mostardi platt

# Compliance Emissions Test Report

## Performed for: Marquette Board of Light and Power
## At The: Marquette Energy Center
## EU-ENGINE02 Outlet Duct
## Marquette, Michigan
## July 23 and 25, 2019

## Report Submittal Date
## September 17, 2019



## Project No. M193006B

Corporate Headquarters
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# 1.0 EXECUTIVE SUMMARY

MOSTARDI PLATT conducted a compliance emissions test program for Marquette Board of Light and Power (MBLP) on July 23 and 25, 2019 at the Marquette Energy Center (MEC) on the Reciprocating Internal Combustion Engine 2 (EU-ENGINE02) Outlet Duct in Marquette, Michigan. The purpose of the test program was to meet the compliance demonstration requirements for emission rate in accordance with Permit to Install 204-15A, 40 CFR Part 60 Subpart JJJJ, and 40 CFR Part 60 Subpart IIII. This report summarizes the results of the test program and test methods used.

The test location, test dates, and test parameters are summarized below.

| Test Location | Test Dates | Test Parameters |
|---|---|---|
| EU-ENGINE02 Outlet Duct | July 23 and 25, 2019 | Nitrogen Oxides ($NO_x$), Carbon Monoxide (CO), Carbon Dioxide ($CO_2$), Oxygen ($O_2$), Volatile Organic Concentration (VOC), Formaldehyde ($CH_2O$), Filterable Particulate Matter (FPM), Volumetric Flow, and Moisture |

MBLP has installed a dual-fuel Wärtsilä 18V50DFm four stroke, lean burn 17 MW (nominal) engine (173 mmBtu/hr when firing natural gas as primary fuel, 154 mmBtu/hr when firing emergency backup fuel oil), compression ignition reciprocating internal combustion engine used for electrical generation. The RICE electric generating unit utilizes pipeline quality natural gas and is equipped with selective catalytic reduction (SCR) for nitrogen oxides (NOx) control and an oxidation catalyst system for carbon monoxide (CO), volatile organic compound (VOC), and organic hazardous air pollutant (HAP) control. The RICE electric generating unit exhausts into an individual stack.

Selected results of the test program are summarized below. A complete summary of emission test results follows the narrative portion of this report.

| Source | Fuel | Parameter | Emission Limit | Test Results |
|---|---|---|---|---|
| EU-ENGINE02 Outlet Duct<br><br>7/23/19 | Natural Gas | Nitrogen Oxides ($NO_x$) | 3.3 lb/hr | 1.0 lb/hr |
| | | | 1.0 grams/HP-hr | 0.020 grams/HP-hr |
| | | | 82 ppmvd@15% $O_2$ | 1.8 ppmvd@15% $O_2$ |
| | | Carbon Monoxide (CO) | 5.0 lb/hr | 0.2 lb/hr |
| | | | 2.0 grams/HP-hr | 0.003 grams/HP-hr |
| | | | 270 ppmvd@15% $O_2$ | 0.4 ppmvd@15% $O_2$ |
| | | Volatile Organic Compounds (VOC) | 16.5 lb/hr | 1.5 lb/hr |
| | | | 0.7 grams/HP-hr | 0.031 grams/HP-hr |
| | | | 60 ppmvd@15% $O_2$ | 2.9 ppmvd@15% $O_2$ |
| | | Formaldehyde ($CH_2O$) | 0.648 lb/hr | 0.18 lb/hr |

| Source | Fuel | Parameter | Emission Limit | Test Results |
|---|---|---|---|---|
| EU-ENGINE02 Outlet Duct<br><br>7/23/19 and 7/25/19 | Light Fuel Oil | $NO_x$ | 21.0 lb/hr | 8.0 lb/hr |
| | | | 2.58 g/HP-hr | 0.161 g/HP-hr |
| | | CO | N/A | 0.1 lb/hr |
| | | VOC | N/A | 0.5 lb/hr |
| | | $CH_2O$ | N/A | 0.03 lb/hr |
| | | Filterable Particulate Matter (FPM) | 0.15 g/kW-hr | 0.032 g/kW-hr |

The identifications of the individuals associated with the test program are summarized below.

| TEST PERSONNEL INFORMATION | | |
|---|---|---|
| **Location** | **Address** | **Contact** |
| Test Coordinator/ Test Facility | Marquette Board of Light and Power<br>Marquette Energy Center<br>2200 Wright Street<br>Marquette, Michigan 49855 | Mr. Thomas J. Skewis<br>Environmental Technician<br>(906) 225-8670 (office)<br>tskewis@mblp.org |
| Testing Company Representative | Mostardi Platt<br>888 Industrial Drive<br>Elmhurst, Illinois 60126 | Mr. John Nestor<br>Project Manager<br>(630) 993-2100 (phone)<br>rsollars@mp-mail.com |

The test crew consisted of Messrs. J. Carlson, N. Colangelo, and J. Nestor. Mr. Tom Gasloli with the Michigan Department of Environmental Quality observed the test program.

# 2.0 TEST METHODOLOGY

Emission testing was conducted following the methods specified in Code of Federal Regulations, Title 40, Part 60, Appendix A (40CFR60), 40CFR51, and 40CFR63. Schematics of the test section diagrams and sampling trains used are included in Appendix A and B, respectively. Calculation examples and nomenclature are included in Appendix C. Copies of analyzer print-outs and field data sheets for each test run are included in Appendices D and E, respectively.

The following methodologies were used during the test program:

## Method 1 Traverse Point Determination

Test measurement points were selected in accordance with Method 1. The characteristics of the measurement location are summarized below.

| TEST POINT INFORMATION | | | | | | |
|---|---|---|---|---|---|---|
| Location | Diameter (Feet) | Area (Square Feet) | Upstream Distance (Inches) | Downstream Distance (Inches) | Test Parameter | Number of Sampling Points |
| EU-ENGINE02 Outlet Duct | 5.25 | 21.65 | >0.5 | >2.0 | Volumetric Flow | 16 |
| | | | | | $NO_x$/CO/VOC/$O_2$/$CO_2$ | 12 (stratification test), 3 (Runs 1 through 3) |

A null point pitot traverse check was performed utilizing a Type S pitot tube to verify the absence of cyclonic flow per USEPA Method 1, Section 11.4. The null point at the test location averaged 5 degrees which meets the requirements. The results of this traverse can be found in Appendix D.

## Method 2 Volumetric Flowrate Determination

Gas velocity was measured following Method 2, for purposes of calculating stack gas volumetric flow rate. An S-type pitot tube, differential pressure gauge, Thermal couple and temperature readout were used to determine gas velocity at each sample point. All of the equipment used was calibrated in accordance with the specifications of the Method. Calibration data are presented in Appendix F.

## Method 3A Oxygen ($O_2$)/Carbon Dioxide ($CO_2$) Determination

Flue gas $O_2$ was determined in accordance with Method 3A. An ECOM analyzer was used to determine stack gas oxygen content connected to the outlet of the FTIR analyzer.

Flue gas carbon dioxide concentrations and emission rates were determined in accordance with Method 3A. An MKS MultiGas 2030 FTIR spectrometer was used to determine the $CO_2$ concentrations, in the manner specified in the Method. Nitrogen Content was determined from the difference of $CO_2$ and $O_2$.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 375°F. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run.

All of the equipment used was calibrated in accordance with the specifications of the Method and calibration data are included in Appendix F. Copies of the gas cylinder certifications are included in Appendix H.

## Method 5 Filterable Particulate Matter Determination

Flue gas filterable particulate matter concentrations and emission rates are determined in accordance with Method 5. The probe and filter housing are maintained at a temperature of 248°F +/- 25°F. An Environmental Supply Company, Inc. sampling train is used to sample stack gas at an isokinetic rate. Four impingers were utilized. The impingers were weighed prior to and after each test run in order to determine moisture content of the stack gas. The total sample time was 60 minutes, with twelve sample points being utilized. A minimum of 30 dry standard cubic feet was sampled for the run.

Particulate matter in the sample probe was recovered utilizing acetone; a minimum of six passes of the probe brush through the entire probe was performed, followed by a visual inspection of the acetone exiting the probe. The acetone solution exiting the probe was clear, therefor the wash was considered complete. The nozzle was then removed from the probe and cleaned in a similar manner, utilizing an appropriately sized nozzle brush. The filter housing was washed a minimum of three times with acetone and inspected for cleanliness, and the filter placed in its corresponding petri dish. The acetone wash and the filter were labeled and marked, then analyzed off site by Mostardi Platt personnel in accordance with the method.

All of the equipment used is calibrated in accordance with the specifications of the Method. Calibration data is presented in the Appendix of the final report.

## Method 7E Nitrogen Oxide ($NO_X$) Determination

Flue gas $NO_x$ concentrations and emission rates were determined in accordance with Method 7E. An MKS MultiGas 2030 FTIR spectrometer was used to determine nitrogen oxide concentrations, in the manner specified in the Method.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 375°F. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run.

A list of calibration gases used and the results of all calibration and other required quality assurance checks can be found in Appendix F. Copies of calibration gas certifications can be found in Appendix H.

## Method 10 Carbon Monoxide (CO) Determination

Flue gas CO concentrations and emission rates were determined in accordance with Method 10. An MKS MultiGas 2030 FTIR spectrometer was used to determine carbon monoxide concentrations, in the manner specified in the Method.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 375°F. The entire system was calibrated in accordance with the Method, using certified calibration gases introduced at the probe, before and after each test run.

A list of calibration gases used and the results of all calibration and other required quality assurance checks can be found in Appendix F. Copies of calibration gas certifications can be found in Appendix H.

## Method 25A Volatile Organic Compound (VOC) Determination

Total hydrocarbon (THC) concentrations and emission rates were determined in accordance with Method 25A. Stack gas was delivered to the system via a Teflon® sampling line, heated to a minimum temperature of 375ºF.

Methane and ethane concentrations were determined in accordance with Method 320 and then subtracted from the THC concentrations in order to determine VOC emissions. The methane concentration was also corrected for a response factor on the Thermo 51i Total Hydrocarbon analyzer.

The system was calibrated before and after each test run using certified calibration gases of propane for the THC determination. Calibration data are presented in Appendix F, field sheets are presented in Appendix D, and copies of gas certifications are presented in Appendix H.

## Method 320 Fourier Transform Infrared (FTIR) Detector for Methane, Ethane, Formaldehyde, and Moisture Determination

Flue gas methane, ethane, formaldehyde, and moisture concentrations and emission rates were determined in accordance with Method 320. FTIR data was collected using an MKS MultiGas 2030 FTIR spectrometer. The FTIR was equipped with a temperature-controlled, 5.11 meter multi-pass gas cell maintained at 191°C. Gas flows and sampling system pressures were monitored using a rotameter and pressure transducer.

All data was collected at 0.5 $cm^{-1}$ resolution. Each spectrum was derived from the coaddition of 62 scans, with a new data point generated approximately every one minute. Analyzer data for each run is present is Appendix D.

| SAMPLING SYSTEM PARAMETERS | | | | |
|---|---|---|---|---|
| **MKS Serial #** | **Sampling Line** | **Probe Assembly** | **Particulate Filter Media** | **Operating Temperatures** |
| 019088128 | 100' 3/8" dia., heated Teflon | Heated 3', 3/8" dia. SS | 0.01µ heated borosilicate glass fiber | 191°C |

QA/QC procedures followed US EPA Method 320. See below for QA/QC procedure details and list of calibration gas standards. All calibration gases were introduced to the analyzer and the sampling system using an instrument grade stainless steel rotameter. All QA/QC procedures were within the acceptance criteria allowance of the applicable EPA methodology. See Appendix G for FTIR QA/QC Data.

| FTIR QA/QC PROCEDURES | | | | | | |
|---|---|---|---|---|---|---|
| **QA/QC Specification** | **Purpose** | **Calibration Gas Analyte** | **Delivery** | **Frequency** | **Acceptance Criteria** | **Result** |
| M320: Zero | Verify that the FTIR is free of contaminants & zero the FTIR | Nitrogen (zero) | Direct to FTIR | pre/post test | < MDL or Noise | **Pass** |
| M320:Calibration Transfer Standard (CTS) Direct | Verify FTIR stability, confirm optical path length | Ethylene | Direct to FTIR | pretest | +/- 5% cert. value | **Pass** |
| M320: Analyte Direct | Verify FTIR calibration | Formaldehyde, Nitrous Oxide | Direct to FTIR | pretest | +/- 5% cert. value | **Pass** |
| M320: CTS Response | Verify system stability, recovery, response time | Ethylene | Sampling System | Daily, pre/post test | +/- 5% of Direct Measurement | **Pass** |
| M320: Zero Response | Verify system is free of system bias | Nitrogen (zero) | Sampling System | pretest | Bias correct data | **Pass** |
| M320: Analyte Spike | Verify system ability to deliver and quantify analyte of interest in the presence of effluent gases | Formaldehyde, Nitrous Oxide | Dynamic Addition to Sampling System, 1:10 effluent | Throughout testing – daily | +/- 30% theoretical recovery | **Pass** |

Note: The determined concentrations from direct analyses were used in all system/spike recovery calculations.

| CALIBRATION GAS STANDARDS | | | | |
|---|---|---|---|---|
| **Components** | **Concentration (ppm)** | **Vendor** | **Cylinder #** | **Standard Type** |
| Ethylene | 100.0 | Airgas | CC111625 | Primary +/- 1% |
| Formaldehyde,<br>Nitrous Oxide | 0.9715<br>99.10 | Airgas | CC717067 | Certified Standard-Spec +/- 5% |
| Nitrogen | Zero Gas | Airgas | N/A | UHP Grade |

**Analyte Spiking**

Formaldehyde spiking was performed prior to testing to verify the ability of the sampling system to quantitatively deliver a sample containing Formaldehyde from the base of the probe to the FTIR. Analyte spiking assures the ability of the FTIR sampling system to recover volatile organics in the presence of effluent gas.

As part of the spiking procedure, samples were measured to determine native formaldehyde concentrations to be used in the spike recovery calculations. The analyte spiking gases contained Nitrous Oxide (N2O). The determined N2O concentration in the spiked sample was used to calculate the dilution factor of the spike and thus used to calculate the concentration of the spiked formaldehyde. The spike target dilution ratio was 1:10 or less.

The following equation illustrates the percent recovery calculation.

$$DF = \frac{SF6(spk)}{SF6(direct)} \qquad \text{(Sec. 9.2.3 (3) USEPA Method 320)}$$

$$CS = DF * Spike(dir) + Unspike(1 - DF) \qquad \text{(Sec. 9.2.3 (4) USEPA Method 320)}$$

DF = Dilution factor of the spike gas
$SF_{6(dir)}$ = $SF_6$ concentration measured directly in undiluted spike gas
$SF_{6(spk)}$ = Diluted $SF_6$ concentration measured in a spiked sample
$Spike_{dir}$ = Concentration of the analyte in the spike standard measure by the FTIR directly
CS = Expected concentration of the spiked samples
Unspike = Native concentration of analytes in unspiked samples

***Post Collection Data Validation***

As part of the data validation procedure, reference spectra are manually fit to that of the sample spectra and a concentration is determined. The reference spectra are scaled to match the peak amplitude of the sample, thus providing a scale factor. The scale factor multiplied by the reference spectra concentration is used to determine the concentration value for the sample spectra. Sample pressure and temperature corrections are then applied to compute the final sample concentration. The manually calculated results are then compared with the software-generated results. The data is then validated if the two concentrations are within ± 20% agreement. If there is a difference greater than ± 20% the spectra are reviewed for possible spectra interferences or any other possible causes leading to incorrectly quantified data.

### *Detection Limit*

The detection limit of each analyte was calculated following Annex A2 of ASTM D6348-12 procedure using spectra that contained similar amounts of moisture and carbon dioxide.

| Analyte | Detection Limit (ppmv wet) | Detection Limit (%v) |
|---|---|---|
| **Methane** | **1.0** | **-** |
| **Ethane** | **0.5** | **-** |
| **Formaldehyde** | **0.2** | |
| **Moisture** | **-** | **0.1** |

QA/QC data are found in Appendix G. Copies of gas cylinder certifications are found in Appendix H. All concentration data were recorded on a wet, volume basis. The sample and data collection followed the procedures outlined in Method 320.

# 3.0 TEST RESULT SUMMARY

Marquette Board of Light and Power
Marquette Energy Center
EU-ENGINE02
Gaseous Summary
Full Load - Natural Gas Firing

| Test No. | Date | Start Time | End Time | $NO_x$ ppmvd | CO ppmvd | $CO_2$ % (dry) | $O_2$ % (dry) | Formaldehyde, ppmvd | Moisture, % | Flowrate, DSCFM | Flowrate, SCFM | THC ppm as $C_3H_8$ (wet) | $CH_4$ ppm as $CH_4$ (wet) | $CH_4$ ppm as $C_3H_8$ (wet)* | $C_2H_6$ (wet) | $C_2H_6$ ppm as $C_3H_8$ (wet) | VOC ppm as $C_3H_8$ (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 07/23/19 | 10:26 | 11:25 | 2.6 | 0.9 | 5.4 | 11.4 | 0.8 | 10.3 | 48,528 | 54,100 | 404.0 | 886.2 | 357.4 | 62.5 | 41.7 | 4.9 |
| 2 | 07/23/19 | 12:04 | 13:04 | 2.8 | 0.7 | 5.4 | 11.4 | 0.8 | 10.3 | 48,816 | 54,422 | 403.6 | 886.1 | 357.4 | 62.4 | 41.6 | 4.6 |
| 3 | 07/23/19 | 13:34 | 14:34 | 3.2 | 0.5 | 5.4 | 11.4 | 0.8 | 10.2 | 49,966 | 55,672 | 399.8 | 878.0 | 354.1 | 64.2 | 42.8 | 2.9 |
| Average | | | | 2.9 | 0.7 | 5.4 | 11.4 | 0.8 | 10.3 | 49,103 | 54,731 | 402.5 | 883.4 | 356.3 | 63.0 | 42.0 | 4.1 |

Emission Rate Summary

| Test No. | Date | Start Time | End Time | Fd Factor, dscf/MMBtu | CO ppmvd @ 15% $O_2$ | $NO_x$ ppmvd @ 15% $O_2$ | NMNE VOC ppmvd @ 15% $O_2$ | Formaldehyde, lb/hr | $NO_x$ lb/hr | CO lb/hr | NMNE VOC lb/hr | Horsepower | $NO_x$ g/hp-hr | CO g/hp-hr | NMNE VOC g/hp-hr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 07/23/19 | 10:26 | 11:25 | 8,710.0 | 0.6 | 1.6 | 3.4 | 0.18 | 0.9 | 0.2 | 1.8 | 22,442.5 | 0.018 | 0.004 | 0.037 |
| 2 | 07/23/19 | 12:04 | 13:04 | 8,710.0 | 0.4 | 1.7 | 3.2 | 0.18 | 1.0 | 0.2 | 1.7 | 22,472.0 | 0.020 | 0.003 | 0.035 |
| 3 | 07/23/19 | 13:34 | 14:34 | 8,710.0 | 0.3 | 2.0 | 2.0 | 0.18 | 1.2 | 0.1 | 1.1 | 22,419.9 | 0.023 | 0.002 | 0.022 |
| Average | | | | 8,710.0 | 0.4 | 1.8 | 2.9 | 0.18 | 1.0 | 0.2 | 1.5 | 22,444.8 | 0.020 | 0.003 | 0.031 |

Marquette Board of Light and Power
Marquette Energy Center
EU-ENGINE02
Gaseous Summary
Full Load - Fuel Oil

| Test No. | Date | Start Time | End Time | $NO_x$ ppmvd | CO ppmvd | $CO_2$ % (dry) | $O_2$ % (dry) | Formaldehyde, ppmvd | Moisture, % | Flowrate, DSCFM | Flowrate, SCFM | THC ppm as $C_3H_8$ (wet) | $CH_4$ ppm as $CH_4$ (wet) | $CH_4$ ppm as $C_3H_8$ (wet)* | $C_2H_6$ (wet) | $C_2H_6$ ppm as $C_3H_8$ (wet) | VOC ppm as $C_3H_8$ (wet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 07/23/19 | 15:52 | 16:51 | 2.5 | 0.4 | 6.3 | 12.3 | 0.1 | 6.8 | 53,813 | 57,262 | 1.2 | 0.3 | 0.1 | 0.1 | 0.1 | 1.0 |
| 2 | 07/23/19 | 19:42 | 20:41 | 27.0 | 0.3 | 6.3 | 12.2 | 0.1 | 6.7 | 53,181 | 57,230 | 1.1 | 0.3 | 0.1 | 0.1 | 0.1 | 0.9 |
| 3 | 07/25/19 | 8:55 | 9:54 | 33.4 | 1.0 | 6.4 | 12.3 | 0.1 | 7.2 | 53,637 | 57,320 | 1.8 | 0.5 | 0.2 | 0.1 | 0.1 | 1.5 |
| Average | | | | 21.0 | 0.6 | 6.3 | 12.3 | 0.1 | 6.9 | 53,544 | 57,271 | 1.4 | 0.4 | 0.1 | 0.1 | 0.1 | 1.2 |

Emission Rate Summary

| Test No. | Date | Start Time | End Time | Fd Factor, dscf/MMBtu | CO ppmvd @ 15% $O_2$ | $NO_x$ ppmvd @ 15% $O_2$ | NMNE VOC ppmvd @ 15% $O_2$ | Formaldehyde, lb/hr | $NO_x$ lb/hr | CO lb/hr | NMNE VOC lb/hr | Horsepower | $NO_x$ g/hp-hr | CO g/hp-hr | NMNE VOC g/hp-hr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 07/23/19 | 15:52 | 16:51 | 9,190.0 | 0.3 | 1.7 | 0.7 | 0.03 | 1.0 | 0.1 | 0.4 | 22,521.6 | 0.019 | 0.002 | 0.008 |
| 2 | 07/23/19 | 19:42 | 20:41 | 9,190.0 | 0.2 | 18.3 | 0.7 | 0.03 | 10.3 | 0.1 | 0.4 | 22,578.1 | 0.207 | 0.001 | 0.007 |
| 3 | 07/25/19 | 8:55 | 9:54 | 9,190.0 | 0.7 | 22.9 | 1.1 | 0.03 | 12.8 | 0.2 | 0.6 | 22,542.0 | 0.258 | 0.005 | 0.012 |
| Average | | | | 9,190.0 | 0.4 | 14.3 | 0.8 | 0.03 | 8.0 | 0.1 | 0.5 | 22,547.2 | 0.161 | 0.003 | 0.009 |

* Methane is corrected for a response factor of 1.21 for the Thermo 51i FID Analyzer

| | |
|---|---|
| **Client:** | **Marquette Board of Light and Power** |
| **Facility:** | **Marquette Energy Center** |
| **Test Location:** | **EU-ENGINE02** |
| **Test Method:** | **5** |

| | | | | |
|---|---|---|---|---|
| **Source Condition** | **Light Fuel Oil** | **Light Fuel Oil** | **Light Fuel Oil** | |
| **Date** | **7/23/19** | **7/23/19** | **7/25/19** | |
| **Start Time** | **15:45** | **19:42** | **8:50** | |
| **End Time** | **18:07** | **20:54** | **9:58** | |
| | **Run 1** | **Run 2** | **Run 3** | **Average** |
| **Stack Conditions** | | | | |
| **Average Gas Temperature, °F** | 714.5 | 710.1 | 724.1 | 716.2 |
| **Flue Gas Moisture, percent by volume** | 6.0% | 7.1% | 6.4% | 6.5% |
| **Average Flue Pressure, in. Hg** | 29.44 | 29.44 | 29.44 | 29.44 |
| **Gas Sample Volume, dscf** | 45.781 | 45.472 | 45.812 | 45.688 |
| **Average Gas Velocity, ft/sec** | 98.180 | 97.752 | 99.078 | 98.337 |
| **Gas Volumetric Flow Rate, acfm** | 129,472 | 128,907 | 130,656 | 129,678 |
| **Gas Volumetric Flow Rate, dscfm** | 53,813 | 53,181 | 53,637 | 53,544 |
| **Gas Volumetric Flow Rate, scfm** | 57,262 | 57,230 | 57,320 | 57,271 |
| **Average $\%CO_2$ by volume, dry basis** | 6.3 | 6.3 | 6.4 | 6.3 |
| **Average $\%O_2$ by volume, dry basis** | 12.3 | 12.2 | 12.3 | 12.3 |
| **Isokinetic Variance** | 100.9 | 101.4 | 101.3 | 101.2 |
| **Kilowatts** | 16807.0 | 16849.0 | 16822.0 | 16826.0 |
| **Standard Fuel Factor Fd, dscf/mmBtu** | 9,190.0 | 9,190.0 | 9,190.0 | 9,190.0 |
| **Filterable Particulate Matter (Method 5)** | | | | |
| **grams collected** | 0.00968 | 0.00745 | 0.00541 | 0.00751 |
| **grains/acf** | 0.0014 | 0.0010 | 0.0007 | 0.0010 |
| **grains/dscf** | 0.0033 | 0.0025 | 0.0018 | 0.0025 |
| **lb/hr** | 1.505 | 1.152 | 0.838 | 1.165 |
| **g/kW-hr** | 0.041 | 0.031 | 0.023 | 0.032 |

# 4.0 CERTIFICATION

MOSTARDI PLATT is pleased to have been of service to Marquette Board of Light and Power. If you have any questions regarding this test report, please do not hesitate to contact us at 630-993-2100.

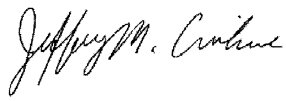
## CERTIFICATION

As project manager, I hereby certify that this test report represents a true and accurate summary of emissions test results and the methodologies employed to obtain those results, and the test program was performed in accordance with the methods specified in this test report.

MOSTARDI PLATT

_____ Program Manager

John S. Nestor



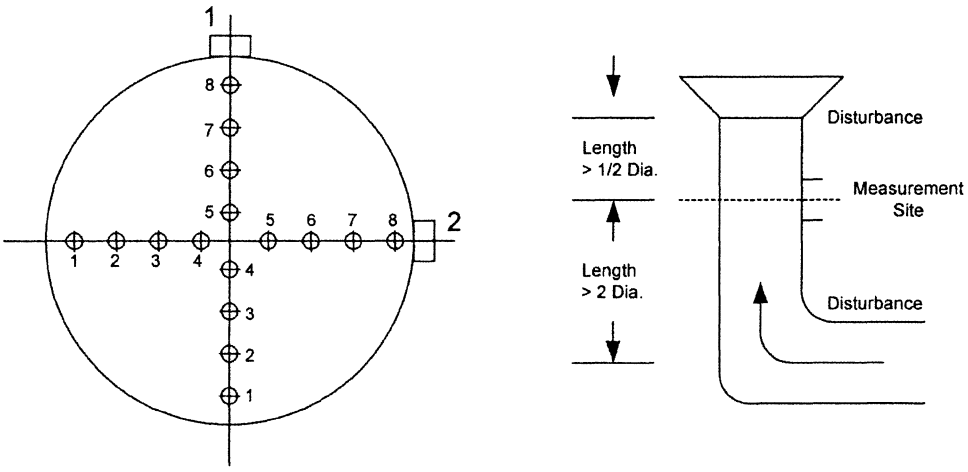
_____ Quality Assurance

Jeffery M. Crivlare

# APPENDICES

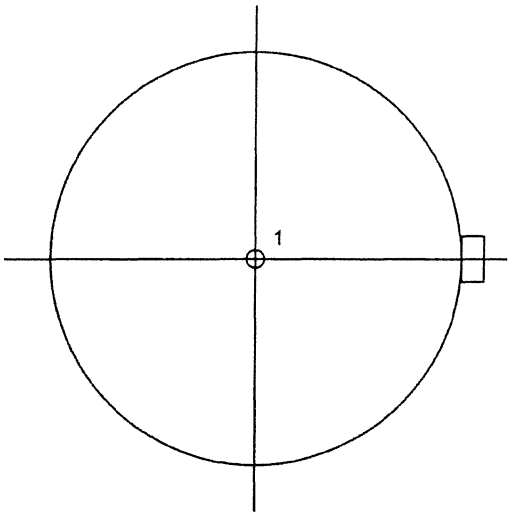
# Appendix A - Test Section Diagrams

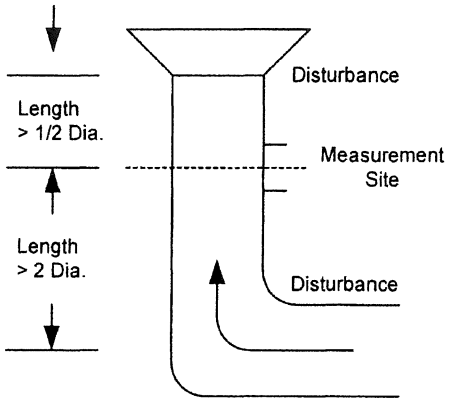
# VOLUMETRIC FLOW TRAVERSE FOR ROUND DUCTS




| | |
|---|---|
| Job: | Marquette Board of Light and Power<br>Marquette Energy Center<br>Marquette, Michigan |
| Date: | July 23, 2019 |
| Test Location: | EU-ENGINE02 Outlet Duct |
| Duct Diameter: | 5.29 Feet |
| Duct Area: | 21.979 Square Feet |
| No. Points Across Diameter: | 6 |
| No. of Ports: | 2 |
| Port Length: | 8.0 Inches |

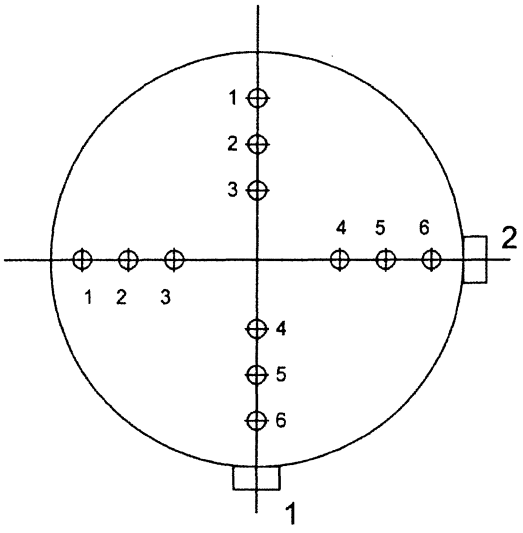
# REPRESENTATIVE POINT FOR GASEOUS RUNS ON ROUND DUCTS

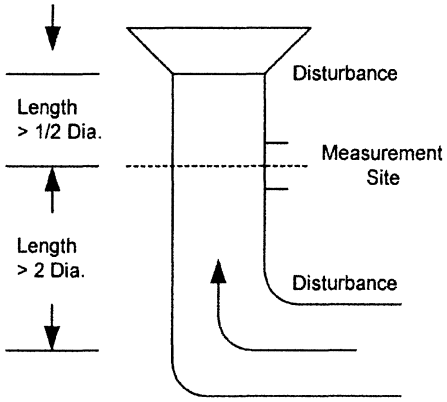



| | |
|---|---|
| Job: | Marquette Board of Light and Power<br>Marquette Energy Center<br>Marquette, Michigan |
| Date: | July 23 and 25, 2019 |
| Test Location: | EU-ENGINE02 Outlet Duct |
| Duct Diameter: | 5.29 Feet |
| Duct Area: | 21.979 Square Feet |
| No. Points Across Diameter: | 1 |
| No. of Ports: | 1 |
| Port Length: | 8.0 Inches |

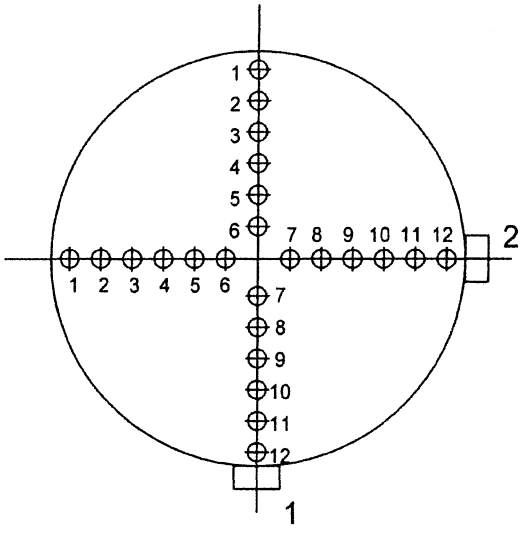
# GASEOUS STRATIFICATION TEST FOR ROUND DUCTS

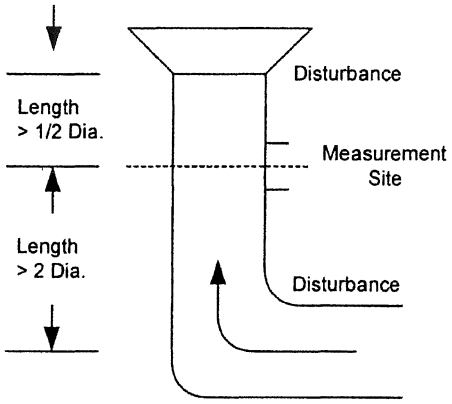



| | |
|---|---|
| Job: | Marquette Board of Light and Power<br>Marquette Energy Center<br>Marquette, Michigan |
| Date: | July 23, 2019 |
| Test Location: | EU-ENGINE02 Outlet Duct |
| Duct Diameter: | 5.29 Feet |
| Duct Area: | 21.979 Square Feet |
| No. Points Across Diameter: | 6 |
| No. of Ports: | 2 |
| Port Length: | 8.0 Inches |

# ISOKINETIC TRAVERSE FOR ROUND DUCTS

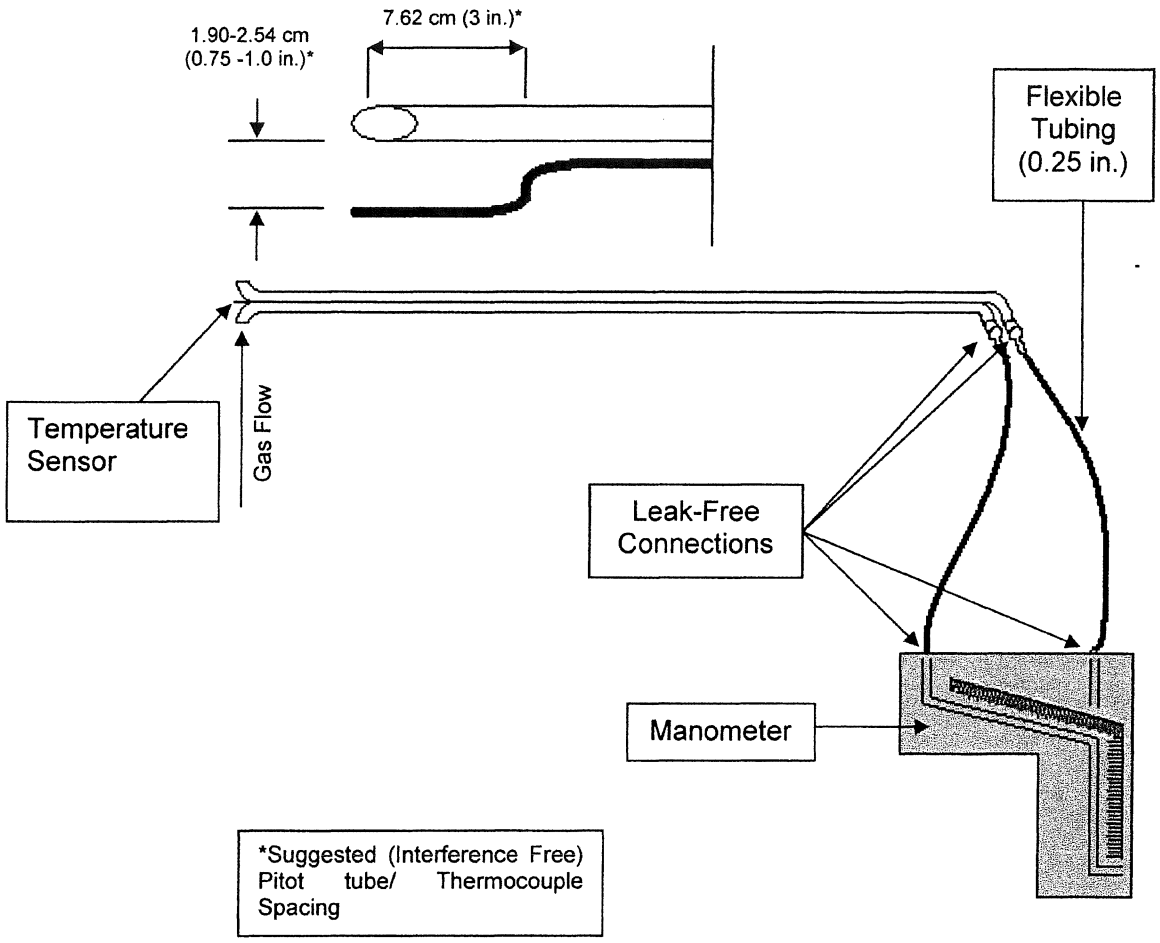


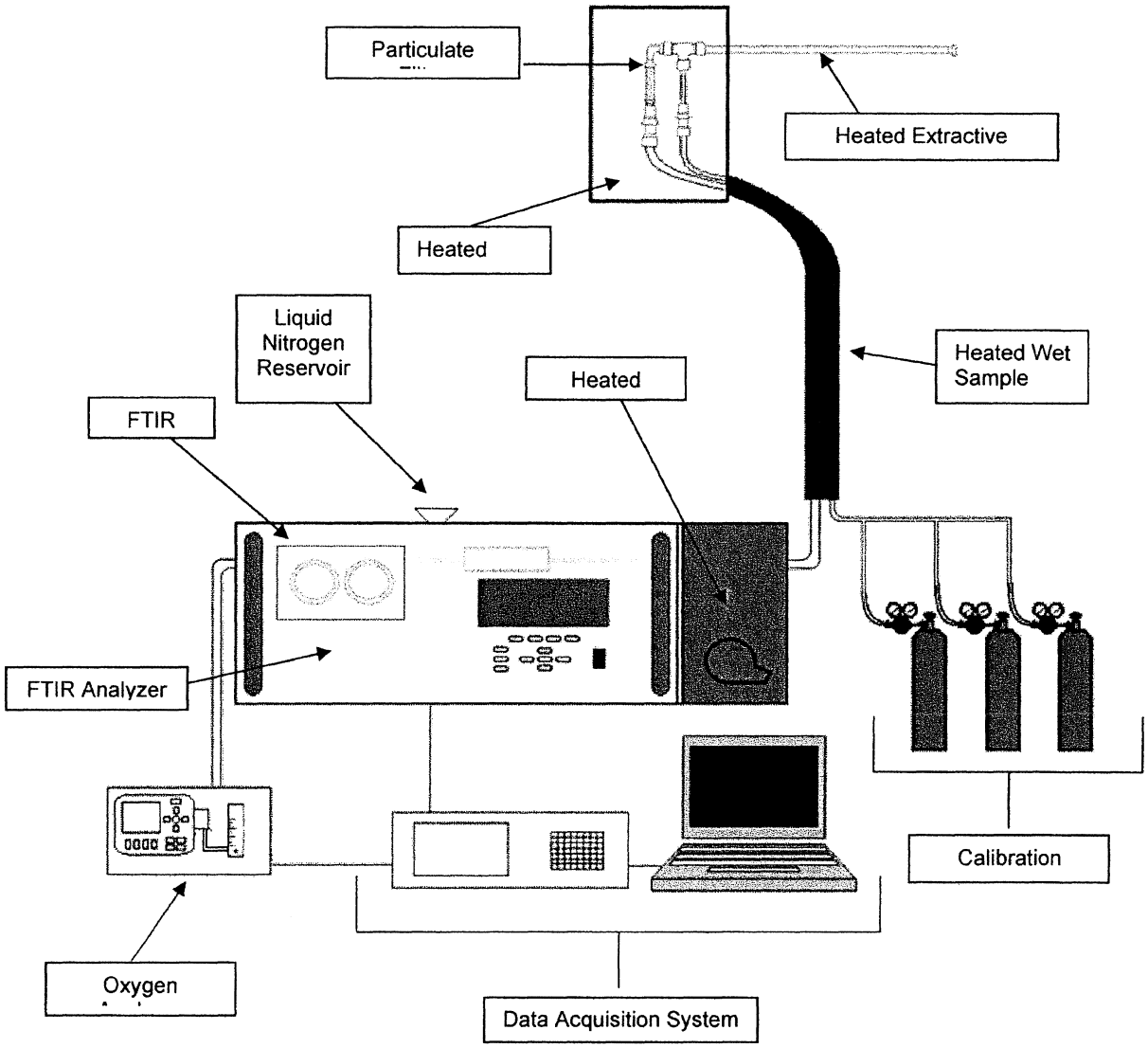

| | |
|---|---|
| Job: | Marquette Board of Light and Power<br>Marquette Energy Center<br>Marquette, Michigan |
| Date: | July 23 and 25, 2019 |
| Test Location: | EU-ENGINE02 Outlet Duct |
| Duct Diameter: | 5.29 Feet |
| Duct Area: | 21.979 Square Feet |
| No. Points Across Diameter: | 12 |
| No. of Ports: | 2 |
| Port Length: | 8.0 Inches |

# Appendix B - Sample Train Diagrams

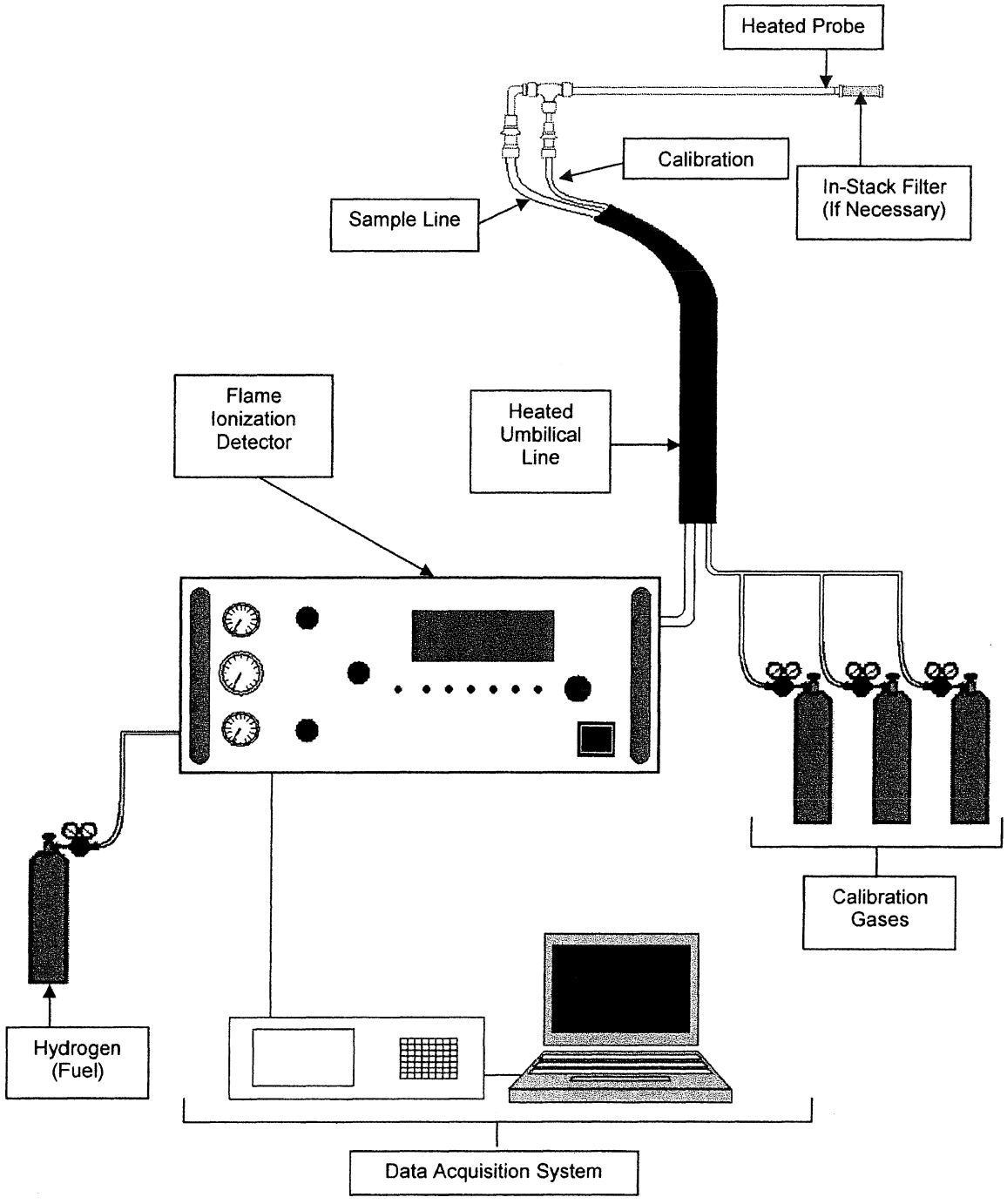
# USEPA Method 2 – Type S Pitot Tube Manometer Assembly



# USEPA Methods 3A and 320 – Sample Train Diagram



# USEPA Method 25A – Total Gaseous Organic Compound Sample Train



# USEPA Method 5 - Particulate Matter Sample Train Diagram