Relative Accuracy Test Audit and Particulate Matter Emissions Test Summary Report

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Prepared for:

Cargill Salt Inc.

916 S Riverside Avenue
St Clair, MI 48079

Project No. 17-4994.00
May 3, 2017

BT Environmental Consulting, Inc.
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BTEC Inc.

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Executive Summary

BT Environmental Consulting, Inc. (BTEC) was retained by Cargill Salt Inc (Cargill) to conduct compliance relative accuracy test audit (RATA) and particulate matter (PM) emissions test at the Cargill facility located in St Clair, Michigan. The RATA was performed on one Continuous Emission Monitoring System (CEMS) serving Boiler No. 15. The boiler fired natural gas and is designated as Boiler No. 15 (EUBoiler15, Stack No. SVBoiler#15). The PM testing was performed on the EUPRETZEL exhaust.

The testing was performed to demonstrate compliance with Michigan Department of Environmental Quality (MDEQ) Permit No. 167-14 and in accordance with Appendix A, 40 CFR, Part 60, U.S. EPA Reference Methods 3A, 7E, 19, 1-4, and 5 found in 40 CFR, Part 60, Appendix A and Performance Specifications (PS) 2 and 3 stipulated in 40 CFR, Part 60, Appendix B. The gaseous testing of the boiler consisted of ten 21-minute test runs performed while operating at approximately 60% of the rated capacity of the boiler and while burning natural gas. The PM testing at EUPRETZEL exhaust consisted of triplicate 60-minute test runs.

The results of the NO_x lb/MMBTU RATA and PM test program are summarized in the following Executive Summary Table I.

Table E-I
Summary of Cargill Boiler No. 15 CEMS RATA and EUPRETZEL PM Results
RATA Test Date: April 11, 2017
PM Test Date: April 12, 2017

Source Name	RM NO_x lb/MMBTU	CEMS NO_x lb/MMBTU	% Relative Accuracy	40 CFR Part 60 % Relative Accuracy Limit
Boiler 15	0.033	0.036	9.3	20
Source Name	Average test results (lb/hr)		Permit Limit (lb/hr)	
EUPRETZEL	8.28		5.2	

1.0 Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Cargill Salt Inc (Cargill) to conduct compliance relative accuracy test audit (RATA) and particulate matter (PM) emissions test at the Cargill facility located in St Clair, Michigan. The RATA was performed on one Continuous Emission Monitoring System (CEMS) serving Boiler No. 15. The boiler fired natural gas and is designated as Boiler No. 15 (EUBoiler15, Stack No. SVBoiler#15). The PM testing was performed on the EUPRETZEL exhaust.

The testing was performed to demonstrate compliance with Michigan Department of Environmental Quality (MDEQ) Permit No. 167-14 and in accordance with Appendix A, 40 CFR, Part 60, U.S. EPA Reference Methods 3A, 7E, 19, 1-4, and 5 found in 40 CFR, Part 60, Appendix A and Performance Specifications (PS) 2 and 3 stipulated in 40 CFR, Part 60, Appendix B. The gaseous testing of the boiler consisted of ten 21-minute test runs performed while operating at approximately 60% of the rated capacity of the boiler and while burning natural gas. The PM testing at EUPRETZEL exhaust consisted of triplicate 60-minute test runs.

The testing was conducted on April 11 and 12, 2017. BTEC personnel Todd Wessel and Mike Nummer performed the testing. Ms. Priscila Gavel of Cargill and Mr. Rick Snyder of Monitoring Solutions assisted the study by coordinating process test times and gathering CEMS data.

2.0 Process Description

EUPRETZEL IS a series of equipment used to process salt. Equipment includes grinders, screens, storage bins, feeders, conveyors, etc. All equipment is operated indoors within its own enclosure and/or is ducted to the auxiliary third floor wet scrubber. Boiler No. 15 has an input capacity of 248.5 MMBTU/hr while firing natural gas (NG). The steam from the boiler is dispatched to various process equipment at the facility. Low-NO_x combustors minimize the emissions of nitrogen oxides from the boilers.

3.0 Sampling and Analytical Methodologies

Sampling and analytical methodologies are summarized in Sections 3.1 through 3.4. A Schematic drawing of BTEC's continuous emissions monitoring system is presented as Figure 1. Traverse point locations for the Boiler are illustrated in Figure 2.

3.1 Continuous Emissions Monitoring

Measurement of exhaust gas concentrations was conducted utilizing the following reference test methods codified at 40 CFR 60, Appendix A:

- Method 3A- Determinations of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources

- Method 7E - Determination of Nitrogen Oxides Emissions from Stationary Sources
- Performance Specification 2 – Specifications and Test Procedures for SO_2 and NO_x Continuous Emission Monitoring Systems in Stationary Sources
- Performance Specification 3 – Specifications and Test Procedures for O_2 and CO_2 Continuous Emission Monitoring Systems in Stationary Sources

BTEC's extractive monitors require that the effluent gas sample be conditioned to eliminate any possible interference (i.e., water vapor and/or particulate matter) before being transported and injected into each analyzer. All components of the sampling system that contact the sample were constructed of Type 316 stainless steel, Pyrex glass or Teflon®. The output signal from each monitor was recorded at 10-second intervals on a PC equipped with data acquisition software (DAS). The samples were extracted from the stack using a heated sample probe/filter assembly, heated sample line, stack gas conditioner with a Teflon diaphragm pump and routed through a distribution manifold for delivery to the analyzers. The configuration of the sampling system allowed for the injection of calibration gases directly to the analyzers or through the sampling system. All monitors in use were calibrated with U.S. EPA Protocol No. 1 calibration gases and operated to insure that zero drift, calibration gas drift, and calibration error met the specified method requirements. Copies of the Protocol gas certificates can be found in Appendix E.

The sample gas was extracted at three points through a heated stainless steel probe positioned at approximately 16.7%, 50% and 83.3% of the sample stream diameter as described by 40 CFR Part 60, Appendix B Performance Specification 2 Section 8.1.3.2 and illustrated in Figure 2. Ten 21-minute test runs were conducted, with the best nine runs used to calculate the relative accuracy (RA).

A diagram of the reference monitoring system is illustrated in Figure 1.

The boiler NO_x concentrations were measured in parts per million (ppm), converted to an emission rate and reported as lb/MMBTU, using equation 19-1 of U.S. EPA Method 19 of Appendix A, 40 CFR 60. Oxygen concentrations are reported in percent (%).

3.1.1 Oxygen (USEPA Method 3A)

A M&C PMA-100 analyzer was used to measure O_2 concentrations following the guidelines of U.S. EPA Method 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from a Stationary Source (Instrumental Analyzer Procedure)", in conjunction with Performance Specification No. 3 of Appendix B, 40 CFR 60. The analyzer was set at 25% instrument span and calibrated before the RATA with zero nitrogen and high range USEPA Protocol 1 span gas (80 to 100% of span). Following calibration, a mid range USEPA Protocol 1 gas (40 to 60% of span) was introduced. The response error did not exceed 2% of the instrument span, as required by the method. Calibration error results are presented in Appendix B. Calibration drift checks were performed at the completion of each test run.

3.1.2 Nitrogen Oxides (USEPA Method 7E)

A Thermo Environmental Model 42i-HL Chemiluminescence analyzer was used to measure parts per million of nitrogen oxides in the dry sample gas following the guidelines of U.S. EPA Method 7E, "Determination of Nitrogen Oxides from Stationary Sources (Instrumental Analyzer Procedure)", in conjunction with Performance Specification No. 2 of Appendix B, 40 CFR 60. The analyzers measure the concentration of NO_x by converting NO_x to NO and then measuring the light emitted by the reaction of NO with ozone. The NO_x analyzer was set at 0-100 ppm instrument span during the RATAs. The NO_x sampling system was calibrated at three points, zero, mid range (40-60% of span), and high range (80-100% of span) with USEPA Protocol 1 calibration gases. BTEC conducted a NO_2 to NO conversion efficiency tests, as specified in U.S. EPA Method 7E on the analyzer. The results of the NO_2 to NO conversion efficiency test can be found on the enclosed compact disk.

3.2 PM Sampling Train and Field Procedures

Sampling and analytical methodologies for the emissions test program can be separated into two categories as follows:

(1) Measurement of exhaust gas velocity, molecular weight, and moisture content;
(2) Measurement of exhaust gas filterable PM concentration;

Sampling and analytical methodologies by category are summarized below.

3.2.1 Exhaust Gas Velocity, Molecular Weight, and Moisture Content

Stack gas velocity traverses were conducted in accordance with the procedures outlined in Method 1 and Method 2. S-type pitot tubes with thermocouple assemblies, calibrated in accordance with Method 2 were used to measure exhaust gas velocity pressures (using a manometer) and temperatures during testing. The S-type pitot tube dimensions were within specified limits, therefore, a baseline pitot tube coefficient of 0.84 (dimensionless) was assigned. A diagram of the sample points is provided in Figure 1.

Cyclonic flow checks were performed at each sampling location. The existence of cyclonic flow is determined by measuring the flow angle at each sample point. The flow angle is the angle between the direction of flow and the axis of the stack. If the average of the absolute values of the flow angles is greater than 20 degrees, cyclonic flow exists. The null angle was determined to be less than 20 degrees at each sampling point.

The Molecular Weight of the gas stream was evaluated according to procedures outlined in Title 40, Part 60, Appendix A, Method 3A. The O_2 /CO_2 content of the gas stream was measured using a Fyrite combustion analyzer.

Exhaust gas was extracted as part of the sampling train. Exhaust gas moisture content was then determined gravimetrically.

3.2.2 Filterable Particulate Matter – Method 5

40 CFR 60, Appendix A, Method 5, "Determination of Particulate Emissions from Stationary Sources" was used to measure PM concentrations and calculate appropriate emission rates (see Figure 2 for a schematic of the sampling train).

BTEC's Nutech® Model 2010 modular isokinetic stack sampling system consisted of (1) a stainless steel nozzle, (2) a glass probe, (3) a set of four Greenburg-Smith (GS) impingers with the first two with 100 ml of H2O (ii) an empty impinger, (iii) and an impinger filled with approximately 300 grams of silica gel, (4) a length of sample line, and (5) a Nutech® control case equipped with a pump, dry gas meter, and calibrated orifice.

Upon completion of the final leak test for each test run, the filter was recovered, and the nozzle, probe, and the front half of the filter holder assembly were brushed and triple rinsed with 100 ml of acetone which was collected in a pre-cleaned sample container.

BTEC labeled each container with the test number, test location, and test date, and marked the level of liquid on the outside of the container. In addition, blank samples of the acetone and filter were collected. BTEC personnel carried all samples to BTEC's laboratory (for filter and acetone gravimetric analysis) in Royal Oak, Michigan.

4.0 Test Results

The Boiler PEMS results are expressed in lb/MMBTU. The percent relative accuracy for Boiler 15 PEMS NO_x lb/MMBTU was 9.3%.

The average PM emission rate from the EUPRETZEL scrubber was 8.28 pounds per hour.

Detailed emissions test results are presented in Tables 1 through 4.

5.0 Sampling Procedure Variations

Sample recovery for the PM testing on the exhaust of EUPRETZEL was modified due to the salt particulate. Triplicate water rinses were used instead of acetone.

BTEC Inc.

Limitations

The information and opinions rendered in this report are exclusively for use by Cargill. BTEC will not distribute or publish this report without Cargill Corporation's consent except as required by law or court order. BTEC accepts responsibility for the competent performance of its duties in executing the assignment and preparing reports in accordance with the normal standards of the profession, but disclaims any responsibility for consequential damages.

This report was prepared by: For

Paul Diven
Project Manager

This report was reviewed by: Brandon Chase

Brandon Chase
Senior Environmental Engineer

Table 1
Summary of NOx lb/mmbtu RATA Results
Cargill Salt
April 11, 2017

Boiler 15

NO_X Lb/MMBtu Relative Accuracy

		Relative Accuracy:		9.3		
Run #	**Time**	**RM Lb/MMBtu**	**PEM Lb/MMBtu**	**Diff**	**%Diff**
1	8:11-8:31	0.0333	0.0350	-0.0017	-0.05
2	**8:51-9:11**	**0.0315**	**0.0350**	**-0.0035**	**-0.11**
3	9:29-9:49	0.0322	0.0350	-0.0028	-0.09
4	10:00-10:20	0.0325	0.0350	-0.0025	-0.08
5	13:32-10:52	0.0323	0.0350	-0.0027	-0.08
6	11:04-11:24	0.0327	0.0360	-0.0033	-0.10
7	11:37-11:57	0.0330	0.0360	-0.0030	-0.09
8	12:10-12:30	0.0339	0.0370	-0.0031	-0.09
9	12:43-13:03	0.0343	0.0370	-0.0027	-0.08
10	13:16-13:36	0.0345	0.0370	-0.0025	-0.07
11	**0**	**0.0000**	**0.0000**	**0.0000**	**#DIV/0!**
12	**0**	**0.0000**	**0.0000**	**0.0000**	**#DIV/0!**
		0.033	0.036	-0.003	-0.082

Sdev	0.0005
CC	0.0004
RA (based on Ref. Meth.)	**9.3%**
Bias Test Pass/Fail	**Pass**
Bias Adjustment Factor	**1.000**

Confidence Coefficient =
n=9
t=2.306

$$CC = t_{0.975}\frac{S_d}{\sqrt{n}}$$

P.S. 2 Equation 2-5

Standard Deviation =

$$S_d = \left[\frac{\sum_{i=1}^{n} d_i^2 - \frac{\left(\sum_{i=1}^{n} d_i\right)^2}{n}}{n-1}\right]^{1/2}$$

P.S. 2 Equation 2-4

Relative Accuracy =
RM=Reference Monitor

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} x 100$$

P.S. 2 Equation 2-6

RA calculated as specified in Performance Specification 2, Appendix B, 40 CFR 60 - Equation 2-4

As specified in P.S. 2, subsection 8.4.4, three sets of test runs may be rejected, these rejected test runs are high-lighted in the table

Used Method 19 Eq. 19-1

Table 2
Summary of NOx PPM RATA Results
Cargill Salt
April 11, 2017

Boiler 15

NO_x PPM Relative Accuracy

	Relative Accuracy:		**8.6**		
Run #	**Time**	**RM NOx PPM**	**PEM NOx PPM**	**Diff**	**%Diff**
1	8:11-8:31	27.08	28.40	-1.32	-0.05
2	**8:51-9:11**	**25.63**	**28.30**	**-2.67**	**-0.10**
3	9:29-9:49	26.29	28.70	-2.41	-0.09
4	10:00-10:20	26.48	28.70	-2.22	-0.08
5	13:32-10:52	26.34	28.50	-2.16	-0.08
6	11:04-11:24	26.61	28.90	-2.29	-0.09
7	11:37-11:57	26.91	29.00	-2.09	-0.08
8	12:10-12:30	27.61	29.80	-2.19	-0.08
9	12:43-13:03	27.99	29.90	-1.91	-0.07
10	13:16-13:36	28.01	30.20	-2.19	-0.08
11	**0**	**0.00**	**0.00**	**0.0000**	**#DIV/0!**
12	**0**	**0.00**	**0.00**	**0.0000**	**#DIV/0!**
		27.036	29.122	-2.087	-0.077
	Sdev		0.3181		
	CC		0.2445		
	RA (based on Ref. Meth.)		**8.6%**		
	Bias Test Pass/Fail		**Pass**		
	Bias Adjustment Factor		**1.000**		

Confidence Coefficient =
n=9
t = 2.306

$$CC = t_{0.975} \frac{S_d}{\sqrt{n}}$$

P.S. 2 Equation 2-5

Standard Deviation =

$$S_d = \left[\frac{\sum_{i=1}^{n} d_i^2 - \frac{\left(\sum_{i=1}^{n} d_i\right)^2}{n}}{n-1} \right]^{1/2}$$

P.S. 2 Equation 2-4

Relative Accuracy =
RM=Reference Monitor

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} x100$$

P.S. 2 Equation 2-6

RA calculated as specified in Performance Specification 2, Appendix B, 40 CFR 60 - Equation 2-4

As specified in P.S. 2, subsection 8.4.4, three sets of test runs may be rejected, these rejected test runs are high-lighted in the table

Part 60 Requires +/- 20% RA, Part 75 Requires +/- 12 PPM

Table 3
Summary of O_2 RATA Results
Cargill Salt
April 11, 2017

Boiler 15

O_2 % Relative Accuracy

Run #	Time	RM O2%	PEM O2%	Diff	%Diff
Relative Accuracy:			**1.0**		
1	8:11-8:31	3.22	3.20	0.02	0.01
2	8:51-9:11	3.21	3.20	0.01	0.00
3	9:29-9:49	3.17	3.20	-0.03	-0.01
4	10:00-10:20	3.20	3.20	0.00	0.00
5	13:32-10:52	3.16	3.20	-0.04	-0.01
6	11:04-11:24	3.19	3.20	-0.01	0.00
7	11:37-11:57	3.16	3.20	-0.04	-0.01
8	12:10-12:30	3.20	3.20	0.00	0.00
9	12:43-13:03	3.16	3.20	-0.04	-0.01
10	**13:16-13:36**	**3.23**	**3.30**	**-0.07**	**-0.02**
11	**0**	**0.00**	**0.00**	**0.00**	**#DIV/0!**
12	**0**	**0.00**	**0.00**	**0.00**	**#DIV/0!**
		3.186	3.200	-0.014	-0.005
	Sdev		0.0235		
	CC		0.0181		
	RA (based on Ref. Meth.)		**1.0%**		
	Bias Test Pass/Fail		**Pass**		
	Bias Adjustment Factor		**1.000**		

Confidence Coefficient = $CC = t_{0.975}\frac{S_d}{\sqrt{n}}$ P.S. 2 Equation 2-5

n=9

t = 2.306

Standard Deviation = $S_d = \left[\frac{\sum_{i=1}^{n} d_i^2 - \frac{(\sum_{i=1}^{n} d_i)^2}{n}}{n-1}\right]^{1/2}$ P.S. 2 Equation 2-4

Relative Accuracy = $RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} x100$ P.S. 2 Equation 2-6

RM=Reference Monitor

RA calculated as specified in Performance Specification 2, Appendix B, 40 CFR 60 - Equation 2-4

As specified in P.S. 2, subsection 8.4.4, three sets of test runs may be rejected, these rejected test runs are high-lighted in the table

Part 60 Requires +/- 20% RA, Part 75 Requires +/- 12 PPM

Table 4
EUPRETZEL Particulate Matter Emission Rates

Company	**Cargill Salt**			
Source Designation	**Pretzel Line**			
Test Date	**4/12/2017**	**4/12/2017**	**4/12/2017**	
Meter/Nozzle Information	Run 1	Run 2	Run 3	Average
Meter Temperature Tm (F)	69.6	72.6	73.1	71.8
Meter Pressure - Pm (in. Hg)	29.9	29.9	29.9	29.9
Measured Sample Volume (Vm)	57.2	56.9	56.7	56.9
Sample Volume (Vm-Std ft3)	57.3	56.7	56.6	56.9
Sample Volume (Vm-Std m3)	1.62	1.61	1.60	1.61
Condensate Volume (Vw-std)	1.509	1.697	1.839	1.682
Gas Density (Ps(std) lbs/ft3) (wet)	0.0738	0.0737	0.0736	0.0737
Gas Density (Ps(std) lbs/ft3) (dry)	0.0745	0.0745	0.0745	0.0745
Total weight of sampled gas (m g lbs) (wet)	4.34	4.31	4.30	4.32
Total weight of sampled gas (m g lbs) (dry)	4.27	4.23	4.22	4.24
Nozzle Size - An (sq. ft.)	0.000314	0.000314	0.000314	0.000314
Isokinetic Variation - I	100.3	100.2	100.7	100.4
Stack Data				
Average Stack Temperature - Ts (F)	74.5	77.5	76.6	76.2
Molecular Weight Stack Gas- dry (Md)	28.8	28.8	28.8	28.8
Molecular Weight Stack Gas-wet (Ms)	28.6	28.5	28.5	28.5
Stack Gas Specific Gravity (Gs)	0.986	0.985	0.984	0.985
Percent Moisture (Bws)	2.56	2.90	3.15	2.87
Water Vapor Volume (fraction)	0.0256	0.0290	0.0315	0.0287
Pressure - Ps ("Hg)	29.6	29.6	29.6	29.6
Average Stack Velocity -Vs (ft/sec)	53.1	53.1	52.6	52.9
Area of Stack (ft2)	6.0	6.0	6.0	6.0
Exhaust Gas Flowrate				
Flowrate ft^3(Actual)	19,103	19,102	18,932	19,046
Flowrate ft^3 (Standard Wet)	18,671	18,572	18,455	18,566
Flowrate ft^3 (Standard Dry)	18,193	18,033	17,873	18,033
Flowrate m^3 (standard dry)	515	511	506	511
Total Particulate Weights (mg)				
Nozzle/Probe/Filter	104.6	141.8	344.6	197.0
Total Particulate Concentration				
lb/1000 lb (wet)	0.053	0.073	0.177	0.101
lb/1000 lb (dry)	0.054	0.074	0.180	0.103
mg/dscm (dry)	64.4	88.2	215.2	122.6
gr/dscf	0.0282	0.0386	0.0940	0.0536
Total Particulate Emission Rate				
lb/ hr	4.41	5.98	14.46	8.28

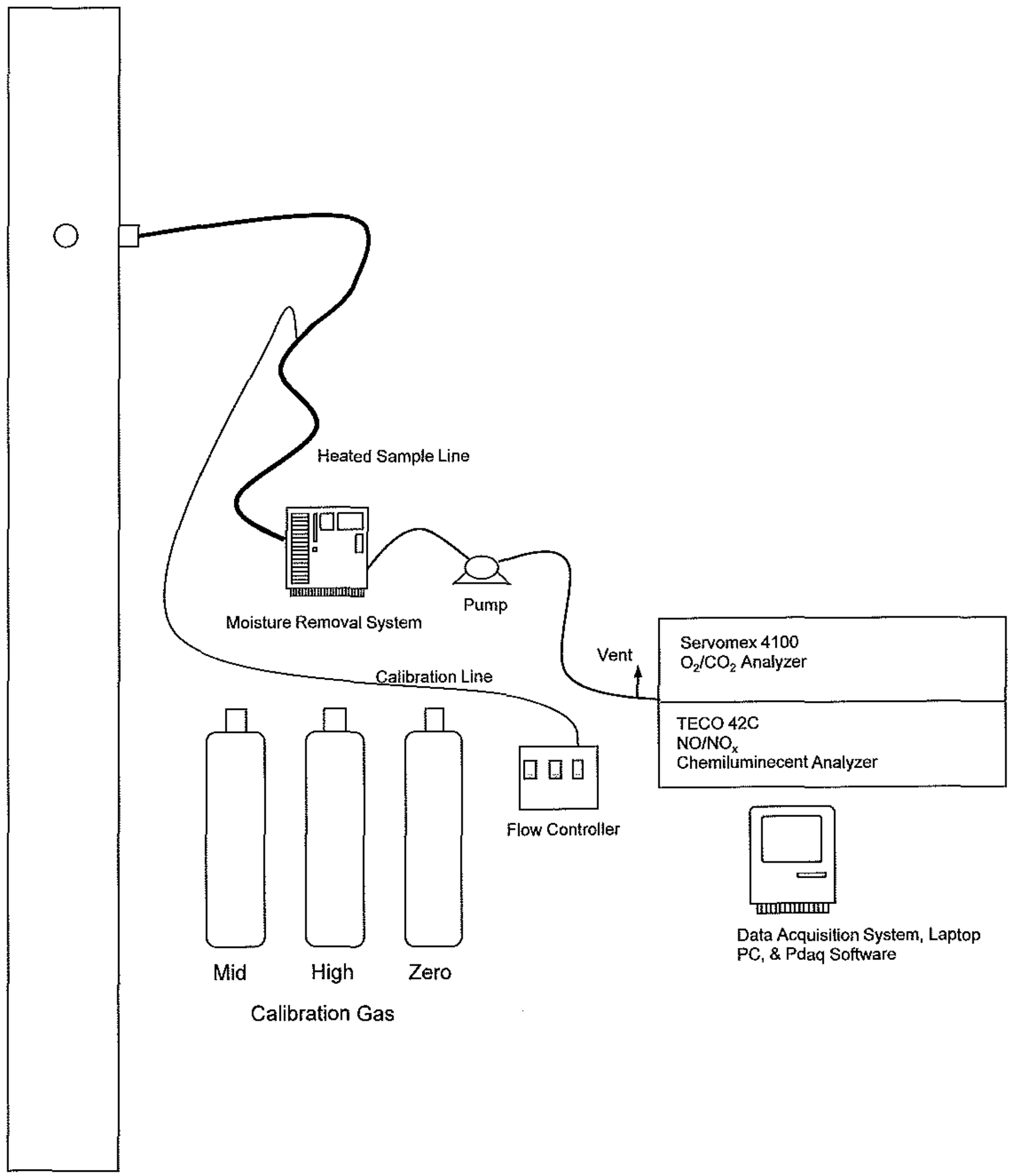
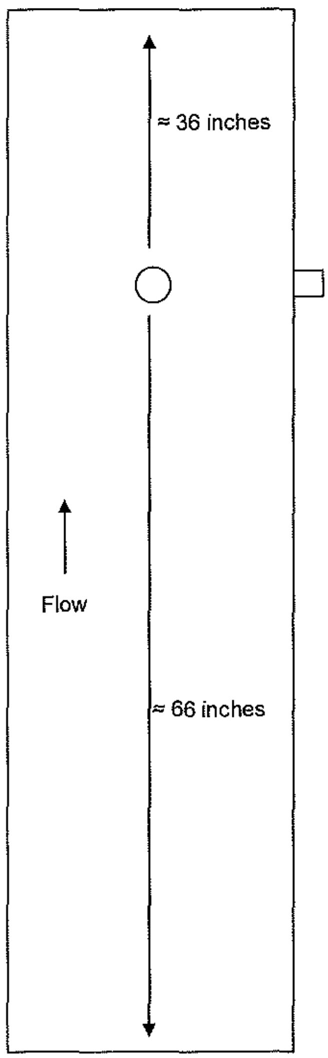


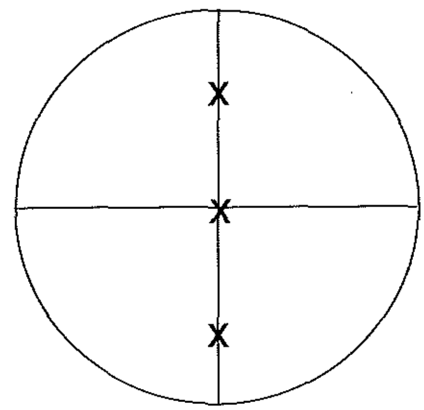
Figure No. 1

Site: **USEPA Method 3A and 7E** **Cargill Salt, Inc.** **St. Clair, Michigan**	**Sampling Date:** **April 11, 2017**	**BT Environmental Consulting Inc.** **4949 Fernlee Avenue** **Royal Oak, MI 48073**

BTEC Inc.

diameter = 52 inches





Not to Scale

Points	Distance "
1	8.7
2	26.0
3	43.3

Figure No. 2

Site:	Sampling Date:	
Boiler 15 Exhaust Cargill Salt, Inc. St. Clair, Michigan	April 11, 2017	<u>BT Environmental Consulting, Inc.</u> 4949 Fernlee Avenue Royal Oak, Michigan 48073

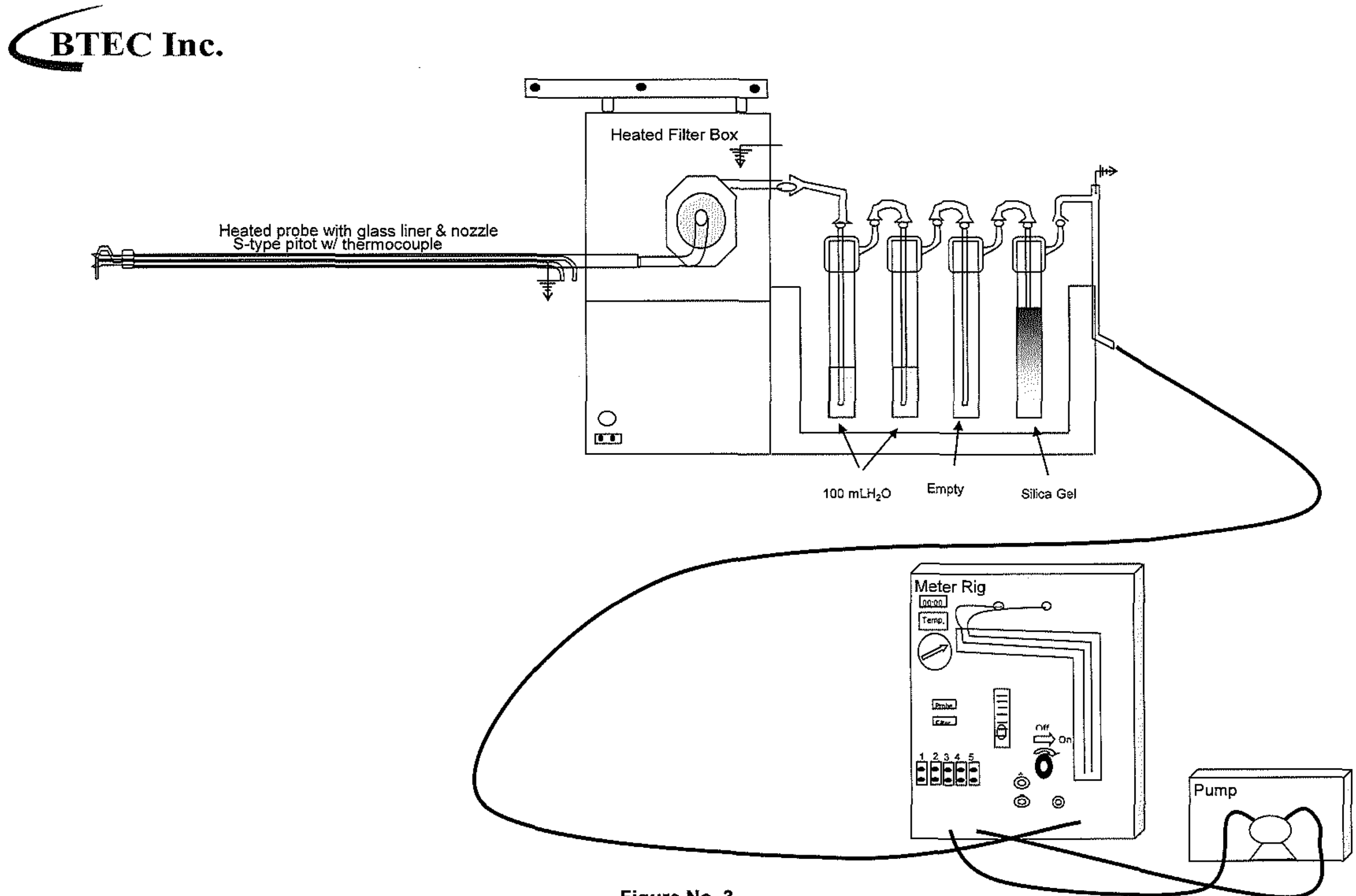
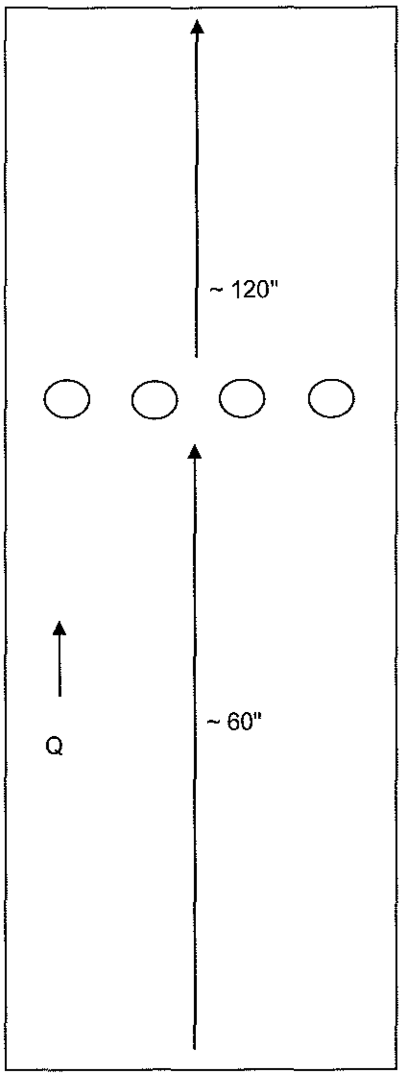


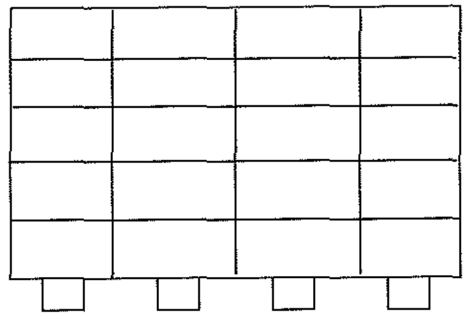
Figure No. 3

Site:	Sampling Date:	
USEPA Method 5 Cargill Salt St.Clair, Michigan	April 12,2017	BT Environmental Consulting, Inc. 4949 Fernlee Avenue Royal Oak, Michigan 48073

BTEC Inc.

Stack Dimensions: 24" deep X 36" wide





Not to Scale

Points	Distance "
1	2.4
2	7.2
3	12
4	16.8
5	21.6

Figure No. 4

Site: **EUPRETZEL Exhaust** **Cargill Salt** **St. Clair, Michigan**	**Sampling Date:** **April 12,2017**	**BT Environmental Consulting, Inc.** **4949 Fernlee** **Royal Oak, Michigan**