1.0 Introduction

Alliance Source Testing, LLC (AST) was retained by GM Components Holdings, LLC (GMCH) (SRN No. A2620) to conduct compliance testing at the Wyoming, Michigan facility. The facility operates under Michigan Department of Environment, Great Lakes, and Energy (EGLE) – Air Quality Division (AQD) Permit To Install (PTI) No. 85-19B. Testing was conducted to determine the emission rate of non-methane volatile organic compounds (NMVOC) at the exhaust of Heat Treat Furnace No. 7 (EUHEATTREAT7).

PTI 85-19B issued by EGLE-AQD requires testing per special condition V.1 within 180 days of trial operation to verify the VOC emission rate of the furnace. The results of this test event have been used to develop a VOC emission factor (lb VOC/million cubic feet of natural gas usage) for the source.

1.1 Process/Control System Descriptions

GMCH operates a newly installed heat treat furnace. Heat Treat Furnace No. 7 is a continuous 700 lb/hr natural gas-fired carbonitriding heat treat furnace with oil quench. The furnace has no add-on pollution control equipment.

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1.2 Project Team

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

Table 1-1
Project Team

GM Facility Personnel	Annette Wendland
GM Corporate Support	Karen Carlson
Regulatory Personnel	Dave Patterson Adam Schaffer
AST Personnel	Justin Bernard Donald Burkey

1.3 Site Specific Test Plan & Notification

Testing was conducted in accordance with the Site Specific Test Plan (SSTP) submitted to the EGLE-AQD on June 15, 2020 and EGLE-AQD protocol review letter dated August 7, 2020.

2.0 Summary of Results

AST conducted compliance testing at the GMCH facility in Wyoming, Michigan on August 26, 2020. Testing consisted of determining the initial emission rate and emission factor of VOC at the exhaust of EUHEATTREAT7.

Table 2-1 provides a summary of the emission testing results. This table also provides a summary of the process operating and control system data collected during testing. Any difference between the summary results listed in the following table and the detailed results contained in appendices is due to rounding for presentation.

Table 2-1
Summary of Results

Emissions Data				
Run Number	**Run 1**	**Run 2**	**Run 3**	**Average**
Date	**8/26/20**	**8/26/20**	**8/26/20**	**--**
Non-Methane Volatile Organic Compounds Data				
Concentration, ppmvd	13.9	13.7	15.2	14.3
Emission Rate, lb/hr	0.66	0.65	0.71	0.67
Emission Factor, lb/MMscf	409.8	385.1	446.3	413.7
Process Operating / Control System Data				
Run Number	**Run 1**	**Run 2**	**Run 3**	**Average**
Date	**8/26/20**	**8/26/20**	**8/26/20**	**--**
Natural Gas Usage, scfh	1,600	1,700	1,600	1,633
Endo Gas Usage, scfh	2,197	2,197	2,198	2,198
Ammonia Usage, scfh	57	57	57	57
Enriching Gas Usage, scfh	110	110	110	110
Furnace Operating Temperature 1, °F	1,649	1,649	1,649	1,649
Furnace Operating Temperature 2, °F	1,650	1,650	1,650	1,650
Furnace Operating Temperature 3, °F	1,627	1,627	1,627	1,627
Quench Oil Operating Temperature, °F	124	122	124	123

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 & 2	Full Velocity Traverses
Oxygen/Carbon Dioxide	3A	Instrumental Analysis
Moisture Content	4	Volumetric / Gravimetric Analysis
Non-Methane Volatile Organic Compounds	18, 25A	Instrumental Analysis
Gas Dilution System Certification	205	---

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 1-2 in U.S. EPA Reference Test Method 1.

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 before and after each test run. The data collected before and after each test run was averaged. The averages 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 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 3A. Data was collected online and reported in one-minute averages. The sampling system consisted of a stainless-steel probe, heated Teflon sample line(s), gas conditioning system and the identified gas analyzer. The gas conditioning system was a non-contact condenser used to remove moisture from the stack gas. The quality control measures are described in Section 3.6.

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

The stack gas moisture content 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. Post testing, the quantities of water and silica gel were measured to determine the amount of moisture condensed during the test run. Alternatively, 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 18 and 25A – Non-Methane Volatile Organic Compounds

The non-methane volatile organic compounds (NMVOC) testing was conducted in accordance with U.S. EPA Reference Test Methods 25A and 18. The sampling system consisted of a stainless-steel probe, heated Teflon sample line(s) and the identified gas analyzer. Total hydrocarbon data was collected online and reported in one-minute averages. The quality control measures are described in Section 3.7.

Methane concentration was determined by integrated Tedlar bag sampling and offsite lab analysis using U.S. EPA Reference Test Method 18. The average methane concentration was subtracted from the average total hydrocarbon concentration to provide a non-methane VOC concentration.

3.5 U.S. EPA Reference Test Method 205 – Gas Dilution System Certification

A calibration gas dilution system field check was conducted in accordance with U.S. EPA Reference Method 205. Multiple dilution rates and total gas flow rates were utilized to force the dilution system to perform two dilutions on each mass flow controller. The diluted calibration gases were sent directly to the analyzer, and the analyzer response recorded in an electronic field data sheet. The analyzer response agreed within 2% of the actual diluted gas concentration. A second Protocol 1 calibration gas, with a cylinder concentration within 10% of one of the gas divider settings described above, was introduced directly to the analyzer, and the analyzer response recorded in an electronic field data sheet. The cylinder concentration and the analyzer response agreed within 2%. These steps were repeated three (3) times. Copies of the Method 205 data can be found in the Quality Assurance/Quality Control Appendix.

3.6 Quality Assurance/Quality Control – U.S. EPA Reference Test Method 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 percent of the Calibration Span or 0.5 ppmv absolute difference.

High or Mid Level gas (whichever was closer to the stack gas concentration) was introduced at the probe and the time required for the analyzer reading to reach 95 percent or 0.5 ppm (whichever was less restrictive) of the gas concentration was recorded. The analyzer reading was observed until it reached a stable value, and this value was recorded. Next, Low Level gas was introduced at the probe and the time required for the analyzer reading to decrease to a value within 5.0 percent or 0.5 ppm (whichever was less restrictive) was recorded. If the Low-Level gas was zero gas, the response was 0.5 ppm or 5.0 percent of the upscale gas concentration (whichever was less restrictive). The analyzer reading was observed until it reached a stable value and this value was recorded. The measurement system response time and initial system bias were determined from these data. The System Bias was within 5.0 percent of the Calibration Span or 0.5 ppmv absolute difference.

High or Mid Level gas (whichever was closer to the stack gas concentration) was introduced at the probe. After the analyzer response was stable, the value was recorded. Next, Low Level gas was introduced at the probe, and the analyzer value recorded once it reached a stable response. The System Bias was within 5.0 percent of the Calibration Span or 0.5 ppmv absolute difference or the data was invalidated and the Calibration Error Test and System Bias were repeated.

Drift between pre- and post-run System Bias was within 3% of the Calibration Span or 0.5 ppmv absolute difference. If the drift exceeded 3% or 0.5 ppmv, the Calibration Error Test and System Bias were repeated.

To determine the number of sampling points, a gas stratification check was conducted prior to initiating testing. The pollutant concentrations were measured at three points (16.7, 50.0 and 83.3 percent of the measurement line). Each traverse point was sampled for a minimum of twice the system response time. The pollutant concentration at each traverse point did not differ more than 5% or 0.5 ppm (whichever was less restrictive) of the average pollutant concentration. Therefore, single point sampling was conducted during the test runs. Copies of stratification check data can be found in the Quality Assurance/Quality Control Appendix.

A Data Acquisition System with battery backup was used to record the instrument response in one (1) minute averages. The data was continuously stored as a *.CSV file in Excel format on the hard drive of a computer. At the completion of testing, the data was also saved to the AST server. All data was reviewed by the Field Team Leader before leaving the facility. Once arriving at AST's office, all written and electronic data was relinquished to the report coordinator and then a final review was performed by the Project Manager.

3.7 Quality Assurance/Quality Control – U.S. EPA Reference Test Method 25A

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.

Within two (2) hours prior to testing, zero gas was introduced through the sampling system to the analyzer. After adjusting the analyzer to the Zero gas concentration and once the analyzer reading was stable, the analyzer value was recorded. This process was repeated for the High-Level gas, and the time required for the analyzer reading to reach 95 percent of the gas concentration was recorded to determine the response time. Next, Low and Mid-Level gases were introduced through the sampling system to the analyzer, and the response was recorded when it was stable. All values were less than +/- 5 percent of the calibration gas concentrations.

Mid Level gas was introduced through the sampling system. After the analyzer response was stable, the value was recorded. Next, Zero gas was introduced through the sampling system, and the analyzer value recorded once it reached a stable response. The Analyzer Drift was less than +/- 3 percent of the span value.

A Data Acquisition System with battery backup was used to record the instrument response in one (1) minute averages. The data was continuously stored as a *.CSV file in Excel format on the hard drive of a computer. At the completion of testing, the data was also saved to the AST server. All data was reviewed by the Field Team Leader before leaving the facility. Once arriving at AST's office, all written and electronic data was relinquished to the report coordinator and then a final review was performed by the Project Manager.

Alliance
SOURCE TESTING

Location	**GM Components Holding, LLC**
Source	**Heat Treat Furnace No. 7**
Project No.	**2020-1033**
Run No.	**1**
Parameter(s)	**VFR**

Meter Pressure (Pm), in. Hg

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

where,

Pb	29.40	= barometric pressure, in. Hg
ΔH	1.000	= pressure differential of orifice, in H_2O
Pm	29.47	= in. Hg

Absolute Stack Gas Pressure (Ps), in. Hg

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

where,

Pb	29.40	= barometric pressure, in. Hg
Pg	-0.24	= static pressure, in. H_2O
Ps	29.38	= in. Hg

Standard Meter Volume (Vmstd), dscf

$$Vmstd = \frac{17.647 \times Vm \times Pm}{Tm}$$

where,

Y	0.973	= meter correction factor
Vm	34.593	= meter volume, cf
Pm	29.47	= absolute meter pressure, in. Hg
Tm	539.4	= absolute meter temperature, °R
Vmstd	32.457	= dscf

Standard Wet Volume (Vwstd), scf

$$Vwstd = 0.04707 \times Vlc$$

where,

Vlc	16.3	= volume of H2O collected, ml
Vwstd	0.769	= scf

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

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

where,

Ts	204.7	= stack temperature, °F
Ps	29.4	= absolute stack gas pressure, in. Hg
BWSsat	0.9	= dimensionless

Moisture Fraction (BWS), dimensionless

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

where,

Vwstd	0.769	= standard wet volume, scf
Vmstd	32.457	= standard meter volume, dscf
BWS	0.023	= dimensionless

Alliance SOURCE TESTING

Location	**GM Components Holding, LLC**
Source	**Heat Treat Furnace No. 7**
Project No.	**2020-1033**
Run No.	**1**
Parameter(s)	**VFR**

Moisture Fraction (BWS), dimensionless

$$BWS = BWSmsd \ unless \ BWSsat < BWSmsd$$

where,

BWSsat	0.866	= moisture fraction (theoretical at saturated conditions)
BWSmsd	0.023	= moisture fraction (measured)
BWS	0.023	

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

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

where,

CO2	0.6	= carbon dioxide concentration, %
O2	20.1	= oxygen concentration, %
Md	28.90	= lb/lb mol

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

$$Ms = Md\ (1 - BWS) + 18\ (BWS)$$

where,

Md	28.90	= molecular weight (DRY), lb/lb mol
BWS	0.023	= moisture fraction, dimensionless
Ms	28.65	= lb/lb mol

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	0.84	= pitot tube coefficient
$\Delta P^{1/2}$	0.572	= average pre/post test velocity head of stack gas, $(in.\ H2O)^{1/2}$
Ts	664.7	= average pre/post test absolute stack temperature, °R
Ps	29.38	= absolute stack gas pressure, in. Hg
Ms	28.65	= molecular weight of stack gas, lb/lb mol
Vs	36.5	= ft/sec

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

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

where,

Vs	36.5	= stack gas velocity, ft/sec
As	4.12	= cross-sectional area of stack, ft^2
Qa	9,039	= acfm

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

$$Qsd = 17.647 \times Qa \times (1 - BWS) \times \frac{Ps}{Ts}$$

where,

Qa	9,039	= average stack gas flow at stack conditions, acfm
BWS	0.023	= moisture fraction, dimensionless
Ps	29.38	= absolute stack gas pressure, in. Hg
Ts	664.7	= average pre/post test absolute stack temperature, °R
Qs	6,888	= dscfm

Alliance
SOURCE TESTING

Location	**GM Components Holding, LLC**
Source	**Heat Treat Furnace No. 7**
Project No.	**2020-1033**
Run No.	**1**
Parameter(s)	**VFR**

Dry Gas Meter Calibration Check (Yqa), dimensionless

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

where,

Y	0.973	= meter correction factor, dimensionless
Θ	60	= run time, min.
Vm	34.593	= total meter volume, dcf
Tm	539.4	= absolute meter temperature, °R
ΔH@	1.842	= orifice meter calibration coefficient, in. H_2O
Pb	29.40	= barometric pressure, in. Hg
ΔH avg	1.000	= average pressure differential of orifice, in H_2O
Md	28.90	= molecular weight (DRY), lb/lb mol
$(\Delta H)^{1/2}$	1.000	= average squareroot pressure differential of orifice, $(in. H_2O)^{1/2}$
Yqa	-0.5	= dimensionless

Location: GM Components Holding, LLC
Source: Heat Treat Furnace No. 7
Project No.: 2020-1033
Run No. /Method Run 1 / Method 25A

THC - Outlet Concentration (C_{THC}), ppmvd

$$C_{THC} = \frac{C_{THCw}}{1 - BWS}$$

where,

C_{THCw}	19.0	= THC - Outlet Concentration, ppmvw
BWS	0.023	= moisture fraction, unitless
C_{THC}	19.4	= ppmvd

CH4 as C3H8 - Outlet Concentration ($C_{CH4\ as\ C3H8}$), ppmvd

$$C_{CH4\ as\ C3H8} = \frac{C_{CH4}}{3}$$

where,

C_{CH4}	16.7	= CH4 - Outlet Concentration, ppmvd
$C_{CH4\ as\ C3H8}$	5.6	= ppmvd

NMHC - Outlet Concentration (C_{NMHC}), ppmvd

$$C_{THC} = C_{THC} - C_{CH4}$$

where,

C_{THC}	19.4	= THC - Outlet Concentration, ppmvd
C_{CH4}	5.57	= CH4 - Outlet Concentration, ppmvd
C_{NMHC}	13.9	= ppmvd

NMHC - Outlet Emission Rate (ER_{NMHC}), lb/hr

$$ER_{NMHC} = \frac{C_{NMHC} \times MW \times Qs \times 60\ \frac{min}{hr} \times 28.32\ \frac{L}{ft^3}}{24.04\ \frac{L}{g-mole} \times 1.0E06 \times 454\frac{g}{lb}}$$

where,

C_{NMHC}	13.9	= NMHC - Outlet Concentration, ppmvd
MW	44.1	= NMHC molecular weight, g/g-mole
Qs	6,888	= stack gas volumetric flow rate at standard conditic
ER_{NMHC}	0.66	= lb/hr

NMHC - Outlet Emission Factor ($EF_{NMHCPPT}$), lb/MMscf

$$EF_{NMHC} = \frac{ER_{NMHC}}{FR} \times 1{,}000{,}000$$

where,

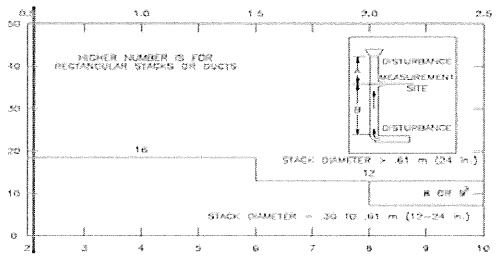
ER_{NMHC}	0.66	= NMHC - Outlet Emission Rate, lb/hr
FR	1,600	= Fuel Rate, scf/hr
EF_{NMHC}	409.8	= lb/MMscf

Method 1 Data

Location GM Components Holding, LLC
Source Heat Treat Furnace No. 7
Project No. 2020-1033
Date: 08/25/20

Stack Parameters

Duct Orientation:	Vertical	
Duct Design:	Circular	
Distance from Far Wall to Outside of Port:	30.50	in
Nipple Length:	3.00	in
Depth of Duct:	27.50	in
Cross Sectional Area of Duct:	4.12	ft^2
No. of Test Ports:	2	
Number of Readings per Point:	1	
Distance A:	9.5	ft
Distance A Duct Diameters:	4.1	(must be > 0.5)
Distance B:	4.8	ft
Distance B Duct Diameters:	2.1	(must be > 2)
Minimum Number of Traverse Points:	16	
Actual Number of Traverse Points:	16	
Measurer (Initial and Date):	DDB 8/25	
Reviewer (Initial and Date):	JJB 8/25	



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LOCATION OF TRAVERSE POINTS

Number of traverse points on a diameter

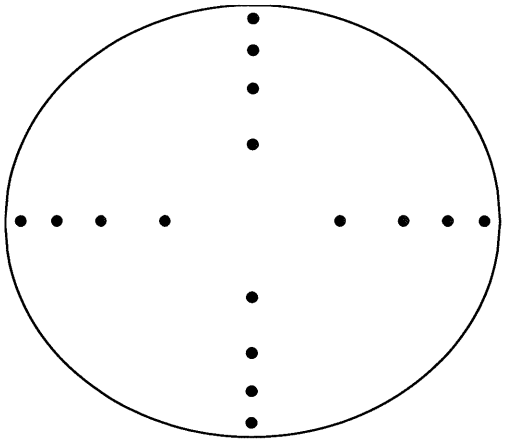
	2	3	4	5	6	7	8	9	10	11	12
1	14.6	--	6.7	--	4.4	--	3.2	--	2.6	--	2.1
2	85.4	--	25.0	--	14.6	--	10.5	--	8.2	--	6.7
3	--	--	75.0	--	29.6	--	19.4	--	14.6	--	11.8
4	--	--	93.3	--	70.4	--	32.3	--	22.6	--	17.7
5	--	--	--	--	85.4	--	67.7	--	34.2	--	25.0
6	--	--	--	--	95.6	--	80.6	--	65.8	--	35.6
7	--	--	--	--	--	--	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

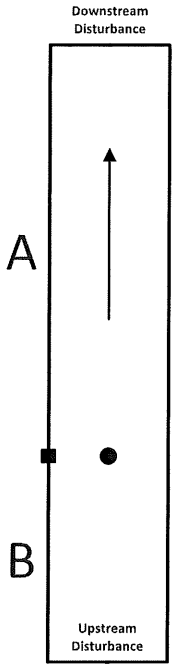
**Percent of stack diameter from inside wall to traverse point.*

Traverse Point	% of Diameter	Distance from inside wall	Distance from outside of port
1	3.2	1.00	4.00
2	10.5	2.89	5.89
3	19.4	5.34	8.34
4	32.3	8.88	11.88
5	67.7	18.62	21.62
6	80.6	22.17	25.17
7	89.5	24.61	27.61
8	96.8	26.50	29.50
9	--	--	--
10	--	--	--
11	--	--	--
12	--	--	--

Stack Diagram
A = 9.5 ft.
B = 4.75 ft.
Depth of Duct = 27.5 in.

Cross Sectional Area





Alliance SOURCE TESTING

Cyclonic Flow Check

Location GM Components Holding, LLC
Source Heat Treat Furnace No. 7
Project No. 2020-1033
Date 8/25/20

Sample Point	Angle (ΔP=0)
1	5
2	3
3	3
4	2
5	2
6	0
7	2
8	4
9	3
10	3
11	2
12	0
13	0
14	1
15	1
16	3
Average	2.1

Location GM Components Holding, LLC
Source Heat Treat Furnace No. 7
Project No. 2020-1033

Run Number		Run 1	Run 2	Run 3	Average
Date		8/26/20	8/26/20	8/26/20	--
Start Time		8:10	10:40	11:57	--
Stop Time		9:10	11:40	12:57	--
Source Data					
Natural Gas Usage, scf/hr	FR	1,600	1,700	1,600	1,633
Ambient Temperature	T_{Amb}	70	73	83	75
Realtive Humidity, %	RH	79	75	61	72
Barometric Pressure, in. Hg	Pb	29.4	29.4	29.3	29.4
Input Data - Outlet					
Moisture Fraction, dimensionless	BWS	0.023	0.025	0.025	0.024
Volumetric Flow Rate (M1-4), dscfm	Qs	6,888	6,942	6,840	6,890
Calculated Data - Outlet					
O_2 Concentration, % dry	C_{O_2}	20.1	20.1	20.2	20.1
CO_2 Concentration, % dry	C_{CO_2}	0.6	0.6	0.6	0.6
THC (as C3H8) Concentration, ppmvd	C_{THC}	19.4	19.6	20.8	20.0
THC (as C3H8) Concentration, ppmvw	$C_{THC\ w}$	19.0	19.1	20.3	19.5
CH4 Concentration, ppmvd	C_{CH4}	16.71	17.59	16.93	17.08
CH4 Concentration (as C3H8), ppmvd	$C_{CH4\ as\ propane}$	5.6	5.9	5.6	5.7
NMHC (as C3H8) Concentration, ppmvd	C_{NMHC}	13.9	13.7	15.2	14.3
NMHC (as C3H8) Emission Rate, lb/hr	ER_{NMHC}	0.66	0.65	0.71	0.67
NMHC (as C3H8) Emission Factor, lb/MMscf	EF_{NMHC}	409.8	385.1	446.3	413.7