SOURCE TEST REPORT
2019 FORMALDEHYDE TESTING
DEARBORN INDUSTRIAL GENERATION
BOILERS 1100, 2100, AND 3100
TURBINES 1100, 2100 AND 3100
DEARBORN, MI

Prepared For:

Dearborn Industrial Generation
2400 Miller Road
Dearborn, MI 48121

For Submittal To:

Michigan Department of Environment, Great Lakes, and Energy
525 West Allegan Street
Lansing, MI 48933

Prepared By:

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4949 Fernlee Avenue
Royal Oak, MI 48073

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Test Dates:	**December 4-6, 2019**
	January 21, 2020
Submittal Date:	**February 14, 2020**

STAC
STACK TESTING ACCREDITATION COUNCIL

ACCREDITED
TO ASTM D7036 ONLY
CERT #3925.01

MONTROSE
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EXECUTIVE SUMMARY

Montrose Air Quality Services, LLC (MAQS) was retained by Dearborn Industrial Generation LLC (DIG) to evaluate formaldehyde (CH_2O) emission rates from 6 sources at the DIG facility located in Dearborn, Michigan. The sources tested included three boilers and two combined cycle turbines and one simple cycle turbine. The boilers fired a mixture of blast furnace gas (BFG) and natural gas (NG) and are designated as EU-BOILER1 (Boiler 1100), EU-BOILER2 (Boiler 2100), and EU-BOILER3 (Boiler 3100). The two combined cycle turbines designated as EUCTG2 (Turbine 2100) and EUCTG3 (Turbine 3100) one simple cycle turbine designated as EUCTG1 (Turbine 1100) fire NG. The emissions test program was conducted on December 4-6, 2019 and January 21, 2020. Turbine 1100 was in a forced outage at the time of the December testing. EGLE approved of the postponing the compliance test to January as well as DIG's request to combine the two sampling events into one report. EGLE requires that DIG submit the combined test report within 30 days of completion of the Turbine 1100 testing.

Michigan Department of Environment, Great Lakes, and Energy (EGLE) issued permit to install (PTI) No. 163-17 to DIG on January 31, 2018 that contains a formaldehyde emission limit of 36 tons per year (tpy), applicable to "FGPLANT" on a 12-month rolling basis. "FGPLANT" includes DIG's three (3) turbines and three (3) boilers as described in PTI No. 163-17.

FGPLANT special condition V.1 requires DIG to perform formaldehyde emissions testing to verify emissions factors during the worst-case season. Based on two (2) formaldehyde tests in 2018, in accordance with FGPLANT DIG has determined that the worst-case season is winter; therefore, this test program constitutes the annual worst-case season testing.

The results of the emissions test program are summarized in Executive Summary Table E-1.

Table E-1
Overall Emission Rates Summary

Source	CH_2O (lb/MMBtu)
Boiler 1100	$9.62*10^{-5}$
Boiler 2100	$7.15*10^{-5}$
Boiler 3100	$7.35*10^{-5}$
Turbine 1100	$7.00*10^{-5}$
Turbine 2100	$7.15*10^{-5}$
Turbine 3100	$8.93*10^{-5}$

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1. Introduction

Montrose Air Quality Services, LLC (MAQS) was retained by Dearborn Industrial Generation LLC (DIG) to evaluate formaldehyde (CH_2O) emission rates from 6 sources at the DIG facility located in Dearborn, Michigan. The sources tested included three boilers and two combined cycle turbines and one simple cycle turbine. The boilers fired a mixture of blast furnace gas (BFG) and natural gas (NG) and are designated as EU-BOILER1 (Boiler 1100), EU-BOILER2 (Boiler 2100), and EU-BOILER3 (Boiler 3100). The two combined cycle turbines designated as EUCTG2 (Turbine 2100) and EUCTG3 (Turbine 3100) one simple cycle turbine designated as EUCTG1 (Turbine 1100) fire NG. Turbine 1100 was in a forced outage at the time of the December testing. EGLE approved of the postponing the compliance test to January as well as DIG's request to combine the two sampling events into one report. EGLE requires that DIG submit the combined test report within 30 days of completion of the Turbine 1100 testing.

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The emissions testing were conducted on December 4-6, 2019 and January 21, 2020. MAQS personnel Todd Wessel, Paul Diven, and Shane Rabideau, and Prism personnel Dave Schuberg and Trevor Tilmann performed the testing. Mr. Paul Snoes of DIG provided onsite coordination for the test program. Mr. Tom Gasloli, Mr. John Lamb, and Mr. Matthew Karl with EGLE were onsite to witness a portion of the testing.

The Air Quality Division (AQD) of EGLE has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (March 2018). The following is a summary of the emissions test program and results in the format outlined by the AQD document.

1.a Identification, Location, and Dates of Test

Field sampling for the emissions compliance test program was conducted on December 4-6, 2019 and January 21, 2020 at the DIG facility at 2400 Miller Road in Dearborn, Michigan. The emission test program included the evaluation of formaldehyde emissions from three boilers and three turbines.

1.b Purpose of Testing

DIG operates according to Michigan Renewable Operating Permit No. MI-ROP-N6631-2012a, PTI No. 8-17, and PTI No. 163-17. PTI No. 163-17 (issued on January 31, 2018) contains a formaldehyde limit of 36 tpy for flexible group "FGPLANT." FGPLANT consists of DIG's three (3) turbines and three (3) boilers, as described in Section 1.c. Recordkeeping for the 36 tpy limit relies on emission factors from stack testing and actual 12-month rolling heat input to demonstrate compliance.

Table 1
Permitted Emission Limits
Dearborn Industrial Generation LLC

Source	Pollutant	Emission Limit
FGPLANT [1]	CH_2O	36 tons/yr

[1] DIG's three boilers and three turbines comprise FGPLANT

PTI No. 163-17 lists emission factors for formaldehyde, as presented in Table 2 below. PTI No. 163-17 requires that DIG perform emissions testing to verify the factors for each equipment category listed in Table 2. PTI No. 163-17 specifies additional activities and reporting if a 3-run test average for a unit is greater than the emission factor for the particular equipment category listed in Table 2.

Table 2
PTI No. 163-17 Formaldehyde Emission Factors [1]
Dearborn Industrial Generation LLC

Equipment Category	Emission Factor
Boilers	1.12E-03
Combined-cycle Turbines	1.36E-03
Simple-cycle Turbine	8.67E-04

[1] These emission factors do not constitute emission limits; however, the results of emissions testing will be compared to these emission factors.

1.c Source Description

The DIG facility located in Dearborn, Michigan operates two combined-cycle turbines and one simple-cycle Turbine that fire natural gas (NG) and three boilers that are capable of firing a mixture of NG and blast furnace gas (BFG), or NG only.

1.d Test Program Contact

The contact for the source and test plan is:

Mr. Paul Snoes
Dearborn Industrial Generation, LLC
2400 Miller Rd.
Dearborn, MI 48120
(313) 336-7189

Testing Team Contact:
Mr. Todd Wessel
Client Project Manager
Montrose Air Quality Services, LLC
4949 Fernlee Avenue
Royal Oak, Michigan 48073
Phone (616) 885-4013

1.e Testing Personnel

Names and affiliations for personnel who were present during the testing program are summarized by Table 3.

Table 3
Test Personnel

Name and Title	Affiliation	Telephone
Mr. Paul Snoes Health & Safety Coordinator	Dearborn Industrial Generation LLC 2400 Miller Rd. Dearborn, MI 48120	(313) 336-7189
Mr. Todd Wessel Client Project Manager	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(616) 885-4013
Mr. Paul Diven Field Project Manager	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Shane Rabideau Field Technician	MAQS 4949 Fernlee Avenue Royal Oak, MI 48073	(248) 548-8070
Mr. Dave Schuberg Field Project Manager	Prism Analytical Technologies 2625 Denison Drive Mt. Pleasant, MI 48858	(989) 772-5088
Mr. Trevor Tilmann Field Technician	Prism Analytical Technologies 2625 Denison Drive Mt. Pleasant, MI 48858	(989) 506-8065
Mr. Matthew Karl Air Quality Division, EGLE	Michigan Department of Environment, Great Lakes and Energy 525 W Allegan Street Lansing, MI 48933	(517) 282-2126
Mr. Tom Gasloli Air Quality Division, EGLE	Michigan Department of Environment, Great Lakes and Energy 525 W Allegan Street Lansing, MI 48933	(517) 284-6778

2. Summary of Results

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

2.a Operating Data

The following information was collected during the performance test and can be found in Appendix E.

1. Date, time, steam flow, heat input (MMBtu/hr),
2. MW generated (turbines)
3. Natural gas flow (Turbines and Boilers)
4. Blast Furnace gas flow (Boilers)
5. Ambient temperature and humidity

2.b Applicable Permit

The applicable permit for this emissions test program is PTI No. 163-17.

2.c Results

The overall results of the emissions compliance test program are summarized by Table 4 (see Section 5.a). Detailed results for each source are included as Tables 6-11.

2.d Emission Regulation Comparison

The emission limitation for "FGPLANT" at DIG is summarized in Table 1. The emission factors (in lb/MMBtu) from this emission test are compared to the emission factors presented in Table 2, as required by PTI No. 163-17.

3. Source Description

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

3.a Process Description

The DIG facility located in Dearborn, Michigan operates two combined-cycle turbines and one simple-cycle Turbine that fire natural gas (NG) and three boilers that are capable of firing a mixture of NG and blast furnace gas (BFG), or NG only.

The simple cycle turbine is nominally rated at an output capacity of approximately 181 Megawatts (MW) and 1,638 million British thermal unit per hour (MMBtu/hr) heat input, and the combined-cycle turbines are each nominally rated at an output capacity of approximately 179 MW and 1,626 MMBtu/hr heat input. The turbines use natural gas as fuel. The turbine generator consists of a compressor, combustion turbine, and generator. Energy is generated at the combustion turbine by drawing in ambient air by means of burning fuel and expanding the hot combustion gases in a three-stage turbine. The hot exhaust gases from the combined-cycle combustion turbines are directed to a multipressure heat recovery steam generator (HRSG) to produce steam. Low-NO_x combustors minimize the emissions of nitrogen oxides from the turbines, while the emissions of CO and SO_2 are minimized by the efficient combustion of low sulfur bearing clean-burning fuels.

Each boiler is nominally rated at an output capacity of 500,000 pounds per hour of superheated steam at a minimum pressure of 1,350 psig and temperature of 960°F. The input capacity of the boilers while firing NG and BFG is 746 MMBtu/hr and 763 MMBtu/hr while burning natural gas only. The steam from the boilers is dispatched to a steam turbine for electrical generation and or utilized as process steam.

The boilers at DIG are designed to burn a mixture of BFG and NG or natural gas only. The BFG to NG ratio is approximately 95% BFG to 5% NG, based upon the heat inputs of the fuels.

3.b Raw and Finished Materials

The raw material supplied includes BFG and NG.

3.c Process Capacity

The simple cycle turbine is nominally rated at an output capacity of approximately 181 Megawatts (MW) and 1,638 million British thermal unit per hour (MMBtu/hr) heat input. The combined-cycle turbines are each nominally rated at an output capacity of approximately 179 MW and 1,626 MMBtu/hr heat input. The turbines operated at approximately 100% of load at the ambient conditions during testing.

Each boiler is nominally rated at an output capacity of 500,000 pounds per hour of superheated steam at a minimum pressure of 1,350 psig and temperature of 960°F. The input capacity of the boilers while firing NG and BFG is 746 MMBtu/hr and 763 MMBtu/hr while burning natural gas only. The boilers were operated in co-firing mode at maximum normal operating load based on available BFG supply during the testing.

3.d Process Instrumentation

The following information was collected during the performance test and can be found in Appendix E.

1. Date, time, steam flow, heat input (MMBtu/hr),
2. MW generated (turbines)
3. Natural gas flow (Turbines and Boilers)
4. Blast Furnace gas flow (Boilers)
5. Ambient temperature and humidity

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used to verify emission rates.

4.a Sampling Train and Field Procedures

Sampling and analysis procedures utilized 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 Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)"
- Method 4 - "Determination of Moisture Content in Stack Gases"

USEPA Methods 1, 2, and 4 were not performed at the turbines, as Method 19 was used to determine emission factors for the combustion turbines.

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 outlined in Sections 2-6 through 2-8 are within specified limits, therefore, a baseline pitot tube coefficient of 0.84 (dimensionless) is assigned.

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. The average of the absolute values of the flow angles is less than 20 degrees; therefore cyclonic flow does not exist.

Exhaust gas moisture content was evaluated using Method 4. Exhaust gas was extracted as part of the moisture sampling train and passed through (i) two impingers, each with 100 ml deionized water, (ii) an empty impinger, and (iii) an impinger filled with silica gel. Exhaust gas moisture content is then determined gravimetrically.

Oxygen and Carbon Dioxide (USEPA Method 3A)

Measurement of oxygen and carbon dioxide content was conducted using the following reference test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 3A - *"Determination of Oxygen and Carbon Dioxide Concentration in Emissions From Stationary Sources (Instrumental Analyzer Procedure)"*

The O_2 and CO_2 content of the gas stream is measured using a Servomex 4100 O_2/CO_2 gas analyzer. The gas stream is drawn through a stainless-steel probe with a heated in-line filter to remove any particulate, a heated Teflon® sample line, through a refrigerated

Teflon® sample conditioner to remove the moisture from the sample before it enters the O_2/CO_2 analyzer. Data is recorded on a PC equipped with data acquisition software. Recorded O_2/CO_2 concentrations are averaged and reported for the duration of each test (as drift corrected per Method 7E). A drawing of the sampling train used for the testing program is presented as Figure 1.

In accordance with Method 3A, a 3-point (zero, mid, and high) bias check and calibration check is performed on the O_2/CO_2 analyzer prior to initiating the test program. Following each test run, a 2-point (zero and high) calibration drift check is performed. The O_2/CO_2 analyzer was operated at the 0-25 ppm range.

Prism Analytical Technologies Method 18 - TDT Sampling and Analysis Procedures for Formaldehyde

Prism Analytical Technologies utilizes thermal desorption tube (TDT) and GC/FTIR (MAX™) methodology for the determination of low level source emissions. These combined technologies minimize or remove the primary interferences from water and carbon dioxide while collecting a time averaged sample. The time averaging provides an additional benefit of concentrating the analytes of interest prior to analysis. 1 to 50 ppbv dry minimum detection limit (MDL) specifications can be met for many VOCs and HAPs while ensuring analytical accuracy. The expected formaldehyde MDL is 10 ppbv. To demonstrate QAQC compliance of the technology to US-EPA Method 18, calibration checks are performed before and after the TDT analysis. Additionally, TDTs pre-spiked with the components of interest are collected simultaneously with a clean (sample) TDT to demonstrate the sample recovery for the analytes of interest.

Instruments and Apparatus

1. Sampling System

    a. MAX™ TDT Sampler and Manifold
        i. Two channel device, collects two TDT samples simultaneously (1 spiked and 1 unspiked)
        ii. Manifold holds the TDTs and maintains the gas temperature at 191C until slipstream is pulled from manifold into TDT.
        iii. Manifold can be mounted on nearly any environmental source (inlet or outlet of abatement device)
        iv. Sample flow control (slipstream) is handled by two 0 – 200 mL/min MFCs that maintain the flow at better than 1% of reading.
        v. No moisture impingers required (water collected with analytes on TDT)

    b. Thermal desorption tube
        i. Prism's AS014 tubes were utilized due to their ability to collect and concentrate formaldehyde without breakthrough
        ii. AS014 is multi-bed adsorbent packed in a stainless tube that can be rapidly heated to desorb the captured analytes.
        iii. TDTs will come in pairs with a spiked and un-spiked tube.

2. Analyzer System (TDT – GC/FTIR)

a. Prism Analytical Technologies MAX™ analyzer technology is a newly designed GC-FTIR technology that provides lower MDLs than traditional GC-FTIR systems and maintains a constant calibration for all analytes.
b. The GC is used to separate the compounds and interferences, the carrier flow is controlled by a 0 – 5 mL/min MFC and the carrier gas is normally N_2.
c. The FTIR is used to qualify and quantify each analyte; each quantified result has additional QAQC data that allows the tester to validate the reported result.
d. In the MAX analyzer the GC effluent is captured and held in the FTIR gas cell so that a constant signal (absorbance) is generated for a constant mass of material. The subsequent data generates a "MAX" peak that is constant for all instruments for a specific mass of material.
e. TDTs are desorbed by the MAX Desorber mounted on the rear side of the instrument. The entire sample is passed to a GC (30 m resistively heated steel capillary column). There is no splitting of the sample, so that all the material that is captured on the TDT goes to the GC and eventually into the FTIR gas cell.

3. Calibration and QAQC
    a. Calibration TDTs containing the analytes of interest are analyzed before and after the sample TDTs to demonstrate the permanent calibration curve for each compound.
        i. A fixed amount (ie 1,000 ng) for each compound is placed on each TDT from a prepared mixture via a calibrated microliter syringe.
        ii. Standards are run in triplicate at each of three levels to demonstrate the calibration curve for each compound.
    b. Spiked tubes are analyzed from each sample pair to determine the percent recovery for specie.

Analysis Methodology

1. Thermal desorption tubes will be analyzed independently by our MAX (GC-FTIR)
    a. The MAX system is calibrated from neat standards.
    b. Analysis will be performed in pairs with the spiked tube first and the sample tube second.
2. Sample analysis will be performed on the MAX system which utilizes the following GC column (MTX-624, 30m, 0.53mm id, 3um film thickness) to separate the compounds in time. As the compounds elute from the GC they are collected by an FTIR gas analyzer that will spectrally identify and quantify each as they elute. The gas cell will be isolated at this time to integrate the effluents into the cell.
3. MAX Analyzer will be used to determine the maximum ng concentration of the analytes of interest using a least squares algorithm approach.

Data Analysis

1. Prism's MAX Source Tester software will be utilized to analyze all the data collected during the data collection of the TDT samples.
2. The user selects the sample directory to be analyzed. Normally one TDT run is present per directory.

3. The user then selects a predefined qualitative and quantitative library to utilize in the analysis.
4. The user then selects a predefined method that will analyze for a specific set of compounds.
5. Normally the Baseline Correct and Background Removal algorithms are checked and utilized but they can be turned off if a better analysis can be obtained without them.
6. The user then presses the Find All IU button for the data analysis to proceed. The entire data set can normally be analyzed within about 1 minute. The time is dependent on the number of analytes and number of spectral files collected.
7. The tester or data validator or both will then review the results, screenshots and %error to validate the result.
8. Tools are available to quantify different or multiple spectral regions to get improved analyses.
9. Once the analysis is complete, the data can be reported to a .CSV file for reporting purposes.
10. The full method analysis of the data can be saved into a .QTA file for further validation

A schematic drawing of the formaldehyde sampling train is provided as Figure 2.

The lb/MMBtu emission factors for the boilers were also calculated using the Fd factor from the PEMS, to demonstrate that Method 19 provides comparable results to those calculated using Methods 1, 2, and 4. The emission rates calculated using Method 19 are presented in Tables 6 to 8 for each boiler.

4.b Recovery and Analytical Procedures

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

4.c Sampling Ports

Sampling port and traverse point locations for the exhaust stacks are illustrated by Figures 4-6.

4.d Traverse Points

Sampling port and traverse point locations for the exhaust stacks are illustrated by Figures 4-6.

5. Test Results and Discussion

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

5.a Results Tabulation

The results of the emissions test program are summarized by Table 4.

Table 4
Overall Emission Rates Summary

Source	CH_2O (lb/MMBtu)
Boiler 1100	$9.62*10^{-5}$
Boiler 2100	$7.15*10^{-5}$
Boiler 3100	$7.35*10^{-5}$
Turbine 1100	$7.00*10^{-5}$
Turbine 2100	$7.15*10^{-5}$
Turbine 3100	$8.93*10^{-5}$

Detailed data for each test run can be found in Tables 5-10.

5.b Discussion of Results

This formaldehyde testing was performed to verify the emission factor from each unit in FGPLANT for comparison to the emission factors listed in PTI No. 163-17, provided in Table 2. This emission factor comparison, shown in Table 5, demonstrates that the formaldehyde emission factors from the Equipment Categories are below the emission factors from PTI No. 163-17.

Table 5
Formaldehyde Emission Factor Comparison

Equipment Category	Emission Unit(s)	Test Result Average [1] (lb/MMBtu)	Emission Factor [2] (lb/MMBtu)
Boilers	Boiler 1100 Boiler 2100 Boiler 3100	8.04E-05	1.12E-03
Combined-cycle Turbines	Turbine 2100 Turbine 3100	8.04E-05	1.36E-03
Simple-cycle Turbine	Turbine 1100	7.00E-05	8.67E-04

[1] The Equipment Category test result averages are calculated as the arithmetic average of the emission unit results in the Equipment Category (refer to Table 4 for individual unit emission rates).

[2] These emission factors do not constitute emission limits; the results of emissions testing are compared to these factors as required by PTI No. 163-17.

5.c Sampling Procedure Variations

During the testing of the Boilers it was noted that the CO_2 concentrations intermittently exceeded the calibration concentration of the gas bottle. This was discussed on site with

Mr. Tom Gasloli and Mr. Matthew Karl of EGLE and approved; deemed to be inconsequential due to the formaldehyde concentration of approximately 50 ppb.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

Only routine maintenance has been performed such as turbine and or replacement, oil changes, etc. on each unit except for turbine 1100. The work that was done in 2019 on GT1 was inspecting & repairing a bearing and replacing the generator rotor (for like in kind). The repairs that were done did not affect operational or environmental output of the turbine.

5.f Audit Sample Analyses

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

5.g Calibration Sheets

All relevant equipment calibration documents are provided as Appendix B.

5.h Sample Calculations

Sample calculations are provided in Appendix C.

5.i Field Data Sheets

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

5.j Laboratory Data

A copy of the report form Prisim Analytical Technologies can be found in Appendix F.

MEASUREMENT UNCERTAINTY STATEMENT

Both qualitative and quantitative factors contribute to field measurement uncertainty and should be taken into consideration when interpreting the results contained within this report. Whenever possible, Montrose Air Quality Services, LLC, (MAQS) personnel reduce the impact of these uncertainty factors through the use of approved and validated test methods. In addition, MAQS personnel perform routine instrument and equipment calibrations and ensure that the calibration standards, instruments, and equipment used during test events meet, at a minimum, test method specifications as well as the specifications of our Quality Manual and ASTM D 7036-04. The limitations of the various methods, instruments, equipment, and materials utilized during this test have been reasonably considered, but the ultimate impact of the cumulative uncertainty of this project is not fully identified within the results of this report.

Limitations

All testing performed was done in conformance to the ASTM D7036-04 standard. The information and opinions rendered in this report are exclusively for use by DIG. MAQS will not distribute or publish this report without DIG's consent except as required by law or court order. MAQS 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: ______________________
Jacob Young
Staff Engineer

This report was reviewed by: ______________________
Todd Wessel
Client Project Manager

Tables

Table 6
Boiler 1100
Formaldehyde Emission Rates
Dearborn Industrial Generation
Dearborn, MI
MAQS Project No. 049AS-669200
Sampling Dates: 12/5/2019

Parameter	Run 1	Run 2	Run 3	Average	Average of Boiler 1 Boiler 2 Boiler 3
Test Run Date	12/5/2019	12/5/2019	12/5/2019		
Test Run Time	15:08-16:08	16:23-17:23	17:37-18:37		
Outlet Flowrate (dscfm)	153,783	155,110	155,361	**154,751**	
Outlet Flowrate (scfm)	169,179	173,307	172,624	**171,703**	
BFG Flow Rate (kscf/hr)	4,281	4,324	4,315	**4,306.35**	
NG Flow Rate (kscf/hr)	38.0	38.1	38.2	**38.10**	
BFG Heat Input (MMBtu/hr)	483.7	488.6	487.6	**486.6**	
NG Heat Input (MMBtu/hr)	40.7	40.8	40.8	**40.8**	
Total Heat Input (MMBtu/hr)	524.4	529.3	528.4	**527.4**	
Oxygen Concentration (%)	4.46	4.17	4.04	**4.22**	
Oxygen Concentration (%, drift corrected as per USEPA 7E)	4.08	3.93	3.92	**3.98**	
Carbon Dioxide Concentration (%)	23.42	23.59	23.81	**23.61**	
Outlet Formaldehyde Concentration (ppmvd)	0.075	0.067	0.069	**0.070**	
Formaldehyde Emission Rate (lb/hr)	0.054	0.048	0.050	**0.051**	
Formaldehyde Emission Rate (lb/MMBtu)	**1.02E-04**	**9.15E-05**	**9.45E-05**	**9.62E-05**	**8.04E-05**

scfm = standard cubic feet per minute
dscfm = dry standard cubic feet per minute
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CH_2O = 30.03)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
1000 = scf per kscf
10^6 = Btu per MMBtu

BFG Gross Heating Value (Btu/scf) from Laboratory Analysis	113	Btu/scf
NG Gross Heating Value (Btu/scf) from Laboratory Analysis	1070	Btu/scf

Equations
MMBtu/hr = kscf/hr * Btu/scf * 1000 * ($1/10^6$)
lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * ***dcfm*** * 60
lb/MMbtu = (lb/hr) / (MMBtu/hr)

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5/8/2012 BC

Table 7
Boiler 2100
Formaldehyde Emission Rates
Dearborn Industrial Generation
Dearborn, MI
MAQS Project No. 049AS-669200
Sampling Dates: 12/6/2019

Parameter	Run 1	Run 2	Run 3	Average	Average of Boiler 1 Boiler 2 Boiler 3
Test Run Date	12/6/2019	12/6/2019	12/6/2019		
Test Run Time	8:36-9:36	9:48-10:48	11:03-12:03		
Outlet Flowrate (dscfm)	149,746	145,220	133,577	**142,848**	
Outlet Flowrate (scfm)	164,737	163,536	142,558	**156,944**	
BFG Flow Rate (kscf/hr)	4,359.6	4,414.6	4,444.9	**4,406.38**	
NG Flow Rate (kscf/hr)	33.5	33.5	33.5	**33.52**	
BFG Heat Input (MMBtu/hr)	488.3	494.4	497.8	**493.5**	
NG Heat Input (MMBtu/hr)	35.9	35.9	35.8	**35.9**	
Total Heat Input (MMBtu/hr)	524.2	530.3	533.7	**529.4**	
Oxygen Concentration (%)	3.60	3.56	3.63	**3.60**	
Oxygen Concentration (%, drift corrected as per USEPA 7E)	3.35	3.42	3.46	**3.41**	
Carbon Dioxide Concentration (%)	24.10	24.50	24.58	**24.39**	
Outlet Formaldehyde Concentration (ppmvd)	0.054	0.056	0.061	**0.057**	
Formaldehyde Emission Rate (lb/hr)	0.038	0.038	0.038	**0.038**	
Formaldehyde Emission Rate (lb/MMBtu)	**7.19E-05**	**7.15E-05**	**7.12E-05**	**7.15E-05**	**8.04E-05**

scfm = standard cubic feet per minute
dscfm = dry standard cubic feet per minute
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CH_2O = 30.03)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
1000 = scf per kscf
10^6 = Btu per MMBtu

BFG Gross Heating Value (Btu/scf) from Laboratory Analysis	112	Btu/scf
NG Gross Heating Value (Btu/scf) from Laboratory Analysis	1070	Btu/scf

Equations
MMBtu/hr = kscf/hr * Btu/scf * 1000 * ($1/10^6$)
lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * ***dcfm*** * 60
lb/MMbtu = (lb/hr) / (MMBtu/hr)

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Table 8
Boiler 3100
Formaldehyde Emission Rates
Dearborn Industrial Generation
Dearborn, MI
MAQS Project No. 049AS-669200
Sampling Dates: 12/6/2019

Parameter	Run 1	Run 2	Run 3	Average	Average of Boiler 1 Boiler 2 Boiler 3
Test Run Date	12/6/2019	12/6/2019	12/6/2019		
Test Run Time	13:50-14:50	15:05-16:05	16:17-17:17		
Outlet Flowrate (dscfm)	156,801	154,873	155,346	**155,674**	
Outlet Flowrate (scfm)	169,514	169,817	169,777	**169,703**	
BFG Flow Rate (kscf/hr)	4,557.580	4,166.923	4,497.086	**4,407.20**	
NG Flow Rate (kscf/hr)	34.606	34.800	34.702	**34.70**	
BFG Heat Input (MMBtu/hr)	510.4	466.7	503.7	**493.61**	
NG Heat Input (MMBtu/hr)	37.0	37.2	37.1	**37.13**	
Total Heat Input (MMBtu/hr)	547.5	503.9	540.8	**530.74**	
Oxygen Concentration (%)	4.77	4.70	4.51	**4.66**	
Oxygen Concentration (%, drift corrected as per USEPA 7E)	4.69	4.73	4.57	**4.66**	
Carbon Dioxide Concentration (%)	22.46	22.73	22.98	**22.72**	
Outlet Formaldehyde Concentration (ppmvd)	0.049	0.055	0.057	**0.054**	
Formaldehyde Emission Rate (lb/hr)	0.036	0.040	0.041	**0.039**	
Formaldehyde Emission Rate (lb/MMBtu)	**6.54E-05**	**7.88E-05**	**7.63E-05**	**7.35E-05**	**8.04E-05**

scfm = standard cubic feet per minute
dscfm = dry standard cubic feet per minute
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CH_2O = 30.03)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
1000 = scf per kscf
10^6 = Btu per MMBtu

BFG Gross Heating Value (Btu/scf) from Laboratory Analysis	112	Btu/scf
NG Gross Heating Value (Btu/scf) from Laboratory Analysis	1070	Btu/scf

Equations
MMBtu/hr = kscf/hr * Btu/scf * 1000 * (1/10^6)
lb/hr = ppmv * MW/24.14 * 1/35.31 * 1/453,600 * ***dcfm*** * 60
lb/MMbtu = (lb/hr) / (MMBtu/hr)

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Table 9
Turbine 2100
Formaldehyde Emission Rates
Dearborn Industrial Generation
Dearborn, MI
MAQS Project No. 049AS-669200
Sampling Dates: 12/4/2019

Parameter	Run 1	Run 2	Run 3	Average	Average of Turbine 2100 and 3100
Test Run Date	12/4/2019	12/4/2019	12/4/2019		
Test Run Time	12:31-13:31	13:47-14:47	14:55-15:55		
Oxygen Concentration (%)	12.85	12.82	12.76	**12.81**	
Oxygen Concentration (%, drift corrected as per USEPA 7E)	12.97	13.21	13.18	**13.12**	
Carbon Dioxide Concentration (%)	4.66	4.77	4.84	**4.76**	
Carbon Dioxide Concentration (%, drift corrected as per USEPA 7E)	4.60	4.58	4.58	**4.59**	
Heat Input (MMBTU/hr)	1796.153	1787.757	1785.188	**1,789.70**	
Outlet Formaldehyde Concentration (ppmvd)	0.039	0.034	0.045	**0.039**	
Formaldehyde Emission Rate (lb/MMBtu)	**6.95E-05**	**6.25E-05**	**8.24E-05**	**7.15E-05**	**8.04E-05**
Formaldehyde Emission Rate (lb/hr)	**1.25E-01**	**1.12E-01**	**1.47E-01**	**1.28E-01**	**1.52E-01**

ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CH_2O = 30.03)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
Fd = 8,710 dscf/MMBtu for natural gas

Equations
(Cd) lb/dscf = ppmv * MW/24.14 * 1/35.31 * 1/453,600
Eq 19-1, lb/MMBtu = Cd * Fd * 20.9/(20.9-O_2%)
lb/hr = (lb/MMBTU)*(MMBTU/hr)
Formaldehyde pounds per hour emission rate calculated by multiplying the pounds per million BTU emission rate by the heat input from PEMS data

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Table 10
Turbine 3100
Formaldehyde Emission Rates
Dearborn Industrial Generation
Dearborn, MI
MAQS Project No. 049AS-669200
Sampling Dates: 12/5/2019

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	12/5/2019	12/5/2019	12/5/2019	
Test Run Time	8:08-9:08	9:20-10:20	10:46-11:46	
Oxygen Concentration (%)	12.93	13.54	13.79	**13.42**
Oxygen Concentration (%, drift corrected as per USEPA 7E)	13.04	13.29	13.08	**13.14**
Carbon Dioxide Concentration (%)	4.37	4.41	4.46	**4.41**
Carbon Dioxide Concentration (%, drift corrected as per USEPA 7E)	4.52	4.55	4.53	**4.53**
Heat Input (MMBTU/hr)	1955.946	1963.534	1972.029	**1,963.84**
Outlet Formaldehyde Concentration (ppmvd)	0.055	0.052	0.040	**0.049**
Formaldehyde Emission Rate (lb/MMBtu)	**9.89E-05**	**9.66E-05**	**7.23E-05**	**8.93E-05**
Formaldehyde Emission Rate (lb/hr)	1.94E-01	1.90E-01	1.43E-01	1.75E-01

ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CH_2O = 30.03)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
Fd = 8,710 dscf/MMBtu for natural gas

Equations
(Cd) lb/dscf = ppmv * MW/24.14 * 1/35.31 * 1/453,600
Eq 19-1, lb/MMBtu = Cd * Fd * 20.9/(20.9-O_2%)
lb/hr = (lb/MMBTU)*(MMBTU/hr)
Formaldehyde pounds per hour emission rate calculated by multiplying the pounds per million BTU emission rate by the heat input from PEMS data

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Table 11
Turbine 1100
Formaldehyde Emission Rates
Dearborn Industrial Generation
Dearborn, MI
MAQS Project No. 049AS-669200
Sampling Dates: 1/21/2020

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	1/21/2020	1/21/2020	1/21/2020	
Test Run Time	8:04-9:04	9:18-10:18	10:32-11:32	
Oxygen Concentration (%)	12.98	13.04	13.03	**13.02**
Oxygen Concentration (%, drift corrected as per USEPA 7E)	13.01	13.13	13.14	**13.09**
Carbon Dioxide Concentration (%)	4.59	4.60	4.59	**4.59**
Carbon Dioxide Concentration (%, drift corrected as per USEPA 7E)	4.55	4.56	4.54	**4.55**
Heat Input (MMBTU/hr)	1843.47	1841.017	1833.711	**1,839.40**
Outlet Formaldehyde Concentration (ppmvd)	0.037	0.037	0.042	**0.039**
Formaldehyde Emission Rate (lb/MMBtu)	**6.63E-05**	**6.73E-05**	**7.65E-05**	**7.00E-05**
Formaldehyde Emission Rate (lb/hr)	1.22E-01	1.24E-01	1.40E-01	1.29E-01

ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CH_2O = 30.03)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb
Fd = 8,710 dscf/MMBtu for natural gas

Equations
(Cd) lb/dscf = ppmv * MW/24.14 * 1/35.31 * 1/453,600

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Figures

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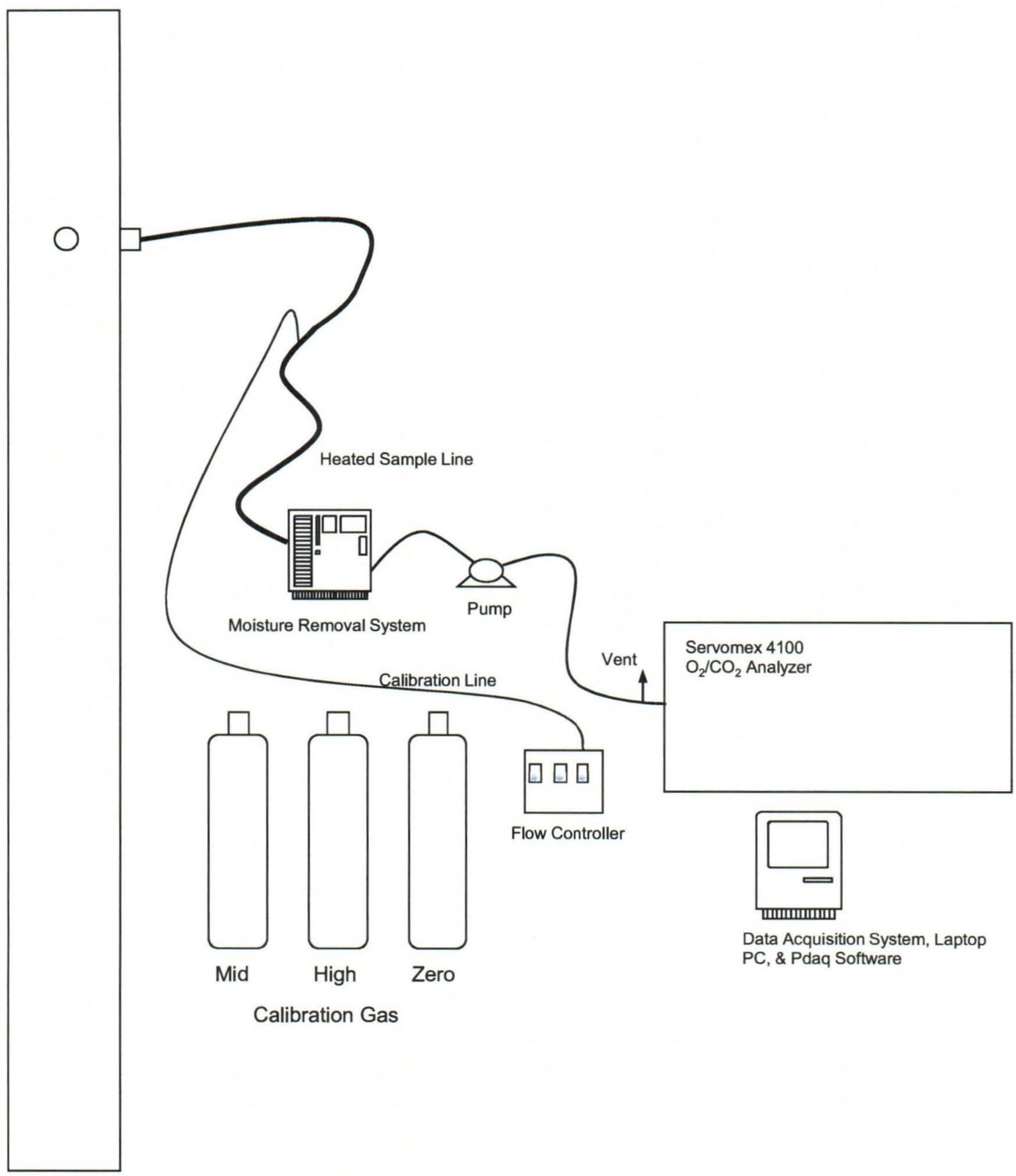

Figure No. 1

Site:	Sampling Date:	Montrose Air Quality Services, LLC.
USEPA Method 3A Dearborn Industrial Generation Dearborn, Michigan	December 4-6 , 2019	4949 Fernlee Avenue Royal Oak, MI 48073

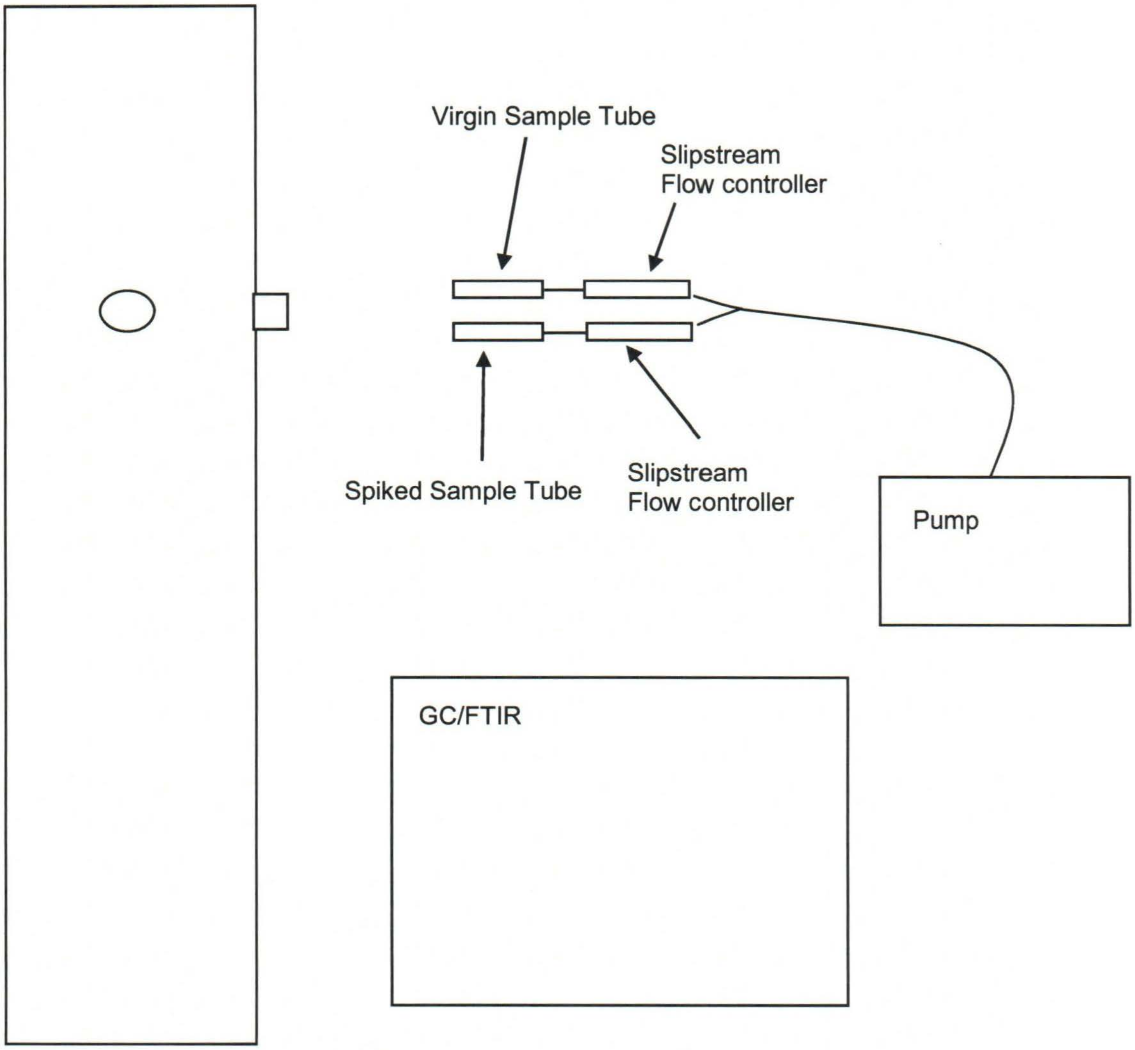

Figure No. 2

Site:	Sampling Date:	Montrose Air Quality Services, LLC.
USEPA Method 18 **Dearborn Industrial Generation** **Dearborn, Michigan**	**December 4-6 , 2019**	**4949 Fernlee Avenue** **Royal Oak, MI 48073**

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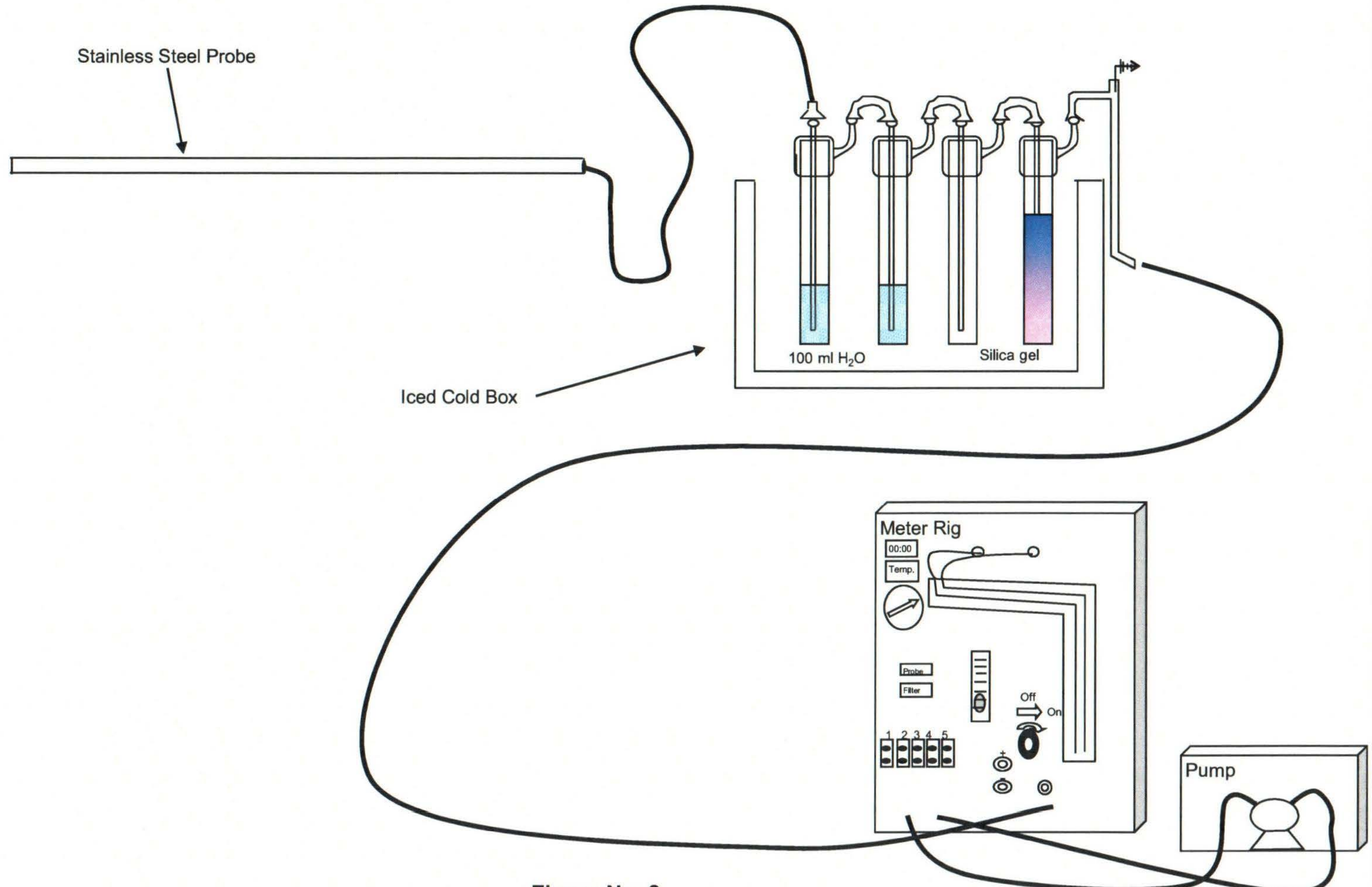

Figure No. 3

Site: **USEPA Method 4** **Dearborn Industrial Generation** **Dearborn, Michigan**	**Sampling Date:** **December 4-6, 2019**	**<u>Montrose Air Quality Services, LLC</u>** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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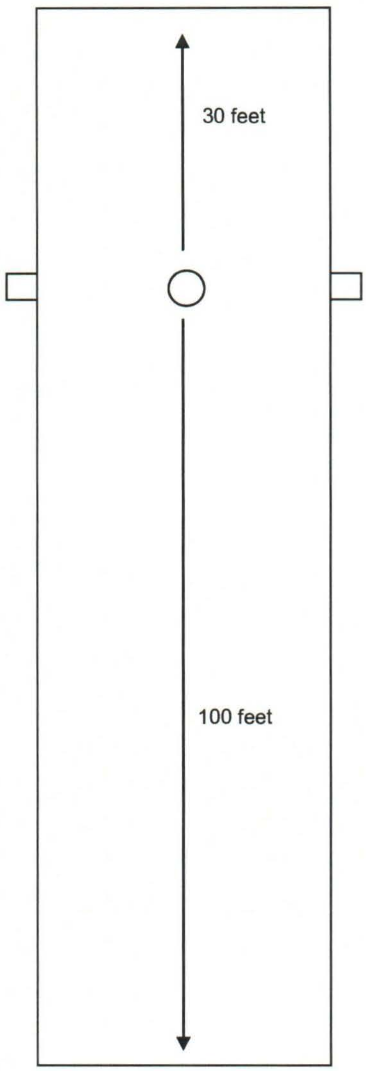
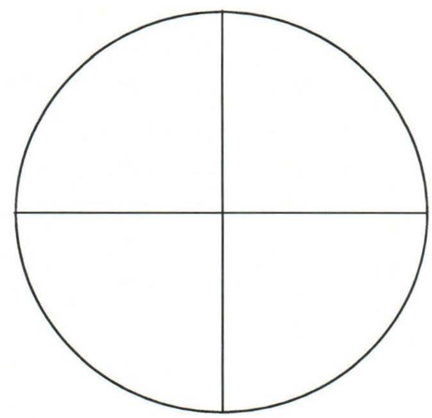
diameter = 210 inches





Not to Scale

All samples were extracted from a single point in the center of the stack

Figure No. 4

Site: **Turbine 2100 and 3100** **Dearborn Industrial Generation** **Dearborn, Michigan**	**Sampling Date:** **December 4-6, 2019**	**Montrose Air Quality Services, LLC** **4949 Fernlee Avenue** **Royal Oak, Michigan 48073**

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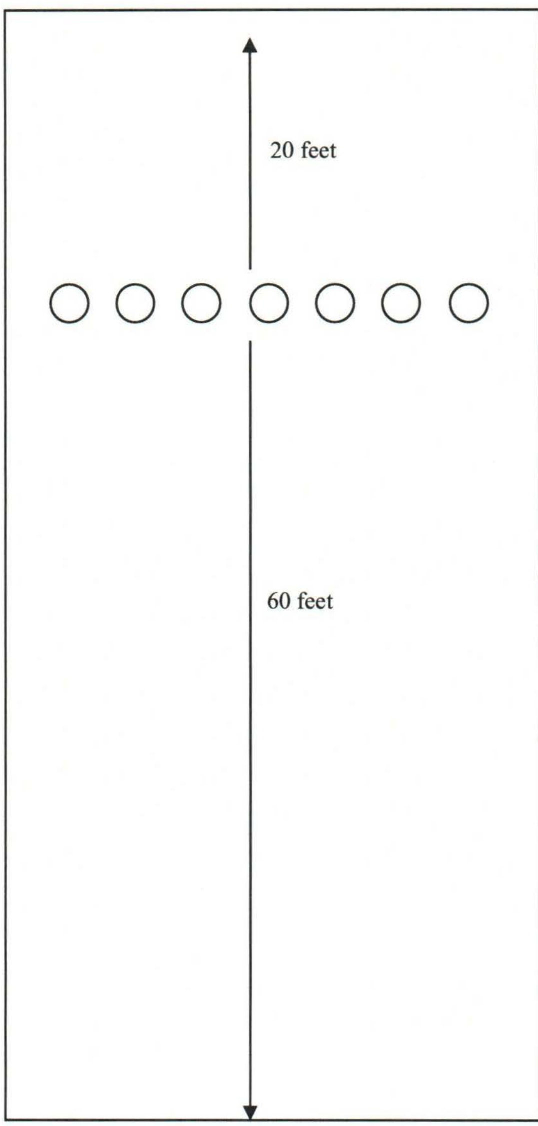
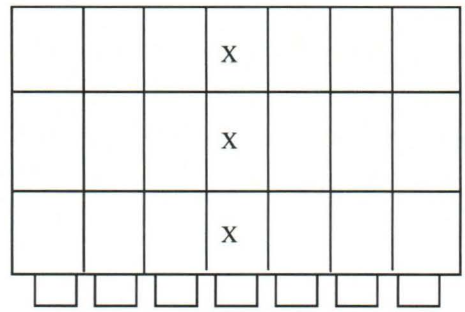
Stack Dimensions: 19' Deep X 22' Wide





X = sample point

Not to Scale

Points	Distance "
1	16.0
2	47.0
3	79.0

As per Performance Specification 2, section 8.1.3.2 the three traverse points may be located on the line at 0.4, 1.2, and 2.0 meters from the stack or duct wall.

Figure 5

Site:	Sampling Date:	
Turbine 1100 Dearborn Industrial Generation Dearborn, Michigan	January 21, 2020	Montrose Air Quality Services, LLC 4949 Fernlee Avenue Royal Oak, Michigan

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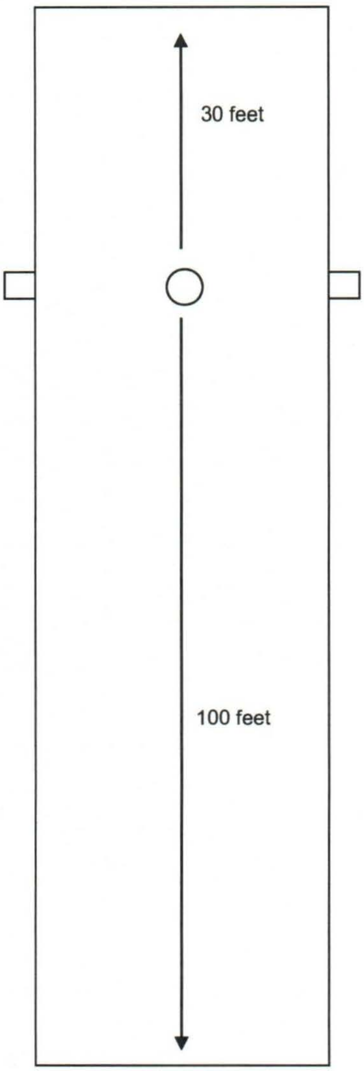
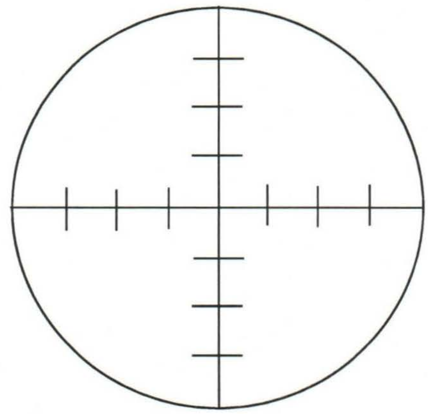
diameter = 126 inches





Not to Scale

Points	Distance "
1	5.5
2	18.4
3	37.3
4	88.7
5	107.60
6	120.46

All samples were extracted from a single point in the center of the stack

Figure No. 6

Site:	**Sampling Date:**	**Montrose Air Quality Services, LLC**
Boilers 1100, 2100, and 3100	**December 4-6, 2019**	**4949 Fernlee Avenue**
Dearborn Industrial Generation		**Royal Oak, Michigan 48073**
Dearborn, Michigan		