



Particulate Matter Emissions Test Report

Prepared for:

Johnson Controls, Inc.

St Louis, Missouri

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JUL 28 2014

AIR QUALITY DIV.

Johnson Controls, Inc.
2280 Ball Drive
St Louis, Missouri 63146

Test Location:
Northern Michigan University
1401 Presque Isle Avenue
Marquette, Michigan 49855

Project No. 14-4547.00
July 9, 2014

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073
(248) 548-8070



EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by Johnson Controls, Inc. (JC) to conduct a particulate matter (PM) emission rate test program at the exhaust of the biomass boiler (EU-RGSBBOILER) at Northern Michigan University (NMU) located in Marquette, Michigan. The emissions test program was conducted on June 3, 2014.

Testing consisted of triplicate 60-minute test runs. The emissions test program was required by MDEQ Air Quality Division Permit to Install No. 29-11. The results of the emission test program are summarized by Table I.

Table I
Overall Emission Summary
Test Date: June 3, 2014

Pollutant	Emission Rate	Emission Limit
PM	0.016 lb/MMBtu	0.03 lb/MMBtu
PM	0.78 lb/hr	PM ₁₀ = 3.0 lbs/hr; PM _{2.5} = 2.7 lbs/hr

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by Johnson Controls, Inc. (JC) to conduct a particulate matter (PM) emission rate test program at the exhaust of the biomass boiler (EU-RGSBBOILER) at Northern Michigan University (NMU) located in Marquette, Michigan. The emissions test program was conducted on June 3, 2014. The purpose of this report is to document the results of the test program.

AQD has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (December 2013). The following is a summary of the emissions test program and results in the format suggested by the aforementioned document.

1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on June 3, 2014 at the Northern Michigan University located in Marquette, Michigan. The test program included evaluation of PM emissions from EU-RGSBBOILER.

1.b Purpose of Testing

AQD Permit to Install No. 29-11 limits emissions from EU-RGSBBOILER as summarized by Table 1.

Table 1
PM Emission Limitations
EU-RGSBBOILER

Source	Pollutant	Permit Limit
EU-RGSBBOILER	PM	0.03 lb/MMBtu
	PM ₁₀	3.0 lb/hr
	PM _{2.5}	2.7 lb/hr

1.c Source Description

The process consists of a 59.59 million British thermal units per hour (MMBtu/hr) reciprocating grate stoker fired biomass boiler with over-fired air combustion using biomass as the sole fuel, including start-up. The boiler is a combination water tube/fired tube design. The boiler, identified as EURGSBBOILER in MDEQ PTI No. 29-11, is equipped with a multiclone and dry electrostatic precipitator (ESP) for the control of particulate matter emissions. The boiler produces steam for use on campus and to generate electricity.



1.d Test Program Contacts

The contact for the source and test report is:

Ms. Gisele Duehring
Associate Director – Facilities/Heating Plant
Northern Michigan University
1401 Presque Isle Avenue
Marquette, Michigan 49855
(906) 227-2158
gduehring@nmu.edu

Mr. Barry Boulianne
BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073
(313) 449-2361
bboulianne@btecinc.com

Names and affiliations for personnel who were present during the testing program are summarized by Table 2.

**Table 2
Test Personnel**

Name and Title	Affiliation	Telephone
Ms. Gisele Duehring Associate Director	Northern Michigan University 1401 Presque Isle Avenue Marquette, Michigan 49855	(906) 227-2158
Mr. Ken Lievens Project Manager	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Steve Smith Environmental Technician	BTEC 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. David Patterson Environmental Quality Analyst	MDEQ Air Quality Division	(517) 284-6782

2. Summary of Results

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

2.a Operating Data

Process data monitored during the emissions test program included the fuel feed rate and ESP data.

2.b Applicable Permit

The applicable permit for this emissions test program is Permit to Install No. 29-11.

2.c Results

The overall results of the emission test program are summarized by Table 3 (see Section 5.a). PM emissions from the boiler were below the corresponding limits of 0.03 lb/MMBtu; 2.7 lb/hr (for PM_{2.5}); and 3.0 lb/hr (for PM₁₀).

3. Source Description

Sections 3.a through 3.e provide a detailed description of the process.

3.a Process Description

The process consists of a 59.59 million British thermal units per hour (MMBtu/hr) reciprocating grate stoker fired biomass boiler with over-fired air combustion using biomass as the sole fuel, including start-up. The boiler is a combination water tube/fired tube design. The boiler, identified as EURGSBBOILER in MDEQ PTI No. 29-11, is equipped with a multiclone and dry electrostatic precipitator (ESP) for the control of particulate matter emissions. The boiler produces steam for use on campus and to generate electricity.

EU-RGSBBOILER is equipped with a multiclone and dry electrostatic precipitator (ESP) for the control of particulate matter emissions.

3.b Process Flow Diagram

Due to the simplicity of the boiler, a process flow diagram is not necessary.

3.c Raw and Finished Materials

The raw material used by the process is biomass. Fuel feed rates recorded during the emissions test program are summarized by the process field data sheets included in Appendix E.

3.d Process Capacity

The nominal generator electrical output rating is less than 1 MW. The steam output design capacity is 42,000 pounds per hour.

3.e Process Instrumentation

Feedwater flow, Feedwater inlet economizer temperature, Feedwater outlet economizer temperature, steam flow, steam pressure, furnace temperature, breeching temperature, flue gas O₂ %, ESP inlet temp, Under-grate air temperature, flyash differential pressure, and hand-held analyzer values O₂ and breeching temperature.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used.

4.a Sampling Train and Field Procedures

The Method 5 sampling train consists of: (1) a borosilicate glass nozzle, (2) a glass probe, (3) a heated borosilicate or quartz glass filter holder containing a pre-weighed 90-mm diameter filter with Teflon filter support; (4) a set of four Greenburg-Smith (GS) impingers with the first modified and second standard GS impingers each containing 100 ml of H₂O, and with a third dry modified GS impinger and a fourth modified GS impinger containing approximately 300 g of silica gel desiccant, (5) a length of sample line, and (6) a Nutech[®] control case equipped with a pump, dry gas meter, and calibrated orifice.

The emissions test program will utilize the following test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 1 - "Sample and Velocity Traverses for Stationary Sources"
- Method 2 - "Determination of Stack Gas Velocity and Volumetric Flowrate"
- Method 3A - "Determination of Molecular Weight of Dry Stack Gas"(Fyrite)
- Method 4 - "Determination of Moisture Content in Stack Gases"
- Method 5 - "Determination of Particulate Matter Emissions from Stationary Sources"
- Method 19 - "Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur dioxide, and Nitrogen Oxide Emission Rates"

After completion of the final leak test for each test run, the impinger train was carefully disassembled. The nozzle, probe, and front half of the filter housing were brushed and rinsed with acetone which was collected in a pre-cleaned sample container. The filter was recovered and placed in its original Petri dish. The liquid volume of each impinger was measured gravimetrically and any mass increase was noted on field sheets.

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 gravimetric analysis) in Ferndale, Michigan.

4.b Recovery and Analytical Procedures

Recovery and analytical procedures were described in Section 4.a.

4.c Sampling Ports

A diagram of the stack showing sampling ports in relation to upstream and downstream disturbances is included as Figure 2.

4.d Traverse Points

A diagram of the stack indicating traverse point locations and stack dimensions is included as Figure 2.

5. Test Results and Discussion

Sections 5.a through 5.k provide a summary of the test results.

5.a Results Tabulation

The overall results of the emissions test program are summarized by Table 3. Detailed results for the emissions test program are summarized by Table 4.

Table 3
Overall Emission Summary
Test Date: June 3, 2014

Pollutant	Emission Rate	Emission Limit
PM	0.016 lb/MMBtu	0.03 lb/MMBtu
PM	0.78 lb/hr	PM ₁₀ = 3.0 lbs/hr; PM _{2.5} = 2.7 lbs/hr

5.b Discussion of Results

The overall results of the emission test program are summarized by Table 3 (see Section 5.a). PM emissions from the boiler were below the corresponding limits of 0.03 lb/MMBtu; 2.7 lb/hr (for PM_{2.5}); and 3.0 lb/hr (for PM₁₀).



5.c Sampling Procedure Variations

There were no sampling variations used during the emission compliance test program.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

There was no control equipment maintenance performed during the emissions test program.

5.f Re-Test

The emissions test program was not a re-test.

5.g Audit Sample Analyses

No audit samples were collected as part of the test program.

5.h Calibration Sheets

Relevant equipment calibration documents are provided in Appendix B.

5.i Sample Calculations

Sample calculations are provided in Appendix C.

5.j Field Data Sheets

Field documents relevant to the emissions test program are presented in Appendix A

5.k Laboratory Data

Laboratory analytical results are provided in Appendix D.

Tables

Table 5
EU-RGSBBOILER Particulate Matter Emission Rates

Company Source Designation Test Date	NMU Biomass Boiler			Average
	6/3/2014	6/3/2014	6/3/2014	
Meter/Nozzle Information	P-1	P-2	P-3	
Meter Temperature Tm (F)	110.1	116.5	118.9	115.2
Meter Pressure - Pm (in. Hg)	29.1	29.1	29.1	29.1
Measured Sample Volume (Vm)	49.0	48.6	44.7	47.4
Sample Volume (Vm-Std ft3)	43.6	42.8	39.1	41.8
Sample Volume (Vm-Std m3)	1.23	1.21	1.11	1.18
Condensate Volume (Vw-std)	9.854	9.524	8.534	9.304
Gas Density (Ps(std) lbs/ft3) (wet)	0.0730	0.0729	0.0730	0.0729
Gas Density (Ps(std) lbs/ft3) (dry)	0.0790	0.0787	0.0787	0.0788
Total weight of sampled gas (m g lbs) (wet)	3.90	3.81	3.48	3.73
Total weight of sampled gas (m g lbs) (dry)	3.44	3.37	3.08	3.30
Nozzle Size - An (sq. ft.)	0.000504	0.000504	0.000504	0.000504
Isokinetic Variation - I	104.2	99.8	100.0	101.3
Stack Data				
Average Stack Temperature - Ts (F)	425.2	415.7	424.8	421.9
Molecular Weight Stack Gas- dry (Md)	30.6	30.5	30.5	30.5
Molecular Weight Stack Gas-wet (Ms)	28.2	28.2	28.2	28.2
Stack Gas Specific Gravity (Gs)	0.975	0.973	0.975	0.974
Percent Moisture (Bws)	18.44	18.21	17.90	18.19
Water Vapor Volume (fraction)	0.1844	0.1821	0.1790	0.1819
Pressure - Ps ("Hg)	29.0	29.0	29.0	29.0
Average Stack Velocity - Vs (ft/sec)	48.9	49.5	45.5	48.0
Area of Stack (ft2)	9.6	9.6	9.6	9.6
Oxygen Concentration (%)	8.0	9.5	9.5	9.0
Fuel Factor (dscf/10 ⁶ btu)	9,242	9,242	9,242	9,242
Exhaust Gas Flowrate				
Flowrate ft ³ (Actual)	28,224	28,556	26,243	27,674
Flowrate ft ³ (Standard Wet)	16,302	16,672	15,164	16,046
Flowrate ft ³ (Standard Dry)	13,295	13,636	12,449	13,127
Flowrate m ³ (standard dry)	376	386	353	372
Total Particulate Weights (mg)				
Nozzle/Probe/Filter	22.6	17.7	15.9	18.7
Total Particulate Concentration				
lb/1000 lb (wet)	0.013	0.010	0.010	0.011
lb/1000 lb (dry)	0.014	0.012	0.011	0.012
mg/dscm (dry)	18.3	14.6	14.3	15.8
gr/dscf	0.0080	0.0064	0.0063	0.0069
Total Particulate Emission Rate				
lb/ hr	0.92	0.75	0.67	0.78
lb/mmbtu	0.017	0.015	0.015	0.016

Figures

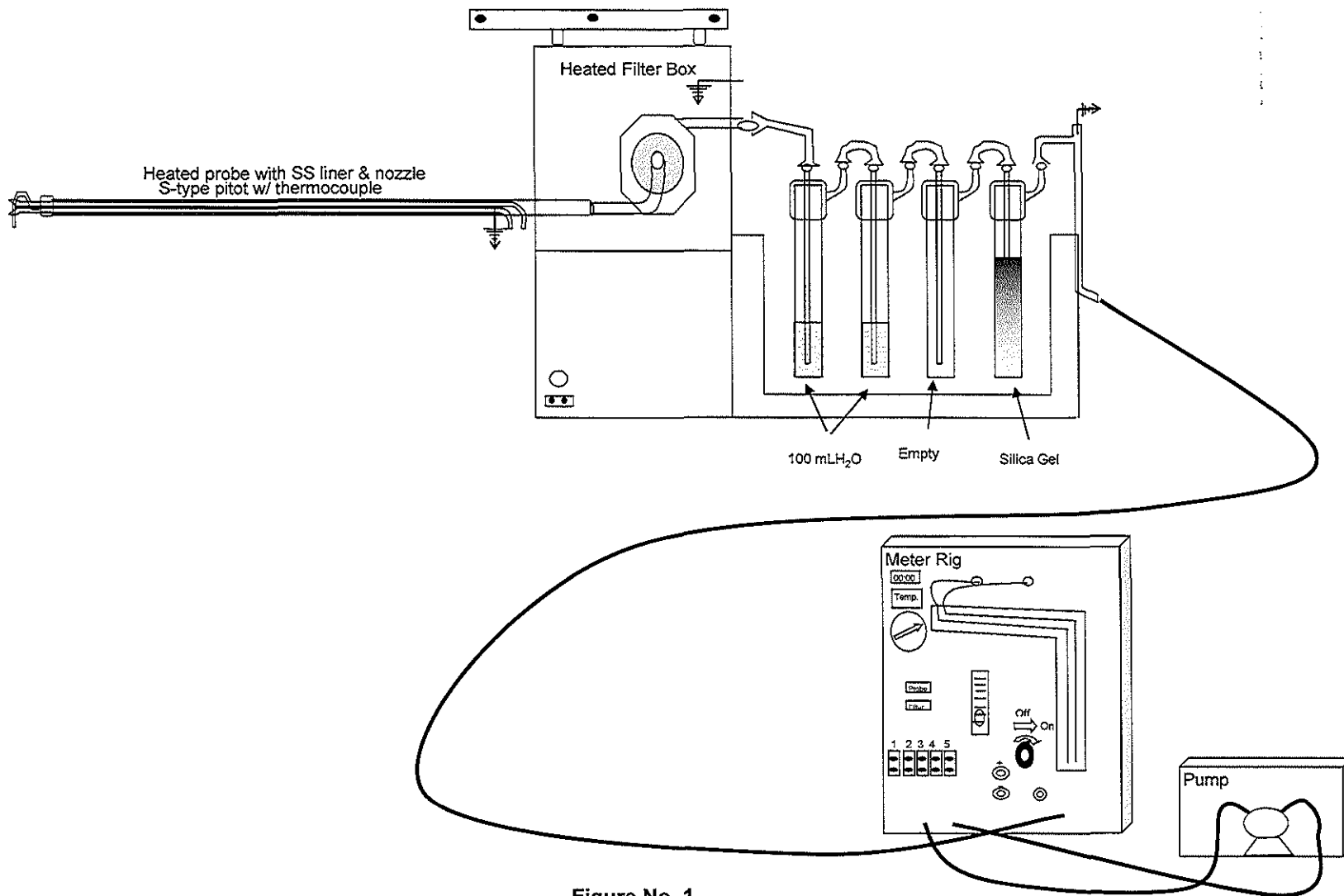


Figure No. 1

Site:
USEPA Method 5
Northern Michigan University
Marquette, Michigan

Sampling Date:
June 3, 2014

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073

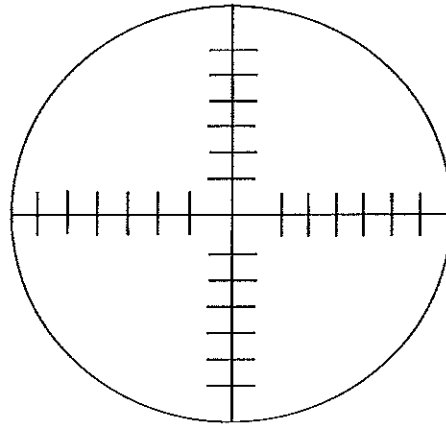
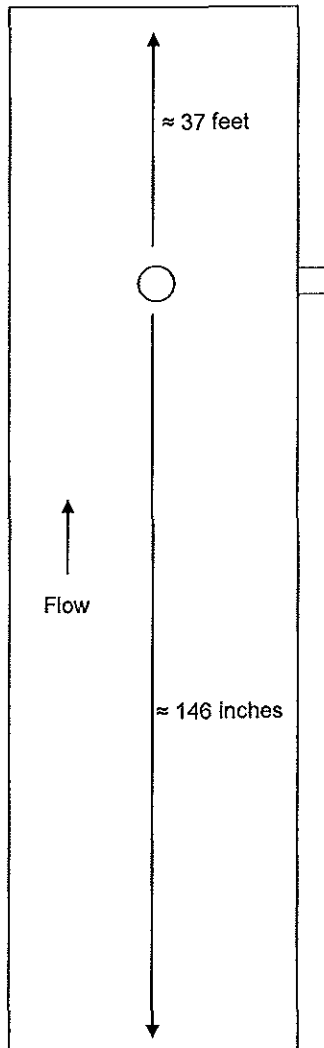
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diameter = 42 inches



Not to Scale

Points	Distance "
1	0.9
2	2.8
3	5.0
4	7.4
5	10.5
6	15.0
7	27.0
8	31.5
9	34.6
10	37.0
11	39.2
12	41.1

Figure No. 2

Site:
EU-RGSBBOILER
Northern Michigan University
Marquette, Michigan

Sampling Date:
June 3, 2014

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4949 Fernlee Avenue
Royal Oak, Michigan 48073