/12/08 11:12:47	70.49	136.03	9.36
03/12/08 11:12:57	72.54	134.53	9.58
03/12/08 11:13:07	72.57	133.11	10.02
03/12/08 11:13:17	69.30	130.02	10.24
03/12/08 11:13:27	66.87	127.06	10.06
03/12/08 11:13:37	67.23	126.77	9.88
03/12/08 11:13:47	69.60	126.48	9.99
03/12/08 11:13:57	78.80	126.45	9.92
03/12/08 11:14:07	83.89	126.44	9.90
03/12/08 11:14:17	80.60	127.28	9.93
03/12/08 11:14:27	73.42	128.17	9.80
03/12/08 11:14:37	71.68	128.50	10.10
03/12/08 11:14:47	79.40	128.48	10.37
03/12/08 11:14:57	102.58	124.35	10.48
03/12/08 11:15:07	138.46	119.97	10.73
03/12/08 11:15:17	166.18	117.38	10.99
03/12/08 11:15:27	170.96	114.39	11.23
03/12/08 11:15:37	164.20	113.79	11.08
03/12/08 11:15:47	155.87	112.89	11.10
03/12/08 11:15:57	145.16	113.46	11.30
03/12/08 11:16:07	137.94	113.79	11.38
03/12/08 11:16:17	140.25	112.29	11.56
03/12/08 11:16:27	149.92	110.73	11.78
03/12/08 11:16:37	167.72	109.85	11.82
03/12/08 11:16:47	181.90	108.99	12.07
03/12/08 11:16:57	182.27	107.55	12.30
03/12/08 11:17:07	178.93	106.11	12.41
03/12/08 11:17:17	179.23	104.94	12.31
03/12/08 11:17:27	191.12	103.38	12.18
03/12/08 11:17:37	216.19	102.77	12.36
03/12/08 11:17:47	253.68	102.06	12.45
03/12/08 11:17:57	275.58	100.82	11.96
03/12/08 11:18:07	273.41	99.62	11.58
03/12/08 11:18:17	254.56	105.16	11.24
03/12/08 11:18:27	236.29	110.44	10.62

03/12/08 11:18:37	214.16	115.26	10.83
03/12/08 11:18:47	188.43	119.96	11.22
03/12/08 11:18:57	167.95	119.63	11.60
03/12/08 11:19:07	145.73	119.67	11.49
03/12/08 11:19:17	126.54	119.66	11.16
03/12/08 11:19:27	108.77	119.99	11.14
03/12/08 11:19:37	97.79	123.33	10.94
03/12/08 11:19:47	97.54	126.16	10.98
03/12/08 11:19:57	97.52	126.15	10.72
03/12/08 11:20:07	95.52	125.84	10.51
03/12/08 11:20:17	90.65	125.83	10.29
03/12/08 11:20:27	87.70	125.86	10.11
Run 2 Average >	**159.43**	**117.34**	**11.01**

Bismarck Run 3

Date/Time mm/dd/yy hh:mm:ss	CO ppm	NOx ppm	O2 %
03/12/08 11:56:27	273.18	101.69	13.12
03/12/08 11:56:37	271.21	103.70	13.15
03/12/08 11:56:47	275.90	106.05	12.92
03/12/08 11:56:57	298.23	106.96	12.84
03/12/08 11:57:07	310.89	107.78	12.63
03/12/08 11:57:17	301.23	110.16	12.17
03/12/08 11:57:27	270.01	112.83	11.89
03/12/08 11:57:37	231.51	116.70	11.62
03/12/08 11:57:47	202.34	120.53	11.62
03/12/08 11:57:57	184.03	122.92	11.48
03/12/08 11:58:07	180.42	124.89	11.39
03/12/08 11:58:17	174.80	125.81	11.42
03/12/08 11:58:27	163.84	127.01	11.61
03/12/08 11:58:37	157.07	127.30	12.01
03/12/08 11:58:47	159.45	127.29	12.33
03/12/08 11:58:57	171.26	122.96	12.55
03/12/08 11:59:07	186.95	118.48	12.63
03/12/08 11:59:17	210.30	116.11	12.82
03/12/08 11:59:27	238.06	114.03	13.07
03/12/08 11:59:37	267.24	110.98	13.20
03/12/08 11:59:47	278.00	107.81	13.35
03/12/08 11:59:57	274.71	106.66	13.42
03/12/08 12:00:07	269.77	105.19	13.47
03/12/08 12:00:17	258.73	104.30	13.44
03/12/08 12:00:27	236.93	103.35	13.75
03/12/08 12:00:37	221.70	101.97	13.91
03/12/08 12:00:47	229.18	100.88	14.01
03/12/08 12:00:57	253.63	98.38	14.01
03/12/08 12:01:07	277.66	95.95	14.04
03/12/08 12:01:17	279.48	95.71	14.11
03/12/08 12:01:27	279.17	95.33	14.19
03/12/08 12:01:37	283.40	94.47	14.40
03/12/08 12:01:47	287.26	93.27	14.24
03/12/08 12:01:57	296.25	91.49	14.21
03/12/08 12:02:07	308.85	89.73	14.44
03/12/08 12:02:17	311.80	88.85	14.47
03/12/08 12:02:27	305.34	88.24	14.54
03/12/08 12:02:37	290.16	88.28	14.44
03/12/08 12:02:47	276.22	88.49	14.38
03/12/08 12:02:57	263.96	90.60	14.31
03/12/08 12:03:07	267.55	92.70	14.22
03/12/08 12:03:17	281.62	93.03	13.91
03/12/08 12:03:27	283.06	93.28	13.74
03/12/08 12:03:37	267.80	97.17	13.70
03/12/08 12:03:47	246.35	101.09	13.80
03/12/08 12:03:57	235.72	101.43	13.97
03/12/08 12:04:07	242.11	101.73	14.05
03/12/08 12:04:17	267.21	99.61	14.13
03/12/08 12:04:27	300.57	97.45	14.16
03/12/08 12:04:37	329.26	95.98	14.24
03/12/08 12:04:47	337.59	94.81	14.45
03/12/08 12:04:57	331.33	93.61	14.60
03/12/08 12:05:07	319.97	92.70	14.49

03/12/08 12:05:17	311.75	92.65	14.63
03/12/08 12:05:27	299.39	92.71	14.75
03/12/08 12:05:37	294.44	91.54	14.90
03/12/08 12:05:47	302.41	90.32	14.93
03/12/08 12:05:57	312.13	88.49	14.89
03/12/08 12:06:07	325.23	86.85	14.96
03/12/08 12:06:17	321.16	87.16	14.84
03/12/08 12:06:27	320.81	87.12	14.71
03/12/08 12:06:37	325.80	87.45	14.45
03/12/08 12:06:47	314.16	87.75	14.40
03/12/08 12:06:57	294.10	90.91	14.43
03/12/08 12:07:07	276.52	94.14	14.31
03/12/08 12:07:17	268.74	93.84	14.20
03/12/08 12:07:27	263.27	93.60	13.98
03/12/08 12:07:37	256.92	95.43	13.91
03/12/08 12:07:47	246.41	97.15	13.23
03/12/08 12:07:57	245.77	100.20	12.48
03/12/08 12:08:07	236.33	103.07	12.33
03/12/08 12:08:17	208.88	112.92	12.43
03/12/08 12:08:27	177.49	122.70	12.47
03/12/08 12:08:37	158.93	122.65	12.64
03/12/08 12:08:47	149.89	122.97	12.87
03/12/08 12:08:57	145.70	120.83	12.96
03/12/08 12:09:07	144.27	118.84	12.83
03/12/08 12:09:17	157.70	118.55	12.64
03/12/08 12:09:27	181.05	118.19	12.77
03/12/08 12:09:37	198.34	117.61	12.97
03/12/08 12:09:47	200.74	117.08	13.10
03/12/08 12:09:57	198.36	115.52	12.84
03/12/08 12:10:07	195.92	114.31	12.62
03/12/08 12:10:17	191.75	116.46	12.47
03/12/08 12:10:27	189.67	118.46	11.92
03/12/08 12:10:37	187.59	121.46	11.89
03/12/08 12:10:47	183.10	124.64	12.10
03/12/08 12:10:57	180.71	124.93	12.62
03/12/08 12:11:07	178.08	125.51	12.90
03/12/08 12:11:17	181.68	122.37	12.98
03/12/08 12:11:27	190.28	119.36	13.09
03/12/08 12:11:37	207.61	117.03	13.20
03/12/08 12:11:47	222.27	114.93	13.22
03/12/08 12:11:57	233.06	114.74	13.28
03/12/08 12:12:07	234.25	114.12	13.43
03/12/08 12:12:17	231.83	112.29	13.68
03/12/08 12:12:27	227.09	110.16	13.65
03/12/08 12:12:37	234.23	107.57	13.51
03/12/08 12:12:47	247.81	104.87	13.43
03/12/08 12:12:57	257.17	106.08	13.49
03/12/08 12:13:07	255.47	107.00	13.53
03/12/08 12:13:17	246.04	105.82	13.67
03/12/08 12:13:27	231.55	104.94	13.77
03/12/08 12:13:37	213.59	103.41	13.71
03/12/08 12:13:47	195.93	102.06	13.62
03/12/08 12:13:57	184.62	103.13	13.66
03/12/08 12:14:07	184.91	104.58	13.55
03/12/08 12:14:17	195.37	103.98	13.64
03/12/08 12:14:27	202.01	103.42	13.69
03/12/08 12:14:37	218.35	102.78	13.91
03/12/08 12:14:47	235.43	101.77	14.07

03/12/08 12:14:57	241.82	99.31	14.01
03/12/08 12:15:07	236.88	96.55	13.86
03/12/08 12:15:17	223.15	98.14	13.71
03/12/08 12:15:27	225.28	99.92	13.63
03/12/08 12:15:37	241.77	100.82	13.41
03/12/08 12:15:47	252.74	101.73	12.84
03/12/08 12:15:57	235.71	105.23	12.22
03/12/08 12:16:07	209.72	109.04	11.91
03/12/08 12:16:17	183.37	114.07	11.61
03/12/08 12:16:27	164.20	118.83	11.49
03/12/08 12:16:37	150.78	119.95	11.26
03/12/08 12:16:47	135.88	121.43	10.97
03/12/08 12:16:57	118.27	123.30	10.91
03/12/08 12:17:07	105.82	125.22	11.11
03/12/08 12:17:17	101.71	126.45	11.09
03/12/08 12:17:27	107.91	127.63	11.20
03/12/08 12:17:37	113.01	126.15	11.13
03/12/08 12:17:47	117.09	124.34	11.03
03/12/08 12:17:57	119.14	125.25	11.14
03/12/08 12:18:07	123.01	126.12	11.51
03/12/08 12:18:17	131.17	124.95	11.38
03/12/08 12:18:27	140.63	123.75	11.78
03/12/08 12:18:37	142.45	121.77	12.07
03/12/08 12:18:47	144.87	119.36	12.13
03/12/08 12:18:57	147.80	115.84	12.08
03/12/08 12:19:07	145.14	112.25	11.88
03/12/08 12:19:17	138.48	114.04	11.72
03/12/08 12:19:27	132.30	115.57	11.63
03/12/08 12:19:37	132.34	117.34	11.49
03/12/08 12:19:47	135.57	119.07	11.33
03/12/08 12:19:57	141.81	120.56	11.05
03/12/08 12:20:07	152.62	122.08	10.57
03/12/08 12:20:17	159.86	122.96	10.60
03/12/08 12:20:27	173.02	124.05	10.63
03/12/08 12:20:37	185.80	122.95	10.71
03/12/08 12:20:47	186.37	121.79	10.29
03/12/08 12:20:57	186.39	121.78	9.80
03/12/08 12:21:07	198.63	121.49	9.56
03/12/08 12:21:17	218.38	120.54	9.19
03/12/08 12:21:27	230.63	119.94	8.63
03/12/08 12:21:37	249.93	122.08	8.05
03/12/08 12:21:47	277.73	124.38	7.53
03/12/08 12:21:57	326.09	126.15	7.51
03/12/08 12:22:07	367.09	128.21	7.38
03/12/08 12:22:17	386.74	128.84	7.68
03/12/08 12:22:27	380.00	129.41	8.00
03/12/08 12:22:37	363.74	127.34	8.12
03/12/08 12:22:47	353.25	124.96	8.70
03/12/08 12:22:57	317.45	122.68	9.53
03/12/08 12:23:07	265.70	120.23	9.99
03/12/08 12:23:17	225.26	117.04	10.53
03/12/08 12:23:27	195.63	113.75	10.75
03/12/08 12:23:37	174.48	112.29	10.84
03/12/08 12:23:47	157.38	111.06	10.97
03/12/08 12:23:57	146.61	110.45	11.08
03/12/08 12:24:07	139.67	110.16	11.17
03/12/08 12:24:17	134.97	110.49	11.25
03/12/08 12:24:27	132.66	110.75	11.19

03/12/08 12:24:37	134.05	110.17	10.84
03/12/08 12:24:47	138.51	109.56	10.45
03/12/08 12:24:57	139.67	111.99	10.43
03/12/08 12:25:07	132.93	114.09	10.39
03/12/08 12:25:17	126.86	113.75	10.29
03/12/08 12:25:27	122.07	113.23	10.08
03/12/08 12:25:37	121.80	113.20	9.80
03/12/08 12:25:47	128.05	113.17	9.61
03/12/08 12:25:57	132.06	113.81	10.07
03/12/08 12:26:07	124.21	114.35	10.49
03/12/08 12:26:17	121.81	114.95	10.44
03/12/08 12:26:27	125.37	115.27	10.38
03/12/08 12:26:37	127.19	117.62	10.19
03/12/08 12:26:47	125.68	119.65	10.06
03/12/08 12:26:57	120.88	121.08	10.33
03/12/08 12:27:07	116.78	122.67	10.65
03/12/08 12:27:17	112.42	121.17	10.46
03/12/08 12:27:27	112.13	119.97	10.23
03/12/08 12:27:37	118.55	121.75	10.15
03/12/08 12:27:47	137.05	123.76	9.85
03/12/08 12:27:57	169.22	122.11	9.32
03/12/08 12:28:07	227.40	120.24	8.51
03/12/08 12:28:17	331.92	118.88	7.93
03/12/08 12:28:27	398.16	117.34	7.92
03/12/08 12:28:37	413.41	118.21	8.02
03/12/08 12:28:47	421.42	119.05	8.49
03/12/08 12:28:57	426.77	116.76	9.15
03/12/08 12:29:07	388.72	114.33	9.77
03/12/08 12:29:17	303.00	113.46	10.14
03/12/08 12:29:27	210.00	112.59	10.41
03/12/08 12:29:37	149.01	114.37	10.39
03/12/08 12:29:47	125.96	115.83	10.23
03/12/08 12:29:57	130.48	116.14	10.48
03/12/08 12:30:07	141.53	116.19	10.85
03/12/08 12:30:17	150.18	114.12	11.25
03/12/08 12:30:27	154.71	112.00	11.42
03/12/08 12:30:37	154.71	109.60	11.46
03/12/08 12:30:47	152.89	107.54	11.64
03/12/08 12:30:57	154.10	108.17	11.73
03/12/08 12:31:07	154.07	108.70	11.79
03/12/08 12:31:17	155.59	108.76	12.03
03/12/08 12:31:27	152.61	108.75	12.27
03/12/08 12:31:37	146.02	106.71	12.31
03/12/08 12:31:47	141.27	104.31	12.29
03/12/08 12:31:57	143.95	104.30	11.91
03/12/08 12:32:07	146.87	103.96	11.66
03/12/08 12:32:17	151.39	107.49	11.50
03/12/08 12:32:27	157.47	110.75	11.24
03/12/08 12:32:37	163.89	111.37	11.03
03/12/08 12:32:47	161.60	111.98	11.15
03/12/08 12:32:57	148.70	115.25	11.35
03/12/08 12:33:07	132.05	118.54	11.58
03/12/08 12:33:17	120.25	116.12	11.35
03/12/08 12:33:27	119.42	114.05	10.88
03/12/08 12:33:37	120.90	114.97	10.61
03/12/08 12:33:47	128.66	116.15	10.86
03/12/08 12:33:57	147.87	116.74	11.00
03/12/08 12:34:07	158.62	117.05	11.30

03/12/08 12:34:17	155.89	115.55	11.12
03/12/08 12:34:27	150.72	114.09	10.95
03/12/08 12:34:37	148.15	114.68	11.02
03/12/08 12:34:47	148.40	115.21	11.23
03/12/08 12:34:57	143.66	115.04	11.26
03/12/08 12:35:07	138.77	114.67	11.12
03/12/08 12:35:17	132.61	116.47	10.97
03/12/08 12:35:27	126.25	117.96	10.93
03/12/08 12:35:37	119.44	119.41	10.52
03/12/08 12:35:47	112.14	120.87	10.34
03/12/08 12:35:57	111.88	119.69	9.95
03/12/08 12:36:07	123.31	118.56	9.72
03/12/08 12:36:17	136.15	119.35	9.49
03/12/08 12:36:27	138.21	120.26	9.52
03/12/08 12:36:37	130.44	121.48	9.28
03/12/08 12:36:47	127.74	122.40	9.49
03/12/08 12:36:57	123.58	121.51	9.53
03/12/08 12:37:07	117.69	120.88	9.71
03/12/08 12:37:17	107.58	123.55	9.79
03/12/08 12:37:27	103.19	126.18	10.11
03/12/08 12:37:37	109.11	125.56	10.99
03/12/08 12:37:47	115.40	124.66	11.48
03/12/08 12:37:57	123.91	117.94	11.80
Run 3 Average >	**204.15**	**111.70**	**11.89**

APPENDIX C:
HIGH-FIRE PM TEST DATA

Bison Engineering
Method 201A Spreadsheet
Method 201A PM_{10} & CT40 $PM_{2.5}$ Test

COMPANY	**Bitter Root**
FACILITY	**Bismarck Landfill**
LOCATION	**Bismarck N.D.**
SOURCE	**Boiler, High Fire**
DATE	**Mar 12, 08**

Method 201A PM10 & CT Method 40 PM2.5

Client	Bitter Root			Number of Runs
Facility	Bismarck Landfill			
Location	Bismarck N.D.			2
Source	Boiler, High Fire			
Test date		Mar 12, 08	Mar 12, 08	
Start time		13:21	14:48	
Test run		Four	Five	
Preliminary info				
Barometric pressure [Bp]	"Hg	27.88	27.88	
Stack Diameter	inch	12	12	
stack exit area	sqft	0.79	0.79	
Meter box ID		3	3	
meter box Yi		1.003	1.003	
meter box delta H@		1.76	1.76	
Pitot tube coefficient Cp		0.84	0.84	
Test Information				
nozzle size [nz]	inch	0.35	0.35	
filter number		2976	2977	
Sample points		12	12	
Test duration	min	48	48	
Isokinetics [i]	%	100	104	
D50 cut rate		10.19	10.17	
Sample volume, eq 4.3	dscf	18.91	18.15	
avg delta P	"H2O	0.061	0.059	
avg sqrt delta P	"H2O	0.246	0.243	
201A Constant sample rate delta H	"H2O	0.60	0.62	
CT40 Constant sample rate delta H	"H2O	0.54	0.55	
avg meter temp [Tm]	deg F	79.5	78.8	
Stack Information				AVERAGES
avg stack temp [ts]	deg F	348	369	358
avg ABS stack temp [Ts]	deg R	808	829	
actual stack flow	acfm	831	830	831
actual stack velocity [Vs]	ft/sec	17.6	17.6	18
Standard stack flow	dscfm	468	454	461
Standard stack flow	dscf/hr	28102	27234	27668
stack moisture [bws], eq 4.4	% v/v	7.46	7.84	8
measured static pressure	"H2O	0	0	0
stack static pressure [ps]	"Hg	27.88	27.88	27.88
Oxygen content	%O2	11.41	10.25	11
Carbon dioxide content	%CO2	9.59	10.75	10
Wet (Actual) Molecular Weight, Ms	lb/lb.mole	29.1	29.2	29.1
Dry Molecular Weight, Md	lb/lb.mole	30.0	30.1	30.1
Lab Information				
Impinger H2O Gain	mls	30	30	
Impinger H2O volume [Vwc(STD)], eq 4.1	scf	1.41	1.41	
Silica Gel H2O Gain	grams (g)	2.4	2.8	
Silica Gel volume [Vsg(STD)], eq 4.2	scf	0.11	0.13	
Lab Data, cyclone > than PM10 weight gain	grams (g)	NA	NA	
Lab Data, cyclone > PM2.5 weight gain	g	0.0240	0.0302	
Lab Data, cyclone PM2.5 weight gain	g	0.0007	0.0000	
Lab Data, Filter PM2.5 weight gain	g	0.0074	0.0412	
Lab data condensible PM (CPM)	g	0.0318	0.0341	
Lab data MeCl Matter (MCEM)	g	0.0012	0.0015	
cyclone > PM2.5 weight gain	grains (gr)	0.3704	0.4661	
cyclone PM2.5 weight gain	gr	0.0108	0.0000	
Filter PM2.5 weight gain	gr	0.1142	0.6358	
condensible PM (CPM)	gr	0.4907	0.5262	
MeCl Matter (MCEM)	gr	0.0185	0.0231	
Grain loading Emissions				AVERAGES
> PM2.5 cut	gr/dscf	0.0196	0.0257	0.0226
PM 2.5 cyclone & filter	gr/dscf	0.0066	0.0350	0.0208
condensible PM (CPM)	gr/dscf	0.0259	0.0290	0.0275
MeCl Matter (MCEM-CPM))	gr/dscf	0.0010	0.0013	0.0011
EPA PM2.5 + CPM	gr/dscf	0.0335	0.0653	0.0494
Total PM	gr/dscf	0.0531	0.0910	0.0721
Mass Rate Emissions				AVERAGES
> PM2.5 cut	lbs/hr	0.079	0.100	0.0893
PM 2.5 cyclone & filter	lbs/hr	0.027	0.136	0.0814
condensible PM (CPM)	lbs/hr	0.104	0.113	0.1085
MeCl Matter (MCEM-CPM))	lbs/hr	0.004	0.005	0.0044
EPA PM2.5 + CPM	lbs/hr	0.135	0.254	0.1944
Total PM	lbs/hr	0.213	0.354	0.2836
Emission Factor				AVERAGES
lab analysis Fd @ 0% oxygen	dscf/MMBtu @ 0%	9242	9242	9242
lab analysis Fd @ stack conditions	dscf/MMBtu @ SK	20354	18137	19245
EPA PM2.5 + CPM	lbs/MMBtu	0.098	0.169	0.1334
TPM	lbs/MMBtu	0.154	0.236	0.1951
Boiler operating rate	MMBtu/hr	1.38	1.50	1.44

Test Run 4 **Bison Engineering, Method 201A PM_{10} & CT40 $PM_{2.5}$ Spreadsheet**

Data by	jw mc	Checked by	cwl

Facility:	Bitter Root			**Location:**	Bismarck N.D.	**Date:**	Mar 12, 08
Operators:	jw mc	**Filter #**	2976	**Source:**	Boiler, High Fire	**Start time:** 13:21	**End time:**

PRELIMINARY INFO.

Pm	Bp			27.88	("Hg)
	Diam	Lngth	Wdth	Rnd sqft	Rect. sqft
(inches)	12			0.79	0
	Stack AREA			0.79	(sqft)
	Yi			1.003	
	Delta H@			1.76	

PRE TEST INFO

	Assumed moisture	3.0	(%)
	Assumed Meter Temp	75.0	(deg F)
	Target Run Time	48.0	(min)
	Total Number of Points	12	

TRAVERSE INFO

Pg	Static, gage pressure	0.00	("H2O)
	Stack Temp, ts	330.0	(deg F)
O_2	Abs stack Temp, Ts	790	(deg R)
CO_2	Oxygen, dry	11.4	(% v/v d)
	Oxygen, wet	11.0677	(% v/v w)
	Carbon Dioxide, dry	9.6	(% v/v d)
	Molecular weight, dry	29.9908	(lb/lb.mole)
	Molecular weight, wet	29.631076	(lb/lb.mole)

201A Calculations

us	201A stack viscosity			244.00	(micropoise)
Qs	201A Cylone flow rate			0.683	(ft^3/min)
ΔH	**201A Delta H ==>**			**0.60**	("H20)
	RANGE	0.53	- 50 °F	0.68	+ 50 °F

CT40 Calculations

us	CT40 stack viscosity			238.32	(micropoise)
C	Cunningham Corr. Factor			1.11	
D_{50LL}	Lower limit cut diameter			9.43	(micrometers
D_{50T}	Cut diam for cyclone			10.22	(micrometers
Qs	CT40 Cylone flow rate			0.647	(ft^3/min)
Nre	Reynolds number			2454	Nre < 3162 *
ΔH	**CT40 Delta H ==>**			**0.54**	("H20)
	RANGE	0.48	- 50 °F	0.61	+ 50 °F

NOZZLE SELECTION

Nd					
201A	•136 •15 •164 •182 •197 •215 •233 •264 •3 •342 •39				
CT40	N1•125 N2•138 N3•156 N4•172 N5•188 N6•20 N7•22 N8•25				
H_2O	Nozzle Diameter estimate	0.338	Selected >	0.35	
H_2O	delta P (min)	ERR	AVG	ERR	AVG
H_2O	delta P (max)	NA	ERR	NA	ERR
H_2O	Alt - delta P (min)	ERR	ERR	ERR	ERR
H_2O	Alt - delta P (max)	0.132	ERR	0.119	ERR

POST TEST INFO

Impinger water	30	Silica gel	2.4 (g)

CALCULATED RESULTS

Ps	Stack pressure, Ps	27.88	(" Hg)
Bws	% H2O in Stack	7.46	(Bws)
Mw	Actual Wet Molecular Weight	29.10	(lb/lb.mole)
Vs	Dry STD sample Volume	18.91	(dscf)
	Final Sampling Time	47.5	(min)
us	Post test stack viscosity	245.75	(micropoise)
C	Post test Cunningham corr. factor	1.12	
D_{50LL}	Post test lower limit cut diameter	9.37	(micrometers)
D_{50T}	Post test cut diam for cyclone	10.19	(micrometers)
Qs std	Post test cyclone flow rate	0.68	(ft^3/min)
I	Isokinetic Avg, { 80 < I < 120 }	100	(%)
D50	D50 Cut Rate, { 9 < d50 < 11 }	10.2	(um)

Revised Sept 08/01 by CWL

Test No	Pre traverse dP	Pre traverse sqrt dP	Point Time	Run Time	MetrVol 96.05	Vel head delta P	Vel head sqrt dP	201A CT40 delta H	Stack Temp	Meter Temp In	Meter Temp Out	Meter Temp Avg	Assumed % I	Actual %I	Rolling %I	STACK Vel. ft/sec	STACK Flow acfm	STACK Flow dscfm
1	0.050	0.22	3.6	3.6	97.72	0.050	0.22	0.60	306	80	79	79.5	109.13	114	114	15.60	735	437
2	0.060	0.24	3.9	7.5	99.51	0.060	0.24	0.60	310	80	79	79.5	98.82	104	109	17.14	808	478
3	0.060	0.24	3.9	11.4	101.17	0.060	0.24	0.60	343	80	79	79.5	93.59	98	105	17.50	825	468
4	0.070	0.26	4.3	15.7	102.89	0.070	0.26	0.60	340	80	79	79.5	81.28	85	100	18.87	889	506
5	0.060	0.24	3.9	19.6	104.55	0.060	0.24	0.60	360	80	79	79.5	94.58	99	100	17.69	833	463
6	0.050	0.22	3.6	23.2	106.13	0.050	0.22	0.60	354	80	79	79.5	106.44	112	102	16.09	758	424
7	0.060	0.24	3.9	27.1	107.84	0.060	0.24	0.60	342	80	79	79.5	96.35	101	102	17.49	824	468
8	0.070	0.26	4.3	31.4	109.48	0.070	0.26	0.60	364	80	79	79.5	78.65	82	99	19.15	902	499
9	0.070	0.26	4.3	35.7	111.16	0.070	0.26	0.60	358	80	79	79.5	80.27	84	98	19.08	899	500
10	0.070	0.26	4.3	40.0	113.00	0.070	0.26	0.60	367	80	79	79.5	88.40	93	97	19.18	904	498
11	0.060	0.24	3.9	43.9	114.62	0.060	0.24	0.60	360	80	79	79.5	92.30	97	97	17.69	833	463
12	0.050	0.22	3.6	47.5	116.69	0.050	0.22	0.60	375	80	79	79.5	141.23	148	101	16.29	768	419
	avg dP	avg. √dP	sample volume		20.640	avg. dP	avg. √dP	dH	Ts		Tm					ft/sec	acfm	dscfm
	0.061	0.246				0.061	0.246	0.60	348.25	ts °F	79.50	tm °F				17.65	832	468
avg sqrt dP squared		0.061							808.25	Ts °R	539.50	Tm °R						

Test Run 5 **Bison Engineering, Method 201A PM_{10} & CT40 $PM_{2.5}$ Spreadsheet**

Data by	jw mk	Checked by	cwl

Facility:	Bitter Root	**Location:**	Bismarck N.D.	**Date:**	Mar 12, 08
Operators:	**Filter #** 2977	**Source:**	Boiler, High Fire	**Start time:** 14:48	**End time:**

PRELIMINARY INFO.

Pm	Bp			27.88	("Hg)
	Diam	Lngth	Wdth	Rnd sqft	Rect. sqft
(inches)	12	0	0	0.79	0
	Stack AREA			0.79	(sqft)
	Yi			1.003	
	Delta H@			1.76	

PRE TEST INFO

	Assumed moisture	3.0	(%)
	Assumed Meter Temp	80.0	(deg F)
	Target Run Time	48.0	(min)
	Total Number of Points	12	

TRAVERSE INFO

Pg	Static, gage pressure	0.00	("H2O)
	Stack Temp, ts	380.0	(deg F)
O_2	Abs stack Temp, Ts	840	(deg R)
CO_2	Oxygen, dry	10.3	(% v/v d)
	Oxygen, wet	9.9425	(% v/v w)
	Carbon Dioxide, dry	10.8	(% v/v d)
	Molecular weight, dry	30.13	(lb/lb.mole)
	Molecular weight, wet	29.7661	(lb/lb.mole)

201A Calculations

us	201A stack viscosity			257.29	(micropoise)
Qs	201A Cylone flow rate			0.733	(ft^3/min)
ΔH	**201A Delta H ==>**			**0.62**	("H20)
	RANGE	0.55	- 50 °F	0.70	+ 50 °F

CT40 Calculations

us	CT40 stack viscosity			248.77	(micropoise)
C	Cunningham Corr. Factor			1.12	
D_{50LL}	Lower limit cut diameter			9.35	(micrometers
D_{50T}	Cut diam for cyclone			10.17	(micrometers
Qs	CT40 Cylone flow rate			0.691	(ft^3/min)
Nre	Reynolds number			2372	Nre < 3162 *
ΔH	**CT40 Delta H ==>**			**0.55**	("H20)
	RANGE	0.49	- 50 °F	0.62	+ 50 °F

NOZZLE SELECTION

Nd					
201A	•136 •15 •164 •182 •197 •215 •233 •264 •3 •342 •39				
CT40	N1•125 N2•138 N3•156 N4•172 N5•188 N6•20 N7•22 N8•25				
H_2O	Nozzle Diameter estamate	0.269	Selected >	0.35	
H_2O	delta P (min)	ERR	AVG	ERR	AVG
H_2O	delta P (max)	NA	ERR	NA	ERR
H_2O	Alt - delta P (min)	ERR	ERR	ERR	ERR
H_2O	Alt - delta P (max)	0.144	ERR	0.128	ERR

POST TEST INFO

Impinger water	30	Silica gel	2.8 (g)

CALCULATED RESULTS

Ps	Stack pressure, Ps	27.88	(" Hg)
Bws	% H2O in Stack	7.84	(Bws)
Mw	Actual Wet Molecular Weight	29.18	(lb/lb.mole)
Vs	Dry STD sample Volume	18.15	(dscf)
	Final Sampling Time	45.3	(min)
us	Post test stack viscosity	250.53	(micropoise)
C	Post test Cunningham corr. factor	1.12	
D_{50LL}	Post test lower limit cut diameter	9.34	(micrometers)
D_{50T}	Post test cut diam for cyclone	10.17	(micrometers)
Qs std	Post test cyclone flow rate	0.70	(ft^3/min)
I	Isokinetic Avg, { 80 < I < 120 }	104	(%)
D50	D50 Cut Rate, { 9 < d50 < 11 }	10.2	(um)

Revised Sept 08/01 by CWL

Test	Pre traverse		Point	Run	MetrVol	Vel head		201A CT40	Stack	Meter Temp			Assumed	Actual	Rolling	STACK Vel.	Flow	Flow
No	dP	sqrt dP	Time	Time	116.80	delta P	sqrt dP	delta H	Temp	In	Out	Avg	% I	%I	%I	ft/sec	acfm	dscfm
1	0.150	0.39	3.8	3.8	118.50	0.060	0.24	0.62	288	79	78	78.5	95.26	100	100	16.87	795	482
2	0.180	0.42	3.8	7.6	120.19	0.060	0.24	0.62	312	79	78	78.5	96.20	101	101	17.14	807	474
3	0.160	0.40	4.1	11.7	121.75	0.070	0.26	0.62	341	79	78	78.5	77.62	82	94	18.85	888	503
4	0.170	0.41	3.8	15.5	123.42	0.060	0.24	0.62	358	79	78	78.5	97.86	103	97	17.64	831	461
5	0.150	0.39	3.8	19.3	125.06	0.060	0.24	0.62	358	79	78	78.5	96.10	101	97	17.64	831	461
6	0.160	0.40	3.5	22.8	126.61	0.050	0.22	0.62	375	79	78	78.5	109.14	115	100	16.27	767	416
7	0.150	0.39	3.5	26.3	128.72	0.050	0.22	0.62	385	79	78	78.5	149.45	157	109	16.37	771	414
8	0.160	0.40	3.8	30.1	130.44	0.060	0.24	0.62	385	79	78	78.5	102.43	108	108	17.93	845	453
9	0.170	0.41	4.1	34.2	132.00	0.070	0.26	0.62	398	80	78	79	80.26	84	106	19.51	919	486
10	0.180	0.42	3.8	38.0	133.67	0.060	0.24	0.62	401	80	79	79.5	100.21	105	106	18.10	853	449
11	0.180	0.42	3.8	41.8	135.15	0.060	0.24	0.62	420	80	79	79.5	89.78	94	105	18.29	862	444
12	0.150	0.39	3.5	45.3	136.58	0.050	0.22	0.62	403	80	79	79.5	102.17	108	105	16.54	779	409
	avg dP	avg. √dP	sample volume		19.780	avg. dP	avg. √dP	dH	Ts		Tm					ft/sec	acfm	dscfm
	0.163	0.404				0.059	0.243	0.60	368.67	ts °F	78.79	tm °F				17.59	829	454
avg sqrt dP squared		0.163							828.67	Ts °R	538.79	Tm °R						

APPENDIX D:
HIGH-FIRE NOx AND CO TEST DATA

Bismarck High Fire NOx CO test data

		Run 4	Run 5	Avg.
Stack Flow	**dscfh**	28102	27234	**27668**
Heat input	**MMBtu/hr**	1.38	1.50	**1.4**
NOx source concentration	**ppmvd**	119.7	133.1	**126.4**
NOx concentration, M19 conversion	**lbs/dscf**	1.424E-05	1.583E-05	**1.504E-05**
NOx mass rate	**lbs/hr**	0.400	0.431	**0.416**
NOx emission factor	**lbs/MMBtu**	0.290	0.287	**0.289**
CO source concentration	**ppmvd**	175.8	100.2	**138.0**
CO concentration, M19 conversion	**lbs/dscf**	1.278E-05	7.283E-06	**1.003E-05**
CO mass rate	**lbs/hr**	0.359	0.198	**0.279**
NOx emission factor	**lbs/MMBtu**	0.260	0.132	**0.196**

Bismarck Run 4

Date/Time mm/dd/yy hh:mm:ss	CO ppm	NOx ppm	O2 %
03/12/08 13:21:17	367.51	96.55	12.54
03/12/08 13:21:27	381.71	98.16	12.44
03/12/08 13:21:37	395.58	97.12	12.10
03/12/08 13:21:47	417.88	97.17	11.73
03/12/08 13:21:57	488.47	99.92	11.33
03/12/08 13:22:07	526.34	102.52	10.64
03/12/08 13:22:17	503.88	108.70	10.49
03/12/08 13:22:27	434.25	111.99	10.60
03/12/08 13:22:37	349.71	112.62	10.78
03/12/08 13:22:47	286.79	111.96	10.87
03/12/08 13:22:57	259.68	109.83	11.13
03/12/08 13:23:07	249.93	109.32	11.35
03/12/08 13:23:17	242.11	109.33	11.49
03/12/08 13:23:27	253.97	108.15	11.79
03/12/08 13:23:37	284.59	106.43	11.15
03/12/08 13:23:47	325.58	106.71	10.52
03/12/08 13:23:57	333.38	113.21	10.55
03/12/08 13:24:07	300.61	114.67	10.63
03/12/08 13:24:17	250.61	116.74	10.55
03/12/08 13:24:27	217.80	116.16	10.60
03/12/08 13:24:37	202.00	119.09	10.86
03/12/08 13:24:47	198.61	123.59	11.16
03/12/08 13:24:57	198.32	122.08	11.33
03/12/08 13:25:07	198.93	117.96	11.58
03/12/08 13:25:17	203.77	116.77	11.99
03/12/08 13:25:27	210.89	114.69	12.03
03/12/08 13:25:37	215.66	113.23	10.93
03/12/08 13:25:47	208.18	119.42	10.46
03/12/08 13:25:57	217.19	122.98	10.54
03/12/08 13:26:07	234.57	118.26	10.39
03/12/08 13:26:17	257.89	117.10	10.15
03/12/08 13:26:27	272.27	118.84	10.29
03/12/08 13:26:37	251.50	123.32	10.41
03/12/08 13:26:47	229.20	124.66	10.80
03/12/08 13:26:57	228.61	121.18	10.69
03/12/08 13:27:07	251.53	117.38	10.50
03/12/08 13:27:17	262.47	114.98	10.14
03/12/08 13:27:27	261.19	116.44	10.13
03/12/08 13:27:37	228.28	124.04	9.24
03/12/08 13:27:47	188.45	131.87	8.63
03/12/08 13:27:57	185.21	134.53	8.15
03/12/08 13:28:07	263.91	130.62	8.59
03/12/08 13:28:17	331.64	127.34	9.09
03/12/08 13:28:27	329.25	124.97	9.65
03/12/08 13:28:37	275.31	122.39	9.70
03/12/08 13:28:47	256.01	119.98	8.89
03/12/08 13:28:57	371.36	118.81	8.18
03/12/08 13:29:07	531.16	122.40	8.43
03/12/08 13:29:17	651.23	122.10	8.44
03/12/08 13:29:27	634.98	121.83	8.58
03/12/08 13:29:37	515.56	127.38	9.10
03/12/08 13:29:47	380.90	128.86	9.76
03/12/08 13:29:57	298.83	123.64	10.15

03/12/08 13:30:07	273.23	118.84	10.42
03/12/08 13:30:17	271.53	116.16	10.63
03/12/08 13:30:27	270.35	113.18	10.48
03/12/08 13:30:37	257.62	114.96	10.51
03/12/08 13:30:47	223.49	119.06	11.00
03/12/08 13:30:57	183.71	119.38	11.38
03/12/08 13:31:07	156.78	116.72	11.58
03/12/08 13:31:17	151.36	114.15	11.66
03/12/08 13:31:27	157.43	112.64	11.83
03/12/08 13:31:37	166.17	111.34	11.79
03/12/08 13:31:47	165.91	112.25	11.73
03/12/08 13:31:57	168.87	114.91	11.71
03/12/08 13:32:07	167.75	115.85	11.46
03/12/08 13:32:17	160.17	118.88	11.38
03/12/08 13:32:27	153.44	119.39	11.37
03/12/08 13:32:37	154.38	119.70	11.56
03/12/08 13:32:47	154.73	116.45	11.88
03/12/08 13:32:57	150.47	113.22	12.24
03/12/08 13:33:07	153.51	110.76	12.28
03/12/08 13:33:17	189.09	106.99	12.36
03/12/08 13:33:27	217.20	107.21	12.39
03/12/08 13:33:37	223.14	108.18	12.36
03/12/08 13:33:47	222.55	109.85	11.96
03/12/08 13:33:57	229.18	114.05	11.79
03/12/08 13:34:07	237.48	118.58	11.24
03/12/08 13:34:17	242.10	122.66	11.09
03/12/08 13:34:27	227.98	127.91	11.15
03/12/08 13:34:37	199.88	127.30	11.20
03/12/08 13:34:47	177.20	128.27	10.62
03/12/08 13:34:57	177.83	130.96	10.37
03/12/08 13:35:07	175.42	133.89	10.03
03/12/08 13:35:17	172.43	136.61	9.94
03/12/08 13:35:27	168.58	135.37	10.18
03/12/08 13:35:37	166.82	131.00	10.34
03/12/08 13:35:47	167.96	130.02	10.53
03/12/08 13:35:57	165.93	128.59	10.37
03/12/08 13:36:07	162.16	128.57	10.61
03/12/08 13:36:17	151.03	128.50	10.78
03/12/08 13:36:27	144.25	125.81	10.99
03/12/08 13:36:37	143.68	123.79	10.92
03/12/08 13:36:47	144.84	123.55	10.93
03/12/08 13:36:57	149.27	123.55	10.46
03/12/08 13:37:07	149.63	124.65	10.43
03/12/08 13:37:17	142.11	125.84	10.79
03/12/08 13:37:27	128.71	124.93	11.04
03/12/08 13:37:37	122.40	122.42	11.10
03/12/08 13:37:47	126.58	120.59	11.37
03/12/08 13:37:57	135.03	114.98	11.40
03/12/08 13:38:07	146.61	112.61	10.43
03/12/08 13:38:17	165.05	115.27	10.05
03/12/08 13:38:27	171.50	122.39	9.72
03/12/08 13:38:37	165.33	125.24	9.17
03/12/08 13:38:47	153.55	130.32	9.06
03/12/08 13:38:57	131.46	135.46	9.79
03/12/08 13:39:07	108.52	134.77	10.46
03/12/08 13:39:17	95.78	129.16	10.89
03/12/08 13:39:27	96.38	122.35	11.09
03/12/08 13:39:37	102.63	118.25	11.15

03/12/08 13:39:47	104.68	117.39	11.18
03/12/08 13:39:57	104.08	117.61	11.26
03/12/08 13:40:07	103.80	116.77	11.12
03/12/08 13:40:17	106.39	115.84	11.04
03/12/08 13:40:27	116.28	116.14	11.43
03/12/08 13:40:37	119.42	115.59	11.55
03/12/08 13:40:47	121.60	114.69	11.49
03/12/08 13:40:57	123.56	117.96	11.65
03/12/08 13:41:07	125.98	117.03	11.76
03/12/08 13:41:17	126.60	116.15	11.84
03/12/08 13:41:27	124.77	114.91	11.81
03/12/08 13:41:37	130.52	113.51	11.96
03/12/08 13:41:47	141.23	110.76	12.21
03/12/08 13:41:57	152.27	107.85	12.69
03/12/08 13:42:07	163.02	104.30	12.96
03/12/08 13:42:17	178.40	100.54	13.13
03/12/08 13:42:27	189.04	98.75	13.27
03/12/08 13:42:37	192.33	98.10	13.40
03/12/08 13:42:47	192.63	98.15	13.48
03/12/08 13:42:57	196.84	97.21	13.79
03/12/08 13:43:07	208.82	95.14	13.69
03/12/08 13:43:17	236.32	92.45	13.45
03/12/08 13:43:27	256.32	94.20	13.10
03/12/08 13:43:37	245.04	99.94	13.08
03/12/08 13:43:47	219.90	101.76	12.86
03/12/08 13:43:57	203.77	101.78	12.72
03/12/08 13:44:07	201.39	103.72	12.84
03/12/08 13:44:17	207.34	103.43	12.90
03/12/08 13:44:27	217.20	102.80	13.18
03/12/08 13:44:37	223.47	101.13	13.38
03/12/08 13:44:47	236.61	98.45	13.12
03/12/08 13:44:57	251.48	101.19	13.34
03/12/08 13:45:07	271.27	100.54	13.41
03/12/08 13:45:17	276.84	99.31	13.82
03/12/08 13:45:27	275.91	96.58	13.98
03/12/08 13:45:37	285.52	93.30	13.69
03/12/08 13:45:47	296.86	94.21	13.74
03/12/08 13:45:57	305.07	97.52	13.92
03/12/08 13:46:07	315.13	95.41	14.32
03/12/08 13:46:17	321.14	94.26	14.74
03/12/08 13:46:27	326.73	88.85	14.97
03/12/08 13:46:37	343.79	84.52	14.89
03/12/08 13:46:47	374.83	84.81	14.97
03/12/08 13:46:57	394.70	85.09	15.11
03/12/08 13:47:07	390.82	82.73	15.33
03/12/08 13:47:17	372.53	80.13	15.45
03/12/08 13:47:27	365.30	77.40	15.51
03/12/08 13:47:37	362.90	76.19	15.54
03/12/08 13:47:47	357.75	75.88	15.41
03/12/08 13:47:57	345.80	77.12	15.27
03/12/08 13:48:07	319.96	79.21	15.19
03/12/08 13:48:17	297.18	80.13	15.09
03/12/08 13:48:27	277.13	81.87	15.10
03/12/08 13:48:37	264.51	82.78	14.98
03/12/08 13:48:47	268.77	83.85	14.83
03/12/08 13:48:57	272.58	87.46	14.75
03/12/08 13:49:07	260.05	89.14	14.67
03/12/08 13:49:17	243.49	90.98	14.48

03/12/08 13:49:27	240.14	93.04	13.80
03/12/08 13:49:37	246.03	96.32	13.13
03/12/08 13:49:47	232.42	107.88	13.21
03/12/08 13:49:57	208.82	111.06	13.40
03/12/08 13:50:07	195.33	107.25	13.37
03/12/08 13:50:17	201.98	105.82	13.35
03/12/08 13:50:27	215.95	105.55	13.28
03/12/08 13:50:37	231.27	106.70	13.24
03/12/08 13:50:47	243.57	107.05	13.28
03/12/08 13:50:57	246.07	105.81	13.16
03/12/08 13:51:07	236.57	108.16	12.84
03/12/08 13:51:17	237.82	111.36	12.71
03/12/08 13:51:27	236.32	117.36	12.69
03/12/08 13:51:37	229.73	120.88	12.47
03/12/08 13:51:47	227.67	122.08	12.42
03/12/08 13:51:57	218.96	120.83	11.99
03/12/08 13:52:07	200.77	127.35	11.85
03/12/08 13:52:17	190.82	133.92	12.02
03/12/08 13:52:27	194.46	130.68	12.27
03/12/08 13:52:37	208.21	127.34	12.20
03/12/08 13:52:47	216.90	125.85	12.32
03/12/08 13:52:57	219.85	125.55	12.72
03/12/08 13:53:07	232.12	120.33	13.10
03/12/08 13:53:17	257.20	114.07	13.47
03/12/08 13:53:27	295.01	107.56	13.20
03/12/08 13:53:37	327.29	105.52	12.84
03/12/08 13:53:47	322.23	115.84	12.60
03/12/08 13:53:57	291.16	120.57	12.59
03/12/08 13:54:07	259.04	119.64	11.84
03/12/08 13:54:17	214.76	128.17	12.28
03/12/08 13:54:27	181.64	126.41	12.76
03/12/08 13:54:37	172.97	114.62	12.83
03/12/08 13:54:47	180.70	110.74	12.36
03/12/08 13:54:57	182.23	113.80	11.94
03/12/08 13:55:07	159.49	127.33	12.25
03/12/08 13:55:17	136.17	125.53	12.74
03/12/08 13:55:27	124.79	119.65	13.13
03/12/08 13:55:37	129.29	113.18	13.41
03/12/08 13:55:47	148.08	108.73	13.36
03/12/08 13:55:57	172.38	107.28	13.03
03/12/08 13:56:07	178.63	109.81	12.46
03/12/08 13:56:17	152.93	121.15	12.33
03/12/08 13:56:27	115.94	129.76	12.52
03/12/08 13:56:37	86.81	130.05	12.48
03/12/08 13:56:47	74.63	125.88	12.27
03/12/08 13:56:57	69.62	130.63	12.21
03/12/08 13:57:07	65.39	132.13	11.74
03/12/08 13:57:17	58.25	134.84	10.98
03/12/08 13:57:27	48.06	138.83	10.82
03/12/08 13:57:37	38.33	136.35	10.78
03/12/08 13:57:47	31.50	137.82	11.35
03/12/08 13:57:57	31.83	132.52	11.56
03/12/08 13:58:07	42.12	124.06	11.18
03/12/08 13:58:17	54.34	120.00	11.28
03/12/08 13:58:27	59.45	119.13	11.51
03/12/08 13:58:37	57.97	122.36	11.39
03/12/08 13:58:47	53.84	125.24	11.45
03/12/08 13:58:57	50.53	128.25	11.65

03/12/08 13:59:07	47.43	128.26	11.05
03/12/08 13:59:17	42.99	134.21	9.76
03/12/08 13:59:27	38.32	142.68	9.05
03/12/08 13:59:37	34.19	147.39	9.31
03/12/08 13:59:47	30.10	148.52	9.50
03/12/08 13:59:57	25.69	145.93	9.18
03/12/08 14:00:07	22.28	142.98	9.54
03/12/08 14:00:17	20.83	136.63	9.97
03/12/08 14:00:27	21.48	131.25	10.48
03/12/08 14:00:37	22.00	130.11	10.80
03/12/08 14:00:47	23.44	130.04	10.80
03/12/08 14:00:57	25.32	130.04	10.90
03/12/08 14:01:07	25.32	135.09	10.93
03/12/08 14:01:17	25.93	136.08	10.97
03/12/08 14:01:27	26.56	136.91	10.99
03/12/08 14:01:37	25.66	138.82	11.11
03/12/08 14:01:47	23.19	139.65	11.22
03/12/08 14:01:57	21.11	139.07	11.15
03/12/08 14:02:07	21.44	139.74	11.28
03/12/08 14:02:17	21.48	140.59	11.22
03/12/08 14:02:27	21.71	140.30	11.22
03/12/08 14:02:37	21.71	143.01	11.05
03/12/08 14:02:47	22.32	144.16	11.00
03/12/08 14:02:57	24.16	145.55	10.98
03/12/08 14:03:07	25.04	144.43	10.90
03/12/08 14:03:17	26.57	141.52	10.48
03/12/08 14:03:27	26.19	141.85	10.52
03/12/08 14:03:37	23.78	145.89	10.58
03/12/08 14:03:47	20.89	148.85	10.63
03/12/08 14:03:57	19.94	150.59	9.97
03/12/08 14:04:07	19.10	158.21	9.07
03/12/08 14:04:17	20.52	163.47	8.24
03/12/08 14:04:27	22.87	162.93	7.96
03/12/08 14:04:37	21.11	164.40	8.47
03/12/08 14:04:47	17.61	163.50	8.94
03/12/08 14:04:57	15.47	158.74	7.49
03/12/08 14:05:07	21.14	153.29	7.66
03/12/08 14:05:17	23.18	145.89	8.67
03/12/08 14:05:27	20.59	145.91	9.54
03/12/08 14:05:37	15.50	146.49	9.07
03/12/08 14:05:47	13.74	146.78	9.29
03/12/08 14:05:57	13.15	148.55	9.69
03/12/08 14:06:07	11.93	149.42	9.58
03/12/08 14:06:17	10.48	150.39	9.58
03/12/08 14:06:27	10.52	147.11	9.68
03/12/08 14:06:37	11.08	143.87	9.67
03/12/08 14:06:47	13.17	140.60	9.58
03/12/08 14:06:57	15.82	136.37	9.58
03/12/08 14:07:07	18.81	133.93	9.94
03/12/08 14:07:17	20.25	133.88	10.00
03/12/08 14:07:27	21.71	134.23	9.97
03/12/08 14:07:37	22.61	133.40	10.33
03/12/08 14:07:47	22.61	131.00	10.63
03/12/08 14:07:57	21.41	130.65	10.55
03/12/08 14:08:07	19.94	132.18	10.46
03/12/08 14:08:17	18.22	133.93	10.46
03/12/08 14:08:27	16.72	136.08	10.34
03/12/08 14:08:37	14.60	138.80	10.15

03/12/08 14:08:47	12.81	141.53	10.07
03/12/08 14:08:57	11.07	145.35	9.98
03/12/08 14:09:07	10.20	148.25	9.88
03/12/08 14:09:17	10.47	148.78	9.34
03/12/08 14:09:27	11.09	153.94	8.95
03/12/08 14:09:37	10.50	161.15	8.49
03/12/08 14:09:47	0.00	0.00	0.00
Run 4 Average >	**175.80**	**119.66**	**11.41**

Bismarck Run 5

Date/Time mm/dd/yy hh:mm:ss	CO ppm	NOx ppm	O2 %
03/12/08 14:48:47	328.48	66.72	15.64
03/12/08 14:48:57	364.07	63.50	15.59
03/12/08 14:49:07	351.55	68.51	15.48
03/12/08 14:49:17	337.26	72.33	15.50
03/12/08 14:49:27	336.98	69.40	15.49
03/12/08 14:49:37	351.20	65.85	15.48
03/12/08 14:49:47	357.40	67.61	15.50
03/12/08 14:49:57	335.48	69.17	15.50
03/12/08 14:50:07	308.87	70.88	15.51
03/12/08 14:50:17	299.45	69.09	15.38
03/12/08 14:50:27	309.50	69.39	15.37
03/12/08 14:50:37	314.49	70.87	15.29
03/12/08 14:50:47	307.70	71.42	15.10
03/12/08 14:50:57	287.30	75.58	14.87
03/12/08 14:51:07	261.87	81.30	14.71
03/12/08 14:51:17	237.20	85.97	14.61
03/12/08 14:51:27	219.30	87.76	14.52
03/12/08 14:51:37	215.08	87.81	14.24
03/12/08 14:51:47	213.63	90.62	14.04
03/12/08 14:51:57	206.15	93.90	13.88
03/12/08 14:52:07	187.35	97.18	13.75
03/12/08 14:52:17	164.20	101.42	13.53
03/12/08 14:52:27	144.24	105.21	13.29
03/12/08 14:52:37	128.35	109.53	13.06
03/12/08 14:52:47	118.89	113.17	12.80
03/12/08 14:52:57	116.57	116.40	12.83
03/12/08 14:53:07	118.56	118.19	12.98
03/12/08 14:53:17	118.26	117.33	13.02
03/12/08 14:53:27	120.23	115.85	13.14
03/12/08 14:53:37	126.55	112.90	13.28
03/12/08 14:53:47	132.05	109.34	12.94
03/12/08 14:53:57	134.13	109.90	12.91
03/12/08 14:54:07	133.82	111.66	12.72
03/12/08 14:54:17	135.59	110.48	12.85
03/12/08 14:54:27	138.23	109.05	12.84
03/12/08 14:54:37	137.35	107.27	12.79
03/12/08 14:54:47	126.59	108.73	12.78
03/12/08 14:54:57	109.38	111.35	12.66
03/12/08 14:55:07	89.46	113.81	12.50
03/12/08 14:55:17	72.56	117.98	12.21
03/12/08 14:55:27	62.16	121.77	11.72
03/12/08 14:55:37	56.17	126.82	11.48
03/12/08 14:55:47	55.33	131.23	11.53
03/12/08 14:55:57	61.25	132.44	11.62
03/12/08 14:56:07	68.14	133.35	11.78
03/12/08 14:56:17	71.57	131.60	11.71
03/12/08 14:56:27	67.49	132.18	11.37
03/12/08 14:56:37	57.38	137.86	11.05
03/12/08 14:56:47	46.84	143.57	11.05
03/12/08 14:56:57	39.82	144.77	11.29
03/12/08 14:57:07	38.04	139.93	11.35
03/12/08 14:57:17	40.95	135.75	11.33
03/12/08 14:57:27	46.02	134.53	11.10

03/12/08 14:57:37	49.54	136.36	10.64
03/12/08 14:57:47	51.39	139.98	10.62
03/12/08 14:57:57	51.69	142.97	10.82
03/12/08 14:58:07	53.21	139.07	11.00
03/12/08 14:58:17	52.93	136.11	11.04
03/12/08 14:58:27	52.31	134.51	10.94
03/12/08 14:58:37	51.09	138.18	11.07
03/12/08 14:58:47	49.55	139.66	11.16
03/12/08 14:58:57	48.05	137.92	10.85
03/12/08 14:59:07	45.02	138.21	10.46
03/12/08 14:59:17	41.50	145.07	10.38
03/12/08 14:59:27	40.11	146.80	10.45
03/12/08 14:59:37	40.95	145.92	10.56
03/12/08 14:59:47	41.85	144.80	10.59
03/12/08 14:59:57	40.07	143.89	10.12
03/12/08 15:00:07	37.45	146.18	9.37
03/12/08 15:00:17	37.77	155.48	9.13
03/12/08 15:00:27	40.06	159.98	9.35
03/12/08 15:00:37	42.14	159.67	9.43
03/12/08 15:00:47	47.20	157.88	9.39
03/12/08 15:00:57	50.23	157.30	9.59
03/12/08 15:01:07	49.88	157.59	9.98
03/12/08 15:01:17	44.73	155.11	10.30
03/12/08 15:01:27	38.53	150.37	10.48
03/12/08 15:01:37	34.79	145.63	10.44
03/12/08 15:01:47	33.90	143.87	10.46
03/12/08 15:01:57	35.66	144.14	10.61
03/12/08 15:02:07	39.22	143.30	10.90
03/12/08 15:02:17	46.54	138.79	11.16
03/12/08 15:02:27	54.69	133.93	11.18
03/12/08 15:02:37	60.63	133.36	11.08
03/12/08 15:02:47	64.17	136.09	11.13
03/12/08 15:02:57	61.83	135.78	11.34
03/12/08 15:03:07	56.17	1.13	11.45
03/12/08 15:03:17	50.81	1.08	11.58
03/12/08 15:03:27	48.94	1.11	11.75
03/12/08 15:03:37	50.16	127.34	11.92
03/12/08 15:03:47	51.69	127.28	11.98
03/12/08 15:03:57	54.12	125.22	12.00
03/12/08 15:04:07	56.82	123.27	12.20
03/12/08 15:04:17	60.41	123.00	12.25
03/12/08 15:04:27	65.14	122.39	12.39
03/12/08 15:04:37	64.82	121.49	12.46
03/12/08 15:04:47	62.47	120.53	12.44
03/12/08 15:04:57	59.77	120.26	12.44
03/12/08 15:05:07	58.28	119.71	12.48
03/12/08 15:05:17	60.32	119.71	12.21
03/12/08 15:05:27	62.45	119.37	12.20
03/12/08 15:05:37	60.33	122.40	12.33
03/12/08 15:05:47	55.58	1.08	12.42
03/12/08 15:05:57	50.54	1.11	12.53
03/12/08 15:06:07	47.51	120.87	12.45
03/12/08 15:06:17	46.57	120.25	12.12
03/12/08 15:06:27	45.03	123.32	11.94
03/12/08 15:06:37	43.00	129.77	11.92
03/12/08 15:06:47	40.91	131.62	12.03
03/12/08 15:06:57	40.33	129.16	12.00
03/12/08 15:07:07	45.08	127.94	10.94

03/12/08 15:07:17	51.98	130.96	9.97
03/12/08 15:07:27	51.69	139.40	10.33
03/12/08 15:07:37	46.27	140.64	10.90
03/12/08 15:07:47	40.96	136.68	11.36
03/12/08 15:07:57	39.18	132.21	11.62
03/12/08 15:08:07	39.50	128.92	11.36
03/12/08 15:08:17	40.70	132.15	11.15
03/12/08 15:08:27	43.28	135.42	10.81
03/12/08 15:08:37	45.07	143.00	10.97
03/12/08 15:08:47	43.27	145.94	10.95
03/12/08 15:08:57	43.89	144.17	11.11
03/12/08 15:09:07	43.53	143.59	11.28
03/12/08 15:09:17	42.99	139.38	10.95
03/12/08 15:09:27	41.85	139.09	10.69
03/12/08 15:09:37	41.79	140.93	10.79
03/12/08 15:09:47	40.61	141.21	10.06
03/12/08 15:09:57	36.86	144.78	9.83
03/12/08 15:10:07	32.45	153.37	9.66
03/12/08 15:10:17	31.02	156.94	9.50
03/12/08 15:10:27	30.15	162.64	9.59
03/12/08 15:10:37	27.75	164.68	9.56
03/12/08 15:10:47	25.35	163.53	9.09
03/12/08 15:10:57	22.56	168.30	9.03
03/12/08 15:11:07	18.46	171.61	8.97
03/12/08 15:11:17	14.32	170.97	8.59
03/12/08 15:11:27	11.67	170.66	7.86
03/12/08 15:11:37	12.85	169.75	6.66
03/12/08 15:11:47	22.04	169.14	6.06
03/12/08 15:11:57	29.84	163.25	6.55
03/12/08 15:12:07	29.57	158.75	6.53
03/12/08 15:12:17	43.03	159.38	5.01
03/12/08 15:12:27	118.58	148.85	4.72
03/12/08 15:12:37	199.23	137.28	5.61
03/12/08 15:12:47	209.18	134.54	6.38
03/12/08 15:12:57	164.46	134.54	7.13
03/12/08 15:13:07	102.94	135.11	7.94
03/12/08 15:13:17	58.93	133.61	8.02
03/12/08 15:13:27	40.62	131.91	8.58
03/12/08 15:13:37	33.05	127.97	9.32
03/12/08 15:13:47	28.70	127.37	9.83
03/12/08 15:13:57	25.06	126.74	10.16
03/12/08 15:14:07	24.47	124.96	10.75
03/12/08 15:14:17	25.65	122.71	11.11
03/12/08 15:14:27	27.18	121.21	11.32
03/12/08 15:14:37	27.48	121.51	11.40
03/12/08 15:14:47	26.61	123.60	11.46
03/12/08 15:14:57	24.45	126.17	11.42
03/12/08 15:15:07	21.99	127.97	11.35
03/12/08 15:15:17	19.98	131.31	11.16
03/12/08 15:15:27	18.20	133.04	10.99
03/12/08 15:15:37	16.72	136.36	10.62
03/12/08 15:15:47	16.39	140.31	10.32
03/12/08 15:15:57	17.07	145.63	10.27
03/12/08 15:16:07	16.40	147.95	10.12
03/12/08 15:16:17	15.18	148.79	10.07
03/12/08 15:16:27	14.29	150.66	10.07
03/12/08 15:16:37	13.46	151.84	10.25
03/12/08 15:16:47	13.13	150.38	10.29

03/12/08 15:16:57	13.43	148.89	10.05
03/12/08 15:17:07	14.03	149.72	9.98
03/12/08 15:17:17	15.81	152.79	9.89
03/12/08 15:17:27	17.30	154.85	9.74
03/12/08 15:17:37	19.06	156.35	9.65
03/12/08 15:17:47	21.16	158.46	9.44
03/12/08 15:17:57	23.52	160.54	9.11
03/12/08 15:18:07	27.19	162.96	8.94
03/12/08 15:18:17	27.80	166.51	8.76
03/12/08 15:18:27	25.00	166.84	8.53
03/12/08 15:18:37	20.87	169.12	8.45
03/12/08 15:18:47	17.28	170.63	8.30
03/12/08 15:18:57	14.86	170.61	8.26
03/12/08 15:19:07	14.57	169.78	8.08
03/12/08 15:19:17	21.41	169.17	7.94
03/12/08 15:19:27	38.26	170.09	7.78
03/12/08 15:19:37	48.10	166.51	7.37
03/12/08 15:19:47	56.47	167.76	7.31
03/12/08 15:19:57	59.21	169.45	7.20
03/12/08 15:20:07	61.52	168.93	6.93
03/12/08 15:20:17	73.15	169.45	6.37
03/12/08 15:20:27	108.22	171.20	6.42
03/12/08 15:20:37	128.40	171.92	6.46
03/12/08 15:20:47	143.95	171.62	6.56
03/12/08 15:20:57	134.42	169.70	6.90
03/12/08 15:21:07	106.13	168.66	7.02
03/12/08 15:21:17	75.49	167.11	6.85
03/12/08 15:21:27	54.91	168.92	6.93
03/12/08 15:21:37	44.45	169.38	7.02
03/12/08 15:21:47	45.70	166.80	6.93
03/12/08 15:21:57	64.20	162.04	7.20
03/12/08 15:22:07	77.92	156.67	7.44
03/12/08 15:22:17	88.30	154.22	7.49
03/12/08 15:22:27	100.83	154.22	7.56
03/12/08 15:22:37	99.34	154.87	7.96
03/12/08 15:22:47	83.83	154.53	7.56
03/12/08 15:22:57	78.26	152.46	7.39
03/12/08 15:23:07	84.13	152.18	7.31
03/12/08 15:23:17	100.52	151.00	7.41
03/12/08 15:23:27	111.53	149.42	7.55
03/12/08 15:23:37	105.54	152.14	7.77
03/12/08 15:23:47	91.82	153.62	7.84
03/12/08 15:23:57	83.04	153.99	7.79
03/12/08 15:24:07	96.37	152.71	8.20
03/12/08 15:24:17	108.29	151.53	8.60
03/12/08 15:24:27	103.53	147.61	8.48
03/12/08 15:24:37	99.60	145.08	7.92
03/12/08 15:24:47	109.78	147.43	7.91
03/12/08 15:24:57	120.68	148.57	8.13
03/12/08 15:25:07	134.07	145.38	8.26
03/12/08 15:25:17	143.70	142.77	8.32
03/12/08 15:25:27	152.62	140.98	8.55
03/12/08 15:25:37	148.72	134.87	8.21
03/12/08 15:25:47	152.61	132.50	8.06
03/12/08 15:25:57	157.44	135.14	7.81
03/12/08 15:26:07	164.19	138.21	7.46
03/12/08 15:26:17	178.87	138.49	6.88
03/12/08 15:26:27	216.95	140.28	6.72

03/12/08 15:26:37	246.02	144.19	6.46
03/12/08 15:26:47	379.42	143.02	6.07
03/12/08 15:26:57	521.19	139.97	6.15
03/12/08 15:27:07	539.84	141.50	6.52
03/12/08 15:27:17	450.36	143.30	6.80
03/12/08 15:27:27	349.74	142.41	6.99
03/12/08 15:27:37	317.83	138.50	7.15
03/12/08 15:27:47	315.44	135.16	7.29
03/12/08 15:27:57	318.69	135.41	7.17
03/12/08 15:28:07	314.54	136.71	7.37
03/12/08 15:28:17	288.77	140.63	6.84
03/12/08 15:28:27	322.55	141.54	6.52
03/12/08 15:28:37	481.23	135.76	6.71
Run 5 Average >	**100.21**	**133.06**	**10.25**

APPENDIX E:
FUEL ANALYSIS

Hazen Research, Inc.
4601 Indiana Street
Golden, CO 80403 USA
Tel: (303) 279-4501
Fax: (303) 278-1528

Date April 4 2008
HRI Project 002-WS5
HRI Series No. C190/08-2
Date Rec'd. 03/21/08
Cust. P.O.#

Bison Engineering, Inc.
Jim Wollenberg
1400 11th Avenue
Helena, MT 59601

Sample Identification
Bismark #1 3/12/08

Reporting Basis >	As Rec'd	Dry	Air Dry
Proximate (%)			
Moisture	4.99	0.00	1.59
Ash	30.11	31.69	31.19
Volatile	94.30	99.26	97.68
Fixed C	<0.01	<0.01	<0.01
Sulfur	0.05	0.05	0.05
Btu/lb (HHV)	10997	11575	11391
MMF Btu/lb	16299	17602	
MAF Btu/lb		16946	
Air Dry Loss (%)	3.46		
Ultimate (%)			
Moisture	4.99	0.00	1.59
Carbon	50.52	53.18	52.33
Hydrogen	7.53	7.93	7.80
Nitrogen	0.04	0.04	0.04
Sulfur	0.05	0.05	0.05
Ash	30.11	31.69	31.19
Oxygen*	6.76	7.11	7.00
Total	100.00	100.00	100.00
Chlorine**			

Forms of Sulfur (as S,%)

Sulfate		
Pyritic		
Organic		
Total	0.05	0.05

Water Soluble Alkalies (%)

Na2O
K2O

Lb. Alkali/MM Btu=
Lb. Ash/MM Btu= 27.38
Lb. SO2/MM Btu= 0.09
HGI= @ % Moisture
As Rec'd. Sp.Gr.=
Free Swelling Index=
F-Factor(dry),DSCF/MM BTU= 9,242

Report Prepared By:
Vicie Buster for
Gerard H. Cunningham
Fuels Laboratory Supervisor

* Oxygen by Difference.
** Not usually reported as part of the ultimate analysis.

APPENDIX F:
NOMENCLATURE AND FORMULAE

Nomenclature

A_n sampling nozzle cross-sectional area , ft^2

A_s stack cross-sectional area, ft^2
Note: Method 2 refers to this as A

a mean particle projected area

Btu unit heat value (British thermal unit)

B_{wm} percent moisture in gas at meter

B_{ws} percent moisture in stack gas

C_1 viscosity constant, 51.12 micropoise for K (51.05 micropoise for °R)

C_2 viscosity constant, 0.372 micropoise/K (0.207 micropoise/°R)

C_3 viscosity constant, 1.05×10^{-4} micropoise/K^2 (3.24×10^{-5} micropoise/$°R^2$)

C_4 viscosity constant, 53.147 micropoise/ fraction O_2

C_5 viscosity constant, 74.143 micropoise/ fraction H_2O

C_a concentration of acetone blank residue, mg/g

C_{cond} concentration of condensibles, grain/dscf

C_{cors} concentration of coarse particulate, gr/dscf

C_p pitot tube calibration coefficient, 0.84 for type S pitot tube

Cp(std) standard pitot-static tube calibration coefficient

C_{PM10} concentration of PM_{10} particulate, gr/dscf

C_s particulate concentration in stack gas, mass/volume

cs12 particulate concentration corrected to 12 percent CO_2

c_{s50} particulate concentration corrected to 50 percent excess air

cws particulate concentration on a wet basis, mass/wet volume

$C_{X\,(corr)}$ actual gas concentration corrected to required percent O_2

D_{50} diameter of particles having a 50 percent probability of penetration, μm

D_e equivalent diameter

D_h hydraulic diameter

$DH_@$ pressure drop across orifice meter for 0.75 CFM at standard conditions

DH pressure drop across orifice meter

D_n source sampling nozzle diameter

D_{p50} 50% effective cutoff diameter of particle, μ

D_s diameter of the stack, feet

E emission rate or mass/unit heat (Btu input)

e base of natural logarithms (ln10 = 2.302585)

%EA percent excess air

E_{hr} emission rate per hour, lb/hr

ER_{cond} emission rate of condensibles, lb/hr

ER_{cors} emission rate of coarse particulate, lb/hr

ER_{mmBtu} emission rate per mmBtu or ton of fuel, etc.

ER_{PM10} emission rate of PM_{10} particulate, lb/hr

ER_X emission rate of compound which replaces x

F_c F factor for CO_2, used with percent CO_2, wet or dry basis

F_d F factor for dry effluent, used with percent O_2, dry basis

f_o stack gas fraction O_2, by volume, dry basis

F_o fuel factor

F_w F factor for wet effluent, used with percent O_2, wet basis

ΔH average pressure differential across orifice meter at control box

$\Delta H_@$ orifice pressure, inches H_2O

ΔH_d	orifice pressure head, inches H_2O, needed for cyclone flow rate
%I	percent sampling rate variation, where 100% = ideal isokinetic conditions
j	equal area centroid
K_1	0.001333 m^3/ml for metric units 01.1 ft^3/ml for English units *Equation 4-1*
K_2	0.001335 m^3/g for metric units 1. ft^3/g for English units *Equation 4-2*
K_3	0.3858 °K/mm Hg for metric units 1. °R/in. Hg for English units *Equation 4-3*
K_p	pitot tube equation dimensional constant, 85.49
L	length of duct cross-section at sampling site
L_1	plume exit diameter
L_2	stack diameter
m	mass
M_a	acetone residue weight after evaporation, mg
mBtu	thousand Btu
M_{cond}	mass of condensibles
M_{cors}	mass of coarse particulate
M_d	dry stack gas molecular weight
m_f	filter weight gain, mg
M_{fine}	mass of PM_{10} particulate
mmBtu	million Btu
m_n	total weight of collected particulate, mg
$m_{n,pm10}$	total weight of collected PM_{10} particulate, mg
M_s	wet stack gas molecular weight
M_w	molecular weight of water, 18.0 g/g-mole (18.0 lb/lb-mole)
M_{wx}	molecular weight of gas species, g/gmol
n	number of particles
N_{re}	Reynolds Number
θ	total sampling time, min.
O_1	plume opacity at exit
O_2	in-stack plume opacity
ΔP	stack differential pressure recorded by the probe's type S pitot tube
Δp	velocity head of stack gas, mm H_2O (in. H_2O) - *Equation 2-8*
$\sqrt{\Delta P}$	average of the square roots of ΔP (may also be referred to as ASΔP)
$\sqrt{\Delta P_1}$	square root of ΔP at point 1 of the current test
$\sqrt{\Delta P_1}'$	square root of ΔP at point 1 of the previous traverse
$\sqrt{\Delta P}'$	average of the square roots of ΔP from the previous traverse (may also be referred to as ASΔP')
$\%CO_2$	percent CO_2 by volume, dry basis
$\%O_2$	percent O_2 by volume, dry basis
%CO	percent CO by volume, dry basis
$\%N_2$	percent N_2 by volume, dry basis
P_{atm}	atmospheric pressure
P_b	barometric pressure ($P_b = P_{atm}$)
P_{bar}	barometric pressure at measurement site, mm Hg (in. Hg)
P_g	stack static pressure, mm Hg (in. Hg)
P_i	pitch angle at traverse point i, degree
P_m	absolute pressure at the meter
pmr	pollutant mass rate
P_p	absolute barometric pressure at the sample location, inches Hg
P_s	absolute pressure in the stack

P_{std}	standard absolute pressure, 760 mm Hg (29.92 in. Hg)
pts	number of traverse points during the test, minimum of 6, maximum of 12
ρ_w	density of water, 0.9982 g/ml (0.002201 lb/ml)
q	time in minutes
Q_a	stack gas volumetric flow rate, acfm
Q_s	average stack gas wet volumetric flow rate, cfm (ft^3/min)
Q_{sc}	actual gas flow rate through the cyclone, acfm
Q_{sc}'	predicted actual gas flow rate through the cyclone, acfm
$Q_{s(std)}$	total cyclone flow rate at standard conditions, dscm/min (dscf/ min)
Q_{std}	dry volumetric stack gas flow rate corrected to standard conditions
Q_w	wet stack gas standard volumetric flow, ft^3/min, wscfm
r	path length
R	ideal gas constant, 0.06236 (mm Hg) (m^3)/(g-mole) (K) for metric units and 21.85 (in. Hg) (ft^3)/(lb-mole) (°R) for English units
R_i	resultant angle at traverse point i, degree
R_{max}	multiplier for V_n
R_{min}	multiplier for V_n
T_m	absolute temperature at meter, K (°R)
t_s	stack temperature, °C (°F)
T_s	absolute stack temperature, K (°R)
$T_{s(avg)}$	average stack gas temperature, absolute, °R
T_{std}	standard absolute temperature, 293 K (528°R)
T_t	duration of test
μ_s	stack gas absolute viscosity, μ poise
V_f	final volume of condenser water, ml
V_i	initial volume, if any, of condenser water, ml
V_m	dry gas volume measured by dry gas meter, dcm (dcf)
ΔV_m	incremental dry gas volume measured by dry gas meter at each traverse point, dcm (dcf)
V_{max}	maximum allowed nozzle velocity , fps
V_{min}	minimum allowed nozzle velocity, fps
$V_{m(std)}$	dry gas volume measured by the dry gas meter, corrected to standard conditions, dscm (dscf)
V_n	target nozzle velocity, fps
v_s	average stack gas velocity, m/sec (ft/sec)
V_w	volume of water vapor
$V_{w(std)}$	volume of water vapor in the gas sample, corrected to standard conditions, scf (standard cubic feet)
$V_{wc(std)}$	volume of water vapor condensed corrected to standard conditions, scm (scf)
$V_{wsg(std)}$	volume of water vapor collected in silica gel corrected to standard conditions, scm (scf)
Volume H_2O	metric units = 0.00134 m^3/ml x ml H_2O English units = 0.04707 ft^3/mlxmlH_2O
W	width of the duct cross-section at the sampling site
W_f	final weight of silica gel or silica gel plus impinger, g
W_i	initial weight of silica gel or silica gel plus impinger, g
W_{lc}	weight of collected water, g
X_d	fraction of dry gas
Y	dry gas meter calibration factor
Y_i	yaw angle at traverse point i, degree

1. 0.280 molecular weight of N_2 or CO divided by 100
2. molecular weight of O_2 divided by 100

	0.440 molecular weight of CO_2 divided by 100
	18.0 molecular weight of water, g/g-mole (lb/lb-mole)
3,600	conversion factor, sec/hr

Subscripts:

atm	atmospheric
ave	average
b	barometric
d	dry gas basis
f	final
g	gauge
i	initial
m	at meter
n	at nozzle
p	of pitot tube
s	at stack
SCF	standard cubic feet
std	standard conditions
w	wet basis

FORMULAE

1. Dry Gas Volume - Corrected to STP (40 CFR 60, App. A, Eq. 5-1)

$$V_{m(std)} = V_m Y \left(\frac{T_{std}}{T_m} \right) \left[\frac{P_{b_{ar}} + \frac{\overline{\Delta H}}{13.6}}{P_{std}} \right]$$

Y is obtained from post-test meter calibrations.

2. Water Vapor Volume - Corrected to STP (40 CFR 60, App. A, Eq. 5-2)

$$V_{w(std)} = V_{lc} \left(\frac{\rho_w}{M_w} \right) \left(\frac{RT_{std}}{P_{std}} \right)$$

Note: $W_{lc} = V_{lc}\, \rho_w$

3. Stack Gas Moisture Content (40 CFR 60 App. A, Eq. 5-3, modified)

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

4. Stack Gas Dry and Wet Molecular Weight (40 CFR 60 App. A, Eq. 3-1, 2-5)

$$M_d = 0.440(\%CO_2) + 0.320(\%O_2) + 0.280(\%N_2 + \%CO)$$

$$M_s = M_d(1 - B_{ws}) + 18.0 B_{ws}$$

5. Average Stack Gas Velocity (40 CFR 60 App. A, Eq. 2-9)

$$v_s = K_p C_p \left(\frac{\sum_1^n \sqrt{\Delta p}}{n} \right) \sqrt{\frac{T_{s(avg)}}{P_S M_S}}$$

6. Average Stack Gas Wet Volumetric Flow Rate

$$Q_s = 60 v_s A_s$$

7. Average Stack Gas Dry Flow Rate Corrected to Standard Conditions (40 CFR 60 App. A, Eq. 2-10, modified)

$$Q_{std} = Q_s (1 - B_{ws}) \frac{T_{std}}{T_{s(avg)}} \frac{P_s}{P_{std}}$$

8. TSP Particulate Concentration Corrected to Standard Conditions (40 CFR 60 App. A, Eq. 5-6, modified)

$$c_{s_{lb}} = 2.205 \, x \, 10^{-6} \frac{m_n}{V_{m(std)}}$$

$$c_{s_{gr}} = 15.43 \, x \, 10^{-3} \frac{m_n}{V_{m(std)}}$$

Note: $C_{s,lb}$ = lb/dscf
$C_{s,gr}$ = grains/dscf
m_n = mg

9. TSP Emission Rate per Hour

$$E_{hr} = c_s Q_{std} 60$$

10. Percent Isokinetic Sampling Variation (40 CFR 60 App. A, Eq. 5-8)

$$I\% = \frac{T_{s(avg)} V_{m(std)} P_{std} 100}{T_{std} v_s \Theta A_n P_s 60 (1 - B_{ws})}$$

11. Percent moisture at 100 percent saturation (%SVP) equation:

$$\% SVP = \left[\frac{100}{P_S}\right] x 10^{\left[6.6911 - \frac{3144}{(T_{ws} - 390.86)}\right]}$$

where: P_s = stack pressure (absolute), inches of mercury
T_{ws} = saturated stack temperature, degrees F

12. Emission Rate Compressor Engines (g/BHP-Hr)

$$E = \frac{(e)\ PPM\ Q_{STD}}{BHP}$$

13. Brake Horsepower for Compressor Engines

$$BHP = [43.6\ x\ MMCFD\ x \left(\frac{T_{ts}}{T_{std2}}\right) x \left(\frac{K}{(K-1)}\right) x \left(R_2^{\frac{(k-1)}{k}} - 1\right) x\ LE\ x\ FE] + Fan\ HP$$

14. Pounds Per Hour Emission Rate

$$lb/hr = E * BHP * \frac{lb}{453.59\ g}$$

15. Analyzer Calibration error, in general, % diff. ≤ 2%

$$\% Diff. = \left(\frac{Cal.\ gas\ ppm - Analyzer\ response\ ppm}{Analyzer\ span\ ppm}\right) x100$$

16. System bias, in general <5% for both zero and upscale gases

$$system\ Bias = \left(\frac{system\ cal.\ response\ ppm - Analyzer\ response\ ppm}{span\ gas\ ppm}\right) x100$$

17. Calibration drift <3% for both zero and upscale gases during each run

$$Cal.\ Drift = \left(\frac{final\ sys\ Cal.\ resp.\ ppm - initial\ sys\ cal.\ resp.\ ppm}{span\ gas\ ppm}\right) x100$$

18.

$$System\ Calibration\ Bias = \left(\frac{System\ Cal.\ Response\ ppm - Analyzer\ Cal.\ Response\ ppm}{span\ gas\ ppm}\right) x100$$

19.

$$Drift = \left(\frac{Final\ System\ Cal.\ Response\ ppm - Initial\ System\ Cal.\ Response\ ppm}{Span\ gas\ ppm}\right) x100$$

20. Analyzer calibration error, in general, %diff. ≤ 2%

$$\%\ Diff. = \left(\frac{Cylinder\ ppm - analyzer\ response\ ppm}{span\ gas\ ppm}\right) x100$$

21. Parts per million by volume (ppmv) to pounds per hour (lbs/hr)

lbs/hr = 1.558×10^{-7} x molecular weight x flow, dscfm x ppmv

lbs/hr = (ppmv) ($1.558\ e^{-7}$) (MW) (dscfm)

ppm = parts per million
dscfm = dry standard cubic feet per minute
MW = molecular weight

22. Corrected concentrations to 12% CO_2

$$Cs_{12} = Cs \frac{12}{\%CO_2}$$

23. Correcting concentrations to 6% O_2

$$Cs_{\%O_2d} = Cs \left[\frac{20.9 - 6\ \%O_2}{20.9 - \%O_{2d}} \right]$$

24. Concentration moisture corrections

$$Cd = (Cw) / (1 - Bws)$$

Cd = concentration dry
Cw = concentration wet
Bws = moisture content

25. Fuel Burning Rule

Fuel Input: Measure fuel introduced to the boiler bank. For example,

$$E = 0.882 * H^{-0.1664}$$
$$E = 0.882\ (12{,}500\ lb_{fuel}/hr \times 4800\ Btu/lb_{fuel})/1\times10^6)^{-0.1664}$$
$$E = 0.882\ (60\ MMBtu/hr)^{-0.1664}$$
$$E = 0.4463\ lb/MMBtu$$

Where E is the maximum allowable particulate emissions rate in lbs per MMBtu.

Steam Production: Measure steam produced by the boiler bank. For example,

$$E = 0.882 * H^{-0.1664}$$
$$E = 0.882\ [(30{,}000\ lb_{steam}/hr \times 1{,}200\ Btu/lb_{steam})/(60\%_{boiler\ efficiency})/(1\times10^6)]^{-0.1664}$$
$$E = 0.882\ (60\ MMBtu/hr)^{-0.1664}$$
$$E = 0.4463\ lb/MMBtu$$

Where E is the maximum allowable particulate emissions rate in lbs per MMBtu.