# Source Test Report

Consumers Energy Company
Covert Generating Station
26000 77th Street
Covert, Michigan 49043

Source Tested: EU-Turbine 1
Test Dates: July 29 and 30, 2024

Project No. AST-2024-3845

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Prepared By
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10441 Hedden Road
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## Regulatory Information

*Permit No.* Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division Renewable Operating Permit MI-ROP-N6767-2020a

## Source Information

| *Source Name* | *Source ID* | *Target Parameter* |
|---|---|---|
| EU-Turbine 1/ Unit 1 | EU-Turbine 1 | TPM |

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Alliance Technical Group, LLC (Alliance) has completed the source testing as described in this report. Results apply only to the source(s) tested and operating condition(s) for the specific test date(s) and time(s) identified within this report. All results are intended to be considered in their entirety, and Alliance is not responsible for use of less than the complete test report without written consent. This report shall not be reproduced in full or in part without written approval from the customer.

To the best of my knowledge and abilities, all information, facts and test data are correct. Data presented in this report has been checked for completeness and is accurate, error-free and legible. Onsite testing was conducted in accordance with approved internal Standard Operating Procedures. Any deviations or problems are detailed in the relevant sections in the test report.

This report is only considered valid once an authorized representative of Alliance has signed in the space provided below; any other version is considered draft. This document was prepared in portable document format (.pdf) and contains pages as identified in the bottom footer of this document.

**Chris Wehner – Operations Manager**
**Alliance Technical Group, LLC**

9.26.24
Date

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# Introduction

## 1.0 Introduction

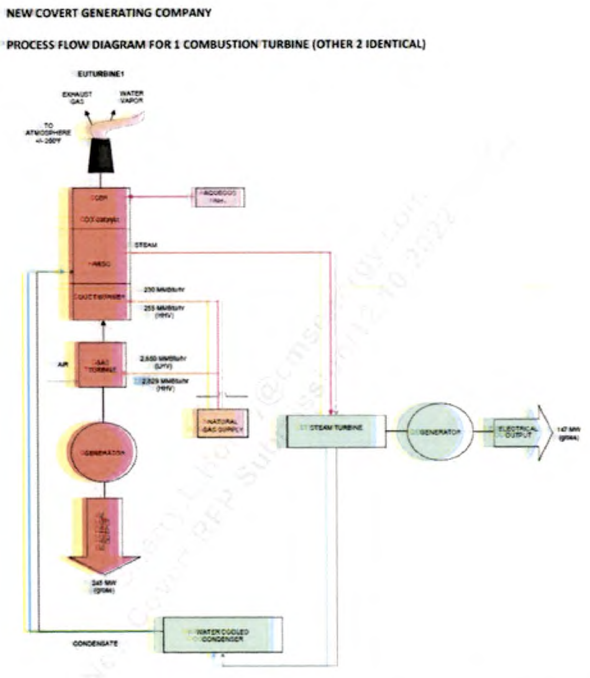
Alliance Technical Group, LLC (Alliance) was retained by Apex Companies, LLC (Apex), on behalf of Consumers Energy Company (CEC), to conduct compliance testing at the Covert, Michigan facility. The facility operates under Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division Renewable Operating Permit (ROP) MI-ROP-N6767-2020a. Testing was conducted to measure the emission rate of total particulate matter (TPM) from the exhaust stack of EU-Turbine 1. In this report, TPM is equivalent to particulate matter less than 10 and 2.5 microns ($PM_{10/2.5}$).

## 1.1 Source and Control System Descriptions

EU-Turbine 1 is a natural gas-fired Mitsubishi model 501G KIA combustion turbine (CT), installed in 2001 and updated in 2020. The turbine is equipped with a dry low nitrogen oxide (DLN) combustor, utilizes inlet air evaporative cooling, and operates in combined cycles with a heat recovery steam generator (HRSG) and a steam turbine generator. This CT/HRSG operation is equipped with a selective catalytic reduction (SCR) and an oxidation catalyst system.

Duct Burner 1 is a natural gas-fired burner installed in 2001, with a maximum heat input capacity of 256 mmBtu/hr in the HRSG of the turbine.

**Figure 1-1: Source Diagram**




*The figure used above is a figure shown in previous reports. This has been edited by Alliance to reflect to correct chemical SCR.

### 1.2 Project Team

Personnel involved in this project are identified in the following table.

**Table 1-1: Project Team**

| | |
|---|---|
| **Facility Personnel** | No Observer Present |
| **Apex Personnel** | Dr. Derek Wong |
| **Regulatory Personnel** | No Observer Present |
| **Alliance Personnel** | Jerrit Hall<br>Sohail Bajwa<br>Kody Brown<br>Jacob Luker |

### 1.3 Process Operating Data and Parameters

The process data of each turbine is monitored and recorded by the facility's responsive data acquisition handling system (DAHS). Data for the following parameters were provided for the duration of each test run and are included in Appendix E of this report. The plant records CEMS data in Eastern Standard Time, which is one hour earlier than the test run times in Eastern Daylight Savings Time. The terms used in the data are the following:

- CTGASFLW = Combustion turbine gas flow in units of hundred standard cubic feet per hour (HSCFH)
- CTHEAT = Combustion turbine heat input in units of millions of Btu per hour (MMBtu/hr)
- CTLOAD = Combustion turbine percent load
- DBGASFLW = Duct burner gas flow in units of HSCFH
- DBHEAT = Duct burner heat input in units of MMBtu/hr
- GASFLOW = Total combustion turbine and duct burner fuel flow in units of HSCFH
- HEATIN = Total combustion turbine and duct burner heat input in units of MMBtu/hr
- LOADMW = Combustion turbine gross load in megawatts (MW)
- TOTLOAD = Total combustion turbine and associated steam turbine gross load in MW

### 1.4 Test Protocol and Notification

Testing was conducted in accordance with portions of the test protocol previously submitted to EGLE by CEC specific to EPA Methods 5 and 202.

### 1.5 Test Program Notes

The following are test program notes:

- During Run 1, the EU-Turbine 1 operating load was approximately 87%.
- Run 2 was voided due to the broken glassware and contamination of the Method 202 sample train.
- During Runs 3 and 4, the EU-Turbine 1 operating load was approximately 58 and 74% respectively.
- The evaporative coolers and duct burners were inactive for each test run.
- Upon internal plant review of the test report, in an effort to review the stack diameter measured onsite, plant drawings and a post test physical measurement of the stack diameter resulted in the drawings showing a diameter of 259 inches and the physical measurement showing 261.5 inches. For the purpose of this test, a diameter of 261.5 inches was used to determine the velocity flow rate. The sample points selected were based on the U.S. EPA Method 1 measurements taken onsite.

# Summary of Results

## 2.0 Summary of Results

Alliance conducted testing at the CEC facility in Covert, Michigan on July 29 and 30, 2024. Testing consisted of measuring the emission rate of TPM (which is equivalent to $PM_{10/2.5}$) at the exhaust of EU-Turbine 1.

Table 2-1 summarizes the emission testing results compared to the applicable federal rule or EGLE permit limits. Any difference between the summary of results listed in the following table and the detailed results contained in the appendices is due to rounding for presentation.

**Table 2-1: Summary of Results – EU-Turbine 1**

| Emissions Data | | | | |
|---|---|---|---|---|
| **Run Number** | **Run 1** | **Run 3** | **Run 4** | **Average** |
| **Date** | **07/29/24** | **07/29/24** | **07/30/24** | -- |
| **Duct Burner** | **Off** | **Off** | **Off** | -- |
| **Evaporative Cooler** | **Off** | **Off** | **Off** | -- |
| **Load, MW*** | **332** | **219** | **276** | -- |
| **Filterable PM Data** | | | | |
| Emission Factor lb/MMBtu ($O_2$) | 0.0029 | 0.0012 | 0.0011 | 0.0017 |
| Concentration, grain/dscf | 8.5E-04 | 3.5E-04 | 3.1E-04 | 5.0E-04 |
| Emission Rate, lb/hr | 6.9 | 2.1 | 2.1 | 3.7 |
| **Condensable PM Data** | | | | |
| Emission Factor lb/MMBtu ($O_2$) | 0.0018 | 0.0018 | 0.0014 | 0.0017 |
| Concentration, grain/dscf | 5.4E-04 | 5.3E-04 | 3.9E-04 | 4.9E-04 |
| Emission Rate, lb/hr | 4.4 | 3.1 | 2.7 | 3.4 |
| **Total PM Data** | | | | |
| Emission Factor lb/MMBtu ($O_2$) | 0.0047 | 0.0030 | 0.0025 | 0.0034 |
| Concentration, grain/dscf | 0.0014 | 0.0009 | 0.0007 | 0.0010 |
| Emission Rate, lb/hr | 11.3 | 5.2 | 4.7 | 7.1 |
| **Permit Limit, lb/hr** | -- | -- | -- | 10.7 |
| **Percent of Limit, %** | -- | -- | -- | **66 %** |

*The evaporative coolers and duct burners were inactive for each test run.

# Testing Methodology

## 3.0 Testing Methodology

The emission testing program was conducted in accordance with the test methods listed in Table 3-1. Method descriptions are provided below while quality assurance/quality control data is provided in Appendix D.

**Table 3-1: Source Testing Methodology**

| Parameter | U.S. EPA Reference Test Methods | Notes/Remarks |
|---|---|---|
| Volumetric Flow Rate | 1 and 2 | Full Velocity Traverses |
| Oxygen/Carbon Dioxide | 3/3A | Integrated Bag / Instrumental Analysis |
| Moisture Content | 4 | Gravimetric Analysis |
| Filterable and Condensable Particulate Matter | 5/202 | Isokinetic Sampling |

### 3.1 U.S. EPA Reference Test Methods 1 and 2 – Sampling/Traverse Points and Volumetric Flow Rate

The sampling location and number of traverse (sampling) points were selected in accordance with U.S. EPA Reference Test Method 1. To determine the minimum number of traverse points, the upstream and downstream distances were equated into equivalent diameters and compared to Figure 1-1 in U.S. EPA Reference Test Method 1. Refer to Appendix B Method 1 data for a summary of the number and location of traverse points used for the TPM sampling. The Method 1 traverse points are presented with a 261.5 inch stack diameter used to calculate volumetric flow rate and 268.5 inch stack diameter as measured on-site.

Full velocity traverses were conducted in accordance with U.S. EPA Reference Test Method 2 to determine the average stack gas velocity pressure, static pressure and temperature. The velocity and static pressure measurement system consisted of a Pitot tube and inclined manometer. The stack gas temperature was measured with a K-type thermocouple and pyrometer.

Stack gas velocity pressure and temperature readings were recorded during each test run. The data collected were utilized to calculate the volumetric flow rate in accordance with U.S. EPA Reference Test Method 2.

### 3.2 U.S. EPA Reference Test Method 3/3A – Oxygen/Carbon Dioxide

The oxygen ($O_2$) and carbon dioxide ($CO_2$) testing was conducted in accordance with U.S. EPA Reference Test Method 3/3A. One (1) integrated Tedlar bag sample was collected during each test run. The bag samples were analyzed on site with a gas analyzer. The remaining stack gas constituent was assumed to be nitrogen for the stack gas molecular weight determination. The samples were collected for the same duration as the particulate test. The quality control measures are described in Section 3.5.

### 3.3 U.S. EPA Reference Test Method 4 – Moisture Content

The stack gas moisture content (BWS) was determined in accordance with U.S. EPA Reference Test Method 4. The gas conditioning train consisted of a series of chilled impingers. Prior to testing, each impinger was filled with a known quantity of water or silica gel. Each impinger was analyzed gravimetrically before and after each test run on the same balance to determine the amount of moisture condensed.

### 3.4 U.S. EPA Reference Test Methods 5 and 202 – Total Particulate Matter

The total particulate matter (filterable and condensable PM) testing was conducted in accordance with U.S. EPA Reference Test Methods 5 and 202. The complete sampling system consisted of a stainless-steel nozzle, glass-lined probe, pre-weighed quartz filter, coil condenser, un-weighed Teflon filter, gas conditioning train, pump and calibrated dry gas meter. The gas conditioning train consisted of a coiled condenser and four (4) chilled impingers. The first and second impingers were initially empty, the third contained 100 mL of de-ionized water and the last impinger contained 200 to 300 grams of silica gel. The un-weighed 90 mm Teflon filter was placed between the second and third impingers. The probe liner heating system was maintained at a temperature of 248 ±25°F, and the impinger temperature was maintained at 68°F or less throughout testing. The temperature of the Teflon filter was maintained greater than 65°F but less than or equal to 85°F.

Following the completion of each test run, the sampling train was leak checked at a vacuum pressure greater than or equal to the highest vacuum pressure observed during the run. The nitrogen purge was conducted on-site during testing. After the leak check, the impinger contents were measured for moisture gain.

The pre-weighed quartz filter was carefully removed and placed in container 1. The probe, nozzle and front half of the filter holder were rinsed six (6) times with acetone to remove adhering particulate matter and these rinses were recovered in container 2. All containers were sealed, labeled and liquid levels marked for transport to the identified laboratory for filterable particulate matter analysis.

The contents of Impingers 1 and 2 were recovered in container CPM Cont. #1. The back half of the filterable PM filter holder, the coil condenser, impingers 1 and 2 and all connecting glassware were rinsed with DIUF water and then rinsed with acetone, followed by hexane. The water rinses were added to container CPM Cont. #1 while the solvent rinses were recovered in container CPM Cont. #2. The Teflon filter was removed from the filter holder and placed in container CPM Cont. #3. The front half of the condensable PM filter holder was rinsed with DIUF water and then with acetone, followed by hexane. The water rinse was added to container CPM Cont. #1 while the solvent rinses were added to container CPM Cont. #2. All containers were sealed, labeled and liquid levels marked for transport to the identified laboratory for condensable particulate matter analysis.

### 3.5 Quality Assurance/Quality Control – U.S. EPA Reference Test Method 3/3A

Cylinder calibration gases used met EPA Protocol 1 (± 2%) standards. Copies of all calibration gas certificates can be found in the Quality Assurance/Quality Control Appendix.

Low-Level gas was introduced directly to the analyzer. After adjusting the analyzer to the Low-Level gas concentration and once the analyzer reading was stable, the analyzer value was recorded. This process was repeated for the High-Level gas. For the Calibration Error Test, Low, Mid, and High-Level calibration gases were sequentially introduced directly to the analyzer. All values were within 2.0% of the Calibration Span or 0.5% absolute difference. The measured results were recorded as raw values and no bias correction was applied.

At the completion of testing, the data was also saved to the Alliance server. All data was reviewed by the Field Team Leader before leaving the facility. Once arriving at Alliance's office, all written and electronic data was relinquished to the report coordinator and then a final review was performed by the Project Manager.

# Appendix A

Alliance TECHNICAL GROUP

**Location:** Consumers Energy Company - Covert, MI
**Source:** EU-Turbine 1 (Unit 1) - Method 5
**Project No.:** 2024-3845
**Run No.:** 1
**Parameter:** PM/CPM

**Meter Pressure (Pm), in. Hg**

$$Pm = Pb + \frac{\Delta H}{13.6}$$

**where,**

| | | |
|---|---|---|
| Pb | 29.27 | = barometric pressure, in. Hg |
| ΔH | 2.642 | = pressure differential of orifice, in $H_2O$ |
| Pm | 29.46 | = in. Hg |

**Absolute Stack Gas Pressure (Ps), in. Hg**

$$Ps = Pb + \frac{Pg}{13.6}$$

**where,**

| | | |
|---|---|---|
| Pb | 29.27 | = barometric pressure, in. Hg |
| Pg | 0.55 | = static pressure, in. $H_2O$ |
| Ps | 29.31 | = in. Hg |

**Standard Meter Volume (Vmstd), dscf**

$$Vmstd = \frac{17.636 \times Y \times Vm \times Pm}{Tm}$$

**where,**

| | | |
|---|---|---|
| Y | 0.994 | = meter correction factor |
| Vm | 111.759 | = meter volume, cf |
| Pm | 29.46 | = absolute meter pressure, in. Hg |
| Tm | 548.3 | = absolute meter temperature, °R |
| Vmstd | 105.281 | = dscf |

**Standard Wet Volume (Vwstd), scf**

$$Vwstd = 0.04716 \times Vlc$$

**where,**

| | | |
|---|---|---|
| Vlc | 231.1 | = weight of $H_2O$ collected, g |
| Vwstd | 10.899 | = scf |

**Moisture Fraction (BWSsat), dimensionless (theoretical at saturated conditions)**

$$BWSsat = \frac{10^{6.37} - \left(\frac{2,827}{Ts + 365}\right)}{Ps}$$

**where,**

| | | |
|---|---|---|
| Ts | 200.0 | = stack temperature, °F |
| Ps | 29.31 | = absolute stack gas pressure, in. Hg |
| BWSsat | 0.785 | = dimensionless |

Alliance TECHNICAL GROUP

**Location:** Consumers Energy Company - Covert, MI
**Source:** EU-Turbine 1 (Unit 1) - Method 5
**Project No.:** 2024-3845
**Run No.:** 1
**Parameter:** PM/CPM

**Moisture Fraction (BWS), dimensionless (measured)**

$$BWS = \frac{Vwstd}{(Vwstd + Vmstd)}$$

**where,**

| | | |
|---|---|---|
| Vwstd | 10.899 | = standard wet volume, scf |
| Vmstd | 105.281 | = standard meter volume, dscf |
| BWS | 0.094 | = dimensionless |

**Moisture Fraction (BWS), dimensionless**

$$BWS = BWSmsd \text{ unless } BWSsat < BWSmsd$$

**where,**

| | | |
|---|---|---|
| BWSsat | 0.785 | = moisture fraction (theoretical at saturated conditions) |
| BWSmsd | 0.094 | = moisture fraction (measured) |
| BWS | 0.094 | |

**Excess Air (EA), %**

$$EA = \frac{(\%O_2 - [0.5 \times \%CO]) \times 100}{(0.264 \times \%N_2) - \%O_2 - (0.5 \times \%CO)}$$

**where,**

| | | |
|---|---|---|
| $CO_2$ | 4.4 | = carbon dioxide concentration, % |
| $O_2$ | 13.2 | = oxygen concentration, % |
| CO | 0.0 | = carbon monoxide concentration, % (assumed zero) |
| $N_2$ | 82.4 | = nitrogen concentration, % |
| EA | 154.3209877 | = % |

**Molecular Weight (DRY) (Md), lb/lb-mole**

$$Md = (0.44 \times \%CO_2) + (0.32 \times \%O_2) + (0.28 \times [100 - \%CO_2 - \%O_2])$$

**where,**

| | | |
|---|---|---|
| $CO_2$ | 4.4 | = carbon dioxide concentration, % |
| $O_2$ | 13.2 | = oxygen concentration, % |
| Md | 29.23 | = lb/lb mol |

**Molecular Weight (WET) (Ms), lb/lb-mole**

$$Ms = (Md \times [1 - BWS]) + (18.015 \times BWS)$$

**where,**

| | | |
|---|---|---|
| Md | 29.23 | = molecular weight (DRY), lb/lb mol |
| BWS | 0.094 | = moisture fraction, dimensionless |
| Ms | 28.18 | = lb/lb mol |

Alliance TECHNICAL GROUP

**Location:** Consumers Energy Company - Covert, MI
**Source:** EU-Turbine 1 (Unit 1) - Method 5
**Project No.:** 2024-3845
**Run No.:** 1
**Parameter:** PM/CPM

**Average Velocity (Vs), ft/sec**

$$Vs = 85.49 \times Cp \times (\Delta P^{1/2})\ avg \times \sqrt{\frac{Ts}{Ps \times Ms}}$$

**where,**

| | | |
|---|---|---|
| Cp | 0.840 | = pitot tube coefficient |
| $\Delta P^{1/2}$ | 0.925 | = velocity head of stack gas, $(in.\ H_2O)^{1/2}$ |
| Ts | 659.7 | = absolute stack temperature, °R |
| Ps | 29.31 | = absolute stack gas pressure, in. Hg |
| Ms | 28.18 | = molecular weight of stack gas, lb/lb mol |
| Vs | 59.4 | = ft/sec |

**Average Stack Gas Flow at Stack Conditions (Qa), acfm**

$$Qa = 60 \times Vs \times As$$

**where,**

| | | |
|---|---|---|
| Vs | 59.4 | = stack gas velocity, ft/sec |
| As | 372.97 | = cross-sectional area of stack, $ft^2$ |
| Qa | 1,328,413 | = acfm |

**Average Stack Gas Flow at Standard Conditions (Qs), dscfm**

$$Qs = \frac{17.636 \times Qa \times (1 - BWS) \times Ps}{Ts}$$

**where,**

| | | |
|---|---|---|
| Qa | 1,328,413 | = average stack gas flow at stack conditions, acfm |
| BWS | 0.094 | = moisture fraction, dimensionless |
| Ps | 29.31 | = absolute stack gas pressure, in. Hg |
| Ts | 659.7 | = absolute stack temperature, °R |
| Qs | 943,297 | = dscfm |

**Dry Gas Meter Calibration Check (Yqa), dimensionless**

$$Yqa = \frac{Y - \left(\frac{\Theta}{Vm} \sqrt{\frac{0.0319 \times Tm \times 29}{\Delta H@ \times \left(Pb + \frac{\Delta\ Havg.}{13.6}\right) \times Md}}\ \sqrt{\Delta H}\ avg.\right)}{Y} \times 100$$

**where,**

| | | |
|---|---|---|
| Y | 0.994 | = meter correction factor, dimensionless |
| Θ | 120 | = run time, min. |
| Vm | 111.759 | = total meter volume, dcf |
| Tm | 548.3 | = absolute meter temperature, °R |
| ΔH@ | 1.811 | = orifice meter calibration coefficient, in. $H_2O$ |
| Pb | 29.27 | = barometric pressure, in. Hg |
| ΔH avg | 2.642 | = average pressure differential of orifice, in $H_2O$ |
| Md | 29.23 | = molecular weight (DRY), lb/lb mol |
| $(\Delta H)^{1/2}$ | 1.617 | = average squareroot pressure differential of orifice, $(in.\ H2O)^{1/2}$ |
| Yqa | 0.4 | = percent |

Alliance TECHNICAL GROUP

**Location:** Consumers Energy Company - Covert, MI
**Source:** EU-Turbine 1 (Unit 1) - Method 5
**Project No.:** 2024-3845
**Run No.:** 1
**Parameter:** PM/CPM

**Volume of Nozzle (Vn), $ft^3$**

$$Vn = \frac{Ts \times \left( 0.002669 \times Vlc + \frac{Vm \times Pm \times Y}{Tm} \right)}{Ps}$$

**where,**

| | | |
|---|---|---|
| Ts | 659.7 | = absolute stack temperature, °R |
| Ps | 29.31 | = absolute stack gas pressure, in. Hg |
| Vlc | 231.1 | = volume of $H_2O$ collected, ml |
| Vm | 111.759 | = meter volume, cf |
| Pm | 29.46 | = absolute meter pressure, in. Hg |
| Y | 0.994 | = meter correction factor, unitless |
| Tm | 548.3 | = absolute meter temperature, °R |
| Vn | 148.237 | = volume of nozzle, $ft^3$ |

**Isokinetic Sampling Rate (I), %**

$$I = \left( \frac{Vn}{\theta \times 60 \times An \times Vs} \right) \times 100$$

**where,**

| | | |
|---|---|---|
| Vn | 148.237 | = nozzle volume, ft3 |
| θ | 120.0 | = run time, minutes |
| An | 0.00034 | = area of nozzle, $ft^2$ |
| Vs | 59.4 | = average velocity, ft/sec |
| I | 101.7 | = % |

**Filterable PM Concentration ($C_s$), grain/dscf**

$$C_s = \frac{M_n \times 0.0154}{Vmstd}$$

**where,**

| | | |
|---|---|---|
| Mn | 5.8 | = filterable PM mass, mg |
| Vmstd | 105.281 | = standard meter volume, dscf |
| $C_s$ | 0.0009 | = grain/dscf |

**Filterable PM Emission Rate (PMR), lb/hr**

$$PMR = \frac{C_s \times Qs \times 60}{7.0E+03}$$

**where,**

| | | |
|---|---|---|
| $C_s$ | 0.0009 | = filterable PM concentration, grain/dscf |
| Qs | 943,297 | = average stack gas flow at standard conditions, dscfm |
| PMR | 6.87 | = lb/hr |

Alliance TECHNICAL GROUP

**Location:** Consumers Energy Company - Covert, MI
**Source:** EU-Turbine 1 (Unit 1) - Method 5
**Project No.:** 2024-3845
**Run No.:** 1
**Parameter:** PM/CPM

**Filterable PM Emission Factor ($EF_{PM\ O2d}$), lb/MMBtu**

$$EF_{PMO2d} = \frac{M_n \times Fd}{Vmstd \times 4.54E+05} \times \frac{20.9}{20.9 - O_2}$$

**where,**

| | | |
|---|---|---|
| Mn | 5.8 | = filterable PM mass, mg |
| Fd | 8,710 | = oxygen based fuel factor, dscf/MMBtu |
| Vmstd | 105.281 | = standard meter volume, dscf |
| $O_2$ | 13.2 | = oxygen concentration, % |
| $EF_{PM\ O2d}$ | 0.003 | = lb/MMBtu |

**Condensable PM Concentration ($C_{CPM}$), grain/dscf**

$$C_{CPM} = \frac{M_{CPM} \times 0.0154}{Vmstd}$$

**where,**

| | | |
|---|---|---|
| $M_{CPM}$ | 3.7 | = condensable PM mass, mg |
| Vmstd | 105.281 | = standard meter volume, dscf |
| $C_{CPM}$ | 0.0005 | = grain/dscf |

**Condensable PM Emission Rate ($ER_{CPM}$), lb/hr**

$$ER_{CPM} = \frac{C_{CPM} \times Qs \times 60\frac{min}{hr}}{7.0E+03}$$

**where,**

| | | |
|---|---|---|
| $C_{CPM}$ | 0.0005 | = condensable PM concentration, grain/dscf |
| Qs | 943,297 | = average stack gas flow at standard conditions, dscfm |
| $ER_{CPM}$ | 4.39 | = lb/hr |

**Condensable PM Emission Factor ($EF_{CPM\ O2d}$), lb/MMBtu**

$$EF_{CPMO2d} = \frac{M_{CPM} \times Fd}{Vmstd \times 4.54E+05} \times \frac{20.9\%\ O_2}{20.9\%\ O_2 - O_2}$$

**where,**

| | | |
|---|---|---|
| $M_{CPM}$ | 3.7 | = condensable PM mass, mg |
| Fd | 8,710 | = oxygen based fuel factor, dscf/MMBtu |
| Vmstd | 105.281 | = standard meter volume, dscf |
| $O_2$ | 13.2 | = oxygen concentration, % |
| $EF_{CPM\ O2d}$ | 0.002 | = lb/MMBtu |

**Total PM Concentration ($C_{TPM}$), grain/dscf**

$$C_{TPM} = C_S + C_{CPM}$$

**where,**

| | | |
|---|---|---|
| $C_s$ | 0.0009 | = filterable PM concentration, grain/dscf |
| $C_{CPM}$ | 0.0005 | = condensable PM concentration, grain/dscf |
| $C_{TPM}$ | 0.0014 | = grain/dscf |

Alliance TECHNICAL GROUP

**Location:** Consumers Energy Company - Covert, MI
**Source:** EU-Turbine 1 (Unit 1) - Method 5
**Project No.:** 2024-3845
**Run No.:** 1
**Parameter:** PM/CPM

**Total PM Emission Rate ($ER_{TPM}$), lb/hr**

$$ER_{TPM} = PMR + ER_{CPM}$$

**where,**

| | | |
|---|---|---|
| PMR | 6.87 | = filterable PM emission rate, lb/hr |
| $ER_{CPM}$ | 4.39 | = condensable PM emission rate, lb/hr |
| $ER_{TPM}$ | 11.26 | = lb/hr |

**Total PM Emission Factor ($EF_{TPM}$), lb/MMBtu (O2d)**

$$EF_{TPM} = EF_{PM} + EF_{CPM}$$

**where,**

| | | |
|---|---|---|
| $EF_{PM}$ | 0.003 | = filterable PM emission factor, lb/MMBtu |
| $EF_{CPM}$ | 0.002 | = condensable PM emission factor, lb/MMBtu |
| $EF_{TPM}$ | 0.005 | = lb/MMBtu |

# Appendix B

Alliance TECHNICAL GROUP

# Emission Calculations

**Location** Consumers Energy Company - Covert, MI
**Source** EU-Turbine 1 (Unit 1) - Method 5
**Project No.** 2024-3845
**Parameter** PM/CPM

| Run Number | | Run 1 | Run 3 | Run 4 | Average |
|---|---|---|---|---|---|
| Date | | 7/29/24 | 7/29/24 | 7/30/24 | -- |
| Start Time | | 9:53 | 16:10 | 15:09 | -- |
| Stop Time | | 12:15 | 18:23 | 17:33 | -- |
| Run Time, min | (θ) | 120.0 | 120.0 | 120.0 | 120.0 |
| **INPUT DATA** | | | | | |
| Heat Input, MMBtu/hr | (HI) | 2,380 | 1,685 | 1,944 | 2,003 |
| Fuel Factor (O2 dry), dscf/MMBtu | (Fd) | 8,710 | 8,710 | 8,710 | 8,710 |
| Barometric Pressure, in. Hg | (Pb) | 29.27 | 29.27 | 29.25 | 29.26 |
| Meter Correction Factor | (Y) | 0.994 | 0.994 | 0.994 | -- |
| Orifice Calibration Value | (ΔH @) | 1.811 | 1.811 | 1.811 | -- |
| Meter Volume, $ft^3$ | (Vm) | 111.759 | 118.936 | 116.766 | 115.820 |
| Meter Temperature, °F | (Tm) | 88.6 | 95.0 | 90.8 | 91.5 |
| Meter Temperature, °R | (Tm) | 548.3 | 554.7 | 550.5 | 551.1 |
| Meter Orifice Pressure, in. WC | (ΔH) | 2.642 | 2.954 | 2.892 | 2.829 |
| Volume $H_2O$ Collected, mL | (Vlc) | 231.1 | 227.0 | 230.1 | 229.4 |
| Nozzle Diameter, in | (Dn) | 0.250 | 0.300 | 0.280 | 0.277 |
| Area of Nozzle, $ft^2$ | (An) | 0.0003 | 0.0005 | 0.0004 | 0.0004 |
| Filterable PM Mass, mg | (Mn) | 5.8 | 2.5 | 2.2 | 3.5 |
| Condensable PM Mass, mg | ($M_{CPM}$) | 3.7 | 3.8 | 2.8 | 3.4 |
| **ISOKINETIC DATA** | | | | | |
| Standard Meter Volume, $ft^3$ | (Vmstd) | 105.281 | 110.841 | 109.559 | 108.560 |
| Standard Water Volume, $ft^3$ | (Vwstd) | 10.899 | 10.705 | 10.852 | 10.819 |
| Moisture Fraction Measured | (BWSmsd) | 0.094 | 0.088 | 0.090 | 0.091 |
| Moisture Fraction @ Saturation | (BWSsat) | 0.785 | 0.523 | 0.637 | 0.648 |
| Moisture Fraction | (BWS) | 0.094 | 0.088 | 0.090 | 0.091 |
| Meter Pressure, in Hg | (Pm) | 29.46 | 29.49 | 29.46 | 29.47 |
| Volume at Nozzle, $ft^3$ | (Vn) | 148.237 | 150.699 | 151.418 | 150.12 |
| Isokinetic Sampling Rate, (%) | (I) | 101.7 | 101.1 | 101.2 | 101.4 |
| DGM Calibration Check Value, (+/- 5%) | ($Y_{qa}$) | 0.4 | 0.3 | 0.1 | 0.3 |
| **EMISSION CALCULATIONS** | | | | | |
| Filterable PM Concentration, grain/dscf | ($C_s$) | 8.5E-04 | 3.5E-04 | 3.1E-04 | 5.0E-04 |
| Filterable PM Emission Rate, lb/hr | (PMR) | 6.9 | 2.1 | 2.1 | 3.7 |
| Filterable PM Emission Factor, lb/MMBtu (O2) | ($EF_{PM\ O2d}$) | 0.0029 | 0.0012 | 0.0011 | 0.0017 |
| Condensable PM Concentration, grain/dscf | ($C_{CPM}$) | 5.4E-04 | 5.3E-04 | 3.9E-04 | 4.9E-04 |
| Condensable PM Emission Rate, lb/hr | ($ER_{CPM}$) | 4.4 | 3.1 | 2.7 | 3.4 |
| Condensable PM Emission Factor, lb/MMBtu (O2) | ($EF_{CPM\ O2d}$) | 0.0018 | 0.0018 | 0.0014 | 0.0017 |
| Total PM Concentration, grain/dscf | ($C_{TPM}$) | 0.0014 | 0.0009 | 0.0007 | 0.0010 |
| Total PM Emission Rate, lb/hr | ($ER_{TPM}$) | 11.3 | 5.2 | 4.7 | 7.1 |
| Total PM Emission Factor, lb/MMBtu (O2) | ($EF_{TPM\ O2d}$) | 0.0047 | 0.0030 | 0.0025 | 0.0034 |

**Location** Consumers Energy Company - Covert, MI
**Source** EU-Turbine 1 (Unit 1) - Method 5
**Project No.** 2024-3845
**Parameter** PM/CPM

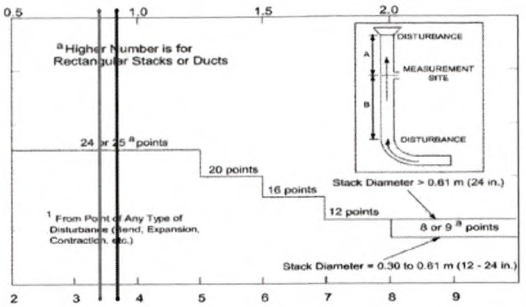
| Run Number | | Run 1 | Run 3 | Run 4 | Average |
|---|---|---|---|---|---|
| Date | | 7/29/24 | 7/29/24 | 7/30/24 | -- |
| Start Time | | 9:53 | 16:10 | 15:09 | -- |
| Stop Time | | 12:15 | 18:23 | 17:33 | -- |
| Run Time, min | | 120.0 | 120.0 | 120.0 | 120.0 |
| **VELOCITY HEAD, in. WC** | | | | | |
| Point 1 | | 0.69 | 0.38 | 0.37 | 0.48 |
| Point 2 | | 0.73 | 0.40 | 0.42 | 0.52 |
| Point 3 | | 0.84 | 0.42 | 0.57 | 0.61 |
| Point 4 | | 0.95 | 0.44 | 0.68 | 0.69 |
| Point 5 | | 1.10 | 0.50 | 0.75 | 0.78 |
| Point 6 | | 0.98 | 0.52 | 0.79 | 0.76 |
| Point 7 | | 0.67 | 0.37 | 0.42 | 0.49 |
| Point 8 | | 0.69 | 0.41 | 0.46 | 0.52 |
| Point 9 | | 0.82 | 0.46 | 0.60 | 0.63 |
| Point 10 | | 0.92 | 0.50 | 0.66 | 0.69 |
| Point 11 | | 0.95 | 0.52 | 0.74 | 0.74 |
| Point 12 | | 0.96 | 0.48 | 0.81 | 0.75 |
| Point 13 | | 0.60 | 0.30 | 0.42 | 0.44 |
| Point 14 | | 0.62 | 0.32 | 0.43 | 0.46 |
| Point 15 | | 0.82 | 0.41 | 0.54 | 0.59 |
| Point 16 | | 0.94 | 0.47 | 0.57 | 0.66 |
| Point 17 | | 1.10 | 0.53 | 0.60 | 0.74 |
| Point 18 | | 1.20 | 0.50 | 0.69 | 0.80 |
| Point 19 | | 0.64 | 0.31 | 0.44 | 0.46 |
| Point 20 | | 0.61 | 0.40 | 0.50 | 0.50 |
| Point 21 | | 0.79 | 0.45 | 0.64 | 0.63 |
| Point 22 | | 0.94 | 0.49 | 0.69 | 0.71 |
| Point 23 | | 1.00 | 0.55 | 0.71 | 0.75 |
| Point 24 | | 1.20 | 0.57 | 0.65 | 0.81 |
| **CALCULATED DATA** | | | | | |
| Square Root of ΔP, (in. WC)$^{1/2}$ | (ΔP) | 0.925 | 0.665 | 0.763 | 0.784 |
| Pitot Tube Coefficient | (Cp) | 0.840 | 0.840 | 0.840 | 0.840 |
| Barometric Pressure, in. Hg | (Pb) | 29.27 | 29.27 | 29.25 | 29.26 |
| Static Pressure, in. WC | (Pg) | 0.55 | 0.21 | 0.48 | 0.41 |
| Stack Pressure, in. Hg | (Ps) | 29.31 | 29.29 | 29.29 | 29.29 |
| Stack Cross-sectional Area, ft$^2$ | (As) | 372.97 | 372.97 | 372.97 | 372.97 |
| Stack Temperature, °F | (Ts) | 200.0 | 180.8 | 189.9 | 190.2 |
| Stack Temperature, °R | (Ts) | 659.7 | 640.5 | 649.6 | 649.9 |
| Moisture Fraction Measured | (BWSmsd) | 0.094 | 0.088 | 0.090 | 0.091 |
| Moisture Fraction @ Saturation | (BWSsat) | 0.785 | 0.523 | 0.637 | 0.648 |
| Moisture Fraction | (BWS) | 0.094 | 0.088 | 0.090 | 0.091 |
| $O_2$ Concentration, % | ($O_2$) | 13.2 | 13.4 | 13.5 | 13.37 |
| $CO_2$ Concentration, % | ($CO_2$) | 4.4 | 4.1 | 4.2 | 4.23 |
| $N_2$ Concentration, % | ($N_2$) | 82.4 | 82.5 | 82.3 | 82.40 |
| Excess Air, % | (EA) | 154.32 | 159.90 | 164.09 | 159.44 |
| Molecular Weight, lb/lb-mole (dry) | (Md) | 29.23 | 29.19 | 29.21 | 29.21 |
| Molecular Weight, lb/lb-mole (wet) | (Ms) | 28.18 | 28.21 | 28.20 | 28.20 |
| Velocity, ft/sec | (Vs) | 59.4 | 42.1 | 48.6 | 50.0 |
| **VOLUMETRIC FLOW RATE** | | | | | |
| At Stack Conditions, acfm | (Qa) | 1,328,413 | 941,409 | 1,087,467 | 1,119,096 |
| At Standard Conditions, scfm | (Qsw) | 1,040,947 | 759,166 | 864,627 | 888,247 |
| At Standard Conditions, dscfm | (Qs) | 943,297 | 692,302 | 786,705 | 807,435 |

# Method 1 Data

Location: Consumers Energy Company - Covert, MI
Source: EU-Turbine 1 (Unit 1) - Method 5
Project No.: 2024-3845
Date: 07/29/24

## Stack Parameters

| | | |
|---|---|---|
| Duct Orientation: | Vertical | |
| Duct Design: | Circular | |
| Distance from Far Wall to Outside of Port: | 273.50 | in |
| Nipple Length: | 12.00 | in |
| Depth of Duct: | 261.50 | in |
| Cross Sectional Area of Duct: | 372.97 | $ft^2$ |
| No. of Test Ports: | 4 | |
| Distance A: | 20.0 | ft |
| Distance A Duct Diameters: | 0.9 | (must be ≥ 0.5) |
| Distance B: | 74.0 | ft |
| Distance B Duct Diameters: | 3.4 | (must be ≥ 2) |
| Minimum Number of Traverse Points: | 24 | |
| Actual Number of Traverse Points: | 24 | |
| Number of Readings per Point: | 1 | |
| Measurer (Initial and Date): | JWH | |
| Reviewer (Initial and Date): | SAB | |




## CIRCULAR DUCT

**LOCATION OF TRAVERSE POINTS**

*Number of traverse points on a diameter*

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14.6 | -- | 6.7 | -- | 4.4 | -- | 3.2 | -- | 2.6 | -- | 2.1 |
| 2 | 85.4 | -- | 25.0 | -- | 14.6 | -- | 10.5 | -- | 8.2 | -- | 6.7 |
| 3 | -- | -- | 75.0 | -- | 29.6 | -- | 19.4 | -- | 14.6 | -- | 11.8 |
| 4 | -- | -- | 93.3 | -- | 70.4 | -- | 32.3 | -- | 22.6 | -- | 17.7 |
| 5 | -- | -- | -- | -- | 85.4 | -- | 67.7 | -- | 34.2 | -- | 25.0 |
| 6 | -- | -- | -- | -- | 95.6 | -- | 80.6 | -- | 65.8 | -- | 35.6 |
| 7 | -- | -- | -- | -- | -- | -- | 89.5 | -- | 77.4 | -- | 64.4 |
| 8 | -- | -- | -- | -- | -- | -- | 96.8 | -- | 85.4 | -- | 75.0 |
| 9 | -- | -- | -- | -- | -- | -- | -- | -- | 91.8 | -- | 82.3 |
| 10 | -- | -- | -- | -- | -- | -- | -- | -- | 97.4 | -- | 88.2 |
| 11 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 93.3 |
| 12 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 97.9 |

**Percent of stack diameter from inside wall to traverse point.*

| Traverse Point | % of Diameter | Distance from inside wall | Distance from outside of port |
|---|---|---|---|
| 1 | 2.1 | 5.49 | 17 1/2 |
| 2 | 6.7 | 17.52 | 29 1/2 |
| 3 | 11.8 | 30.86 | 42 7/8 |
| 4 | 17.7 | 46.29 | 58 5/16 |
| 5 | 25.0 | 65.38 | 77 3/8 |
| 6 | 35.6 | 93.09 | 105 1/8 |
| 7 | -- | -- | -- |
| 8 | -- | -- | -- |
| 9 | -- | -- | -- |
| 10 | -- | -- | -- |
| 11 | -- | -- | -- |
| 12 | -- | -- | -- |

Stack Diagram
A = 20 ft.
B = 74 ft.
Depth of Duct = 261.5 in.

Cross Sectional Area