

1.0 Introduction

Alliance Source Testing, LLC (AST) was retained by Panhandle Eastern Pipe Line (PEPL) to conduct compliance testing at the Howell, Michigan facility. Portions of the facility are subject to provisions of the 40 CFR Part 63 – National Emission Standards for Hazardous Air Pollutants from Natural Gas Storage facilities and the Michigan Department of Environmental, Great Lakes and Energy (EGLE) Air Permit No. PTI 72-20. Testing was conducted to determine the emission rate of benzene, toluene, ethylbenzene and xylene (BTEX) at the exhaust of one (1) Dehydration Unit. Testing also included volatile organic compound (VOC) leak detection and repair (LDAR) monitoring on the dehydration unit and contactor adsorber tower.

1.1 Source and Control System Description

The Howell Compressor Station is a natural gas gathering station where compressors and related auxiliary equipment are used for the agglomeration of natural gas in the production region

1.2 Project Team

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

**Table 1-1
Project Team**

Facility Personnel	Kristin Bollerman – PELP Scott Dibert – PELP
Regulatory Personnel	Mark Dziadosz – EGLE
AST Personnel	Tyler Branca Anthony Delfratte

1.3 Test Protocol & Notification

Testing was conducted in accordance with the test protocol submitted to EGLE by PEPL.

Summary of Results

2.0 Summary of Results

AST conducted compliance testing at the PELP facility in Howell, Michigan on December 16, 2021. Testing consisted of determining the emission rate of BTEX at the exhaust of one (1) Dehydration Unit. LDAR monitoring was also conducted on the contactor absorber tower and dehydration unit.

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

**Table 2-1
Summary of Results - BTEX**

Run Number	Run 1	Run 2	Run 3	Average
Date	12/16/21	12/16/21	12/16/21	--
Benzene Data *				
Emission Rate, lb/hr	9.1E-05	9.9E-05	9.0E-05	9.3E-05
Emission Rate, kg/hr	4.1E-05	4.5E-05	4.1E-05	4.2E-05
Toluene Data *				
Emission Rate, lb/hr	8.3E-05	9.0E-05	8.2E-05	8.5E-05
Emission Rate, kg/hr	3.8E-05	4.1E-05	3.7E-05	3.8E-05
Ethylbenzene Data *				
Emission Rate, lb/hr	8.61E-05	9.32E-05	8.48E-05	8.81E-05
Emission Rate, kg/hr	3.91E-05	4.23E-05	3.85E-05	3.99E-05
Xylene Data *				
Emission Rate, lb/hr	2.5E-04	2.7E-04	2.4E-04	2.5E-04
Emission Rate, kg/hr	1.1E-04	1.2E-04	1.1E-04	1.1E-04
Process Operating Data				
Combustion Zone Temperature, °F	917.2	904.1	905.4	908.9
Reboiler Temperature, °F	384.0	384.1	385.0	384.4
Fuel Flow, MMSCF	65	52	51	56

*All laboratory results were below the laboratory detection limits. The detection limits were used for calculations purposes.

**Table 2-2
Summary of Results – LDAR**

Component Location at Facility	Component No.	Component Description	Identified leak(s) location details	Comments
Contactora Absorber Tower	LIT 100	Level transmitter/gauge	No	Upper tap out Lower tap out Highpoint vent Drain valve
Contactora Absorber Tower	LC 100	NA	No	Upper tap out Lower tap out Highpoint vent Drain valve
Contactora Absorber Tower	NA	Lower manway	No	Large Flange
Contactora Absorber Tower	NA	Upper manway	No	Large Flange
Contactora Absorber Tower	PSV 100	Pressure surge valve	No	NA
Contactora Absorber Tower	NA	Vapor to BTEX	No	NA
Contactora Absorber Tower	NA	BTEX offgas to burner	No	NA
Dehydration Unit	LC 201	Level control displacer	No	Upper tap out Lower tap out Drain valve
Dehydration Unit	LG 201	Level site glass	No	Upper tap out Lower tap out Highpoint vent Drain valve
Dehydration Unit	PSV 201	Pressure relief valve	No	Isolation Vent
Dehydration Unit	LIT 201	NA	No	Upper tap out Lower tap out
Dehydration Unit	LG 200	NA	No	Upper tap out Lower tap out Drain valve Highpoint vent
Dehydration Unit	NA	Fuel gas supply assembly	No	9 valves
Dehydration Unit	NA	Fuel gas control assembly	No	4 valves

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	1-2	Full Velocity Traverses
Oxygen/Carbon Dioxide	3/3A	Instrumental Analysis
Moisture Content	4	Gravimetric Analysis
Benzene, Toluene, Ethylbenzene & Xylene	18	Constant Rate Sampling
LDAR (Positive Pressure Sources)	21	Portable FID – Photovac MicroFID

3.1 U.S. EPA Reference Test Methods 1-2 – 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 during each test run. The data collected was 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 (O₂) and carbon dioxide (CO₂) 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, 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. If an unheated Teflon sample line was used, then a portable non-contact condenser was placed in the system directly after the probe. Otherwise, a heated Teflon sample line was used. 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. 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 Method 18 – BTEX

The BTEX testing was conducted in accordance with U.S. EPA Reference Test Method 18. The gas was withdrawn at a constant rate through a stainless probe, Teflon tubing, chilled midget impinger (moisture knockout), absorbent tubes, rotometer, critical orifice, and pump.

Two (2) identical sample trains, one labeled as spiked and one as unspiked, were used at each sampling location. The first tube in the spiked train was spiked with a known mass of BTEX prior to testing. The midget impinger and both tubes in the unspiked train were unspiked. The sampling system was pretest leak checked using the rotometer to verify the absence of flow. Three (3) spiked sample train were collected concurrently with the all three (3) of the un-spiked sample trains during each run to meet the method QA/QC requirements as U.S. EPA Reference test Method 18 Section 8.4.3. No posttest leak check is permitted for Method 18 adsorbent tubes. The sampling meter was also pre and post calibrated using a Dry-Cal flow meter.

Following the completion of each test run, the contents of the first and second impingers were measured and placed in a sample vial labelled as container 1. The first and second midget impingers and the connecting glassware were rinsed with DI water, and these rinses were added to the vial with zero headspace. Immediately following the recovery, container 1 was placed on ice. The contents of container 1 were analyzed for BTEX. The two-section silica gel tube will be capped and labeled as tube 1 and placed on ice for shipment to the laboratory. The contents of the two-section silica gel tube were analyzed separately for breakthrough determination. The spiked sample train was recovered with the procedures described above. All the samples were kept on ice, sealed, zero-head spaced, labeled and shipped to the identified laboratory for analysis. Upon receiving the samples, the analytical lab analyzed them using gas chromatography / flame ionization detector (GC/FID) following the analytical procedures outlined in U.S. EPA Reference Test Method 18. The quality control measures are described in Section 3.7.

3.5 U.S. EPA Reference Test Method 21 – Positive Pressure Sources

Leaks from any positive pressure sources were determined using U.S. EPA Reference Test Method 21. The VOC detector was a Photovac MicroFID portable analyzer with a flame ionization detector. The instrument was calibrated prior to testing with ambient air and methane balanced air cylinder gas. The methane calibration gas concentration was approximately equal to the applicable leak definition (500 ppm as methane). Each source was evaluated by moving the instrument inlet probe along the potential leak area of each component. If a leak was detected, the area of leakage was monitored for two (2) times the instrument response time and the highest instrument reading recorded. If the instrument reading minus the background concentration was greater than the leak definition, then the source was considered leaking.

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% 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% (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% (whichever was less restrictive) was recorded. If the Low-Level gas was zero gas, the response was 0.5% 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% 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% 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 percent of the Calibration Span or 0.5% absolute difference. If the drift exceeded 3 percent or 0.5%, 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.

If the pollutant concentration at each traverse point did not differ more than 5 percent or 0.3% (whichever was less restrictive) of the average pollutant concentration, then single point sampling was conducted during the test runs. If the pollutant concentration did not meet these specifications but differed less than 10 percent or 0.5% from the average concentration, then three (3) point sampling was conducted (stacks less than 7.8 feet in diameter - 16.7, 50.0 and 83.3 percent of the measurement line; stacks greater than 7.8 feet in diameter - 0.4, 1.0, and 2.0 meters from the stack wall). If the pollutant concentration differed by more than 10 percent or 0.5% from the average concentration, then sampling was conducted at a minimum of twelve (12) traverse points. 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 18

A leak check before each sampling run was performed. The probe inlet was plugged, and a sample pump was turned on to pull a vacuum of at least 10-inch Hg or the highest vacuum experienced during the sampling run. A leakage rate in excess of 2 percent of the average sampling is acceptable. After the completion of the leak check, the probe inlet plug was released carefully before turning off the sample pump.

Initial dry gas meter reading and barometric pressure were recorded before starting each sampling run. The sampling began with the tip of the nozzle/probe assembly positioned close to the centroid of exhaust stack. Once the sample pump is started the sample flow was adjusted to a constant flow rate approximately 400 cc/min. The midget

impinger train was kept cold to maintain the temperature of the gases leaving the last impinger at 68°F or less. After the completion of the sampling run a posttest leak check was not performed.

BTEX spike recovery was checked using the procedures outlined in U.S. EPA Method 18 Section 8.4.3. During all three of the sampling runs, two identical trains were setup and collected, with one of the trains spiked with a known concentration of BTEX. The known concentration was targeted between 40 to 60 percent of the mass expected to be collected in the native/unspiked sample train. The spiked samples were transported to the laboratory with all the other unspiked/native samples and analyzed following the procedures outlined in U.S. EPA Method 18 Section 11.0. The impinger contents and absorbents from the two trains were analyzed utilizing identical analytical procedures and instrumentation. The fraction of spiked BTEX recovered was determined by combining the amount recovered in the impinger and in the absorbent tube, using equations in U.S. EPA Method 18 Section 12.9. Recovery values for all the spiked samples were between the method allowable criteria of 70 to 130 percent as stated in U.S. EPA Method 18 Section 8.4.3.

Appendix A

Location Energy Transfer - Howell, MI
 Source Dehydration Unit
 Project No. 2021-2950
 Run No. 1
 Parameter(s) VFR

Meter Pressure (Pm), in. Hg

$$P_m = P_b + \frac{\Delta H}{13.6}$$

where,

Pb $\frac{28.62}{}$ = barometric pressure, in. Hg
 ΔH $\frac{1.000}{}$ = pressure differential of orifice, in H₂O
 Pm $\frac{28.69}{}$ = in. Hg

Absolute Stack Gas Pressure (Ps), in. Hg

$$P_s = P_b + \frac{P_g}{13.6}$$

where,

Pb $\frac{28.62}{}$ = barometric pressure, in. Hg
 Pg $\frac{-0.28}{}$ = static pressure, in. H₂O
 Ps $\frac{28.60}{}$ = in. Hg

Standard Meter Volume (Vmstd), dscf

$$V_{mstd} = \frac{17.636 \times V_m \times P_m \times Y}{T_m}$$

where,

Y $\frac{1.029}{}$ = meter correction factor
 Vm $\frac{31.790}{}$ = meter volume, cf
 Pm $\frac{28.69}{}$ = absolute meter pressure, in. Hg
 Tm $\frac{521.5}{}$ = absolute meter temperature, °R
 Vmstd $\frac{31.741}{}$ = dscf

Standard Wet Volume (Vwstd), scf

$$V_{wstd} = 0.04716 \times V_{lc}$$

where,

Vlc $\frac{116.6}{}$ = Volume of H₂O collected, ml
 Vwstd $\frac{5.499}{}$ = scf

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

$$BWS_{sat} = 10^{0.37 \cdot \left(\frac{2,827}{T_s + 363} \right) - P_s}$$

where,

Ts $\frac{879.4}{}$ = stack temperature, °F
 Ps $\frac{28.6}{}$ = absolute stack gas pressure, in. Hg
 BWSsat $\frac{437.4}{}$ = dimensionless

Moisture Fraction (BWS), dimensionless

$$BWS = \frac{V_{wstd}}{(V_{wstd} + V_{mstd})}$$

where,

Vwstd $\frac{5.499}{}$ = standard wet volume, scf
 Vmstd $\frac{31.741}{}$ = standard meter volume, dscf
 BWS $\frac{0.148}{}$ = dimensionless

Moisture Fraction (BWS), dimensionless

$$BWS = BWS_{msd} \text{ unless } BWS_{sat} < BWS_{msd}$$

where,

BWSsat $\frac{437.373}{}$ = moisture fraction (theoretical at saturated conditions)
 BWSmsd $\frac{0.148}{}$ = moisture fraction (measured)
 BWS $\frac{0.148}{}$

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

$$M_d = (0.34 \times \% CO_2) + (0.22 \times \% O_2) + (0.28 \cdot (100 - \% CO_2 - \% O_2))$$

where,

CO₂ $\frac{10.1}{}$ = carbon dioxide concentration, %
 O₂ $\frac{3.5}{}$ = oxygen concentration, %
 Md $\frac{29.76}{}$ = lb/lb mol

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

$$M_s = M_d (1 - BWS) + 18.015 (BWS)$$

where,

Md $\frac{29.76}{}$ = molecular weight (DRY), lb/lb mol
 BWS $\frac{0.148}{}$ = moisture fraction, dimensionless
 Ms $\frac{28.03}{}$ = lb/lb mol

Location Energy Transfer - Howell, MI
 Source Dehydration Unit
 Project No. 2021-2950
 Run No. 1
 Parameter(s) VFR

Average Velocity (V_s), ft/sec

$$V_s = 85.49 \times C_p \times (\Delta P)^{1/2} \text{ avg} \times \sqrt{\frac{T_s}{P_s \times M_s}}$$

where,

C_p	0.84	= pitot tube coefficient
$\Delta P^{1/2}$	0.274	= average pre/post test velocity head of stack gas, (in. H ₂ O) ^{1/2}
T_s	1339.0	= average pre/post test absolute stack temperature, °R
P_s	28.60	= absolute stack gas pressure, in. Hg
M_s	28.03	= molecular weight of stack gas, lb/lb mol
V_s	25.5	= ft/sec

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

$$Q_a = 60 \times V_s \times A_s$$

where,

V_s	25.5	= stack gas velocity, ft/sec
A_s	0.66	= cross-sectional area of stack, ft ²
Q_a	1,008	= acfm

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

$$Q_{sd} = 17.636 \times Q_a \times (1 - BWS) \times \frac{P_s}{T_s}$$

where,

Q_a	1,008	= average stack gas flow at stack conditions, acfm
BWS	0.148	= moisture fraction, dimensionless
P_s	28.60	= absolute stack gas pressure, in. Hg
T_s	1339.0	= average pre/post test absolute stack temperature, °R
Q_s	324	= dscfm

Dry Gas Meter Calibration Check (Y_{qa}), dimensionless

$$Y_{qa} = \frac{\left(\frac{\Theta}{V_m} \sqrt{\frac{0.0319 \times P_m \times 29}{\Delta H @ \left(P_b - \frac{\Delta H \text{ avg}}{13.6} \right) \times M_d}} \sqrt{\Delta H} \text{ avg} \right)}{Y} \times 100$$

where,

Y	1.029	= meter correction factor, dimensionless
Θ	60	= run time, min.
V_m	31.79	= total meter volume, ccf
T_m	521.5	= absolute meter temperature, °R
$\Delta H @$	1.778	= orifice meter calibration coefficient, in. H ₂ O
P_b	28.62	= barometric pressure, in. Hg
$\Delta H \text{ avg}$	1.000	= average pressure differential of orifice, in. H ₂ O
M_d	29.76	= molecular weight (DRY), lb/lb mol
$(\Delta H)^{1/2}$	1.000	= average squareroot pressure differential of orifice, (in. H ₂ O) ^{1/2}
Y_{qa}	-3.4	= dimensionless

Appendix B



Location Energy Transfer - Howell, MI
Source Dehydration Unit
Project No. 2021-2950
Parameter(s): Benzene, Toluene, Ethylbenzene, Xylene (BTEX)

Run Number		Run 1	Run 2	Run 3	Average
Date		12/16/21	12/16/21	12/16/21	--
Start Time		10:25	12:17	14:24	--
Stop Time		11:25	13:17	15:24	--
Input Data					
Volumetric Flow Rate, dscfm	(Qs)	324	357	335	339
Moisture Fraction	(BWS)	0.148	0.148	0.147	0.148
Standard Meter Volume, L	(Vmstd)	32.381	32.975	33.995	33.117
Standard Meter Volume, ft ³	(Vmstd)	1.143	1.164	1.200	1.169
Lab Data					
Benzene Mass, ug	M(C6H6)	2.44	2.44	2.44	2.4
Toluene Mass, ug	M(C7H8)	2.21	2.21	2.21	2.2
Ethylbenzene Mass, ug	M(C8H10)	2.30	2.30	2.30	2.300
Xylene Mass, ug	M(C8H10)	6.58	6.58	6.58	6.58
Emissions Calculations					
Benzene Concentration, ppmvd	C(C6H6)	0.023	0.023	0.022	0.023
Benzene Emission Rate, lb/hr	ER(C6H6)	9.1E-05	9.9E-05	9.0E-05	9.3E-05
Benzene Emission Rate, kg/hr	ER(CH4)	4.1E-05	4.5E-05	4.1E-05	4.2E-05
Toluene Concentration, ppmvd	C(C7H8)	0.018	0.017	0.017	0.017
Toluene Emission Rate, lb/hr	ER(C2H6)	8.3E-05	9.0E-05	8.2E-05	8.5E-05
Toluene Emission Rate, kg/hr	ER(C2H6)	3.8E-05	4.1E-05	3.7E-05	3.8E-05
Ethylbenzene Concentration, ppmvd	C(C8H10)	0.016	0.016	0.015	0.016
Ethylbenzene Emission Rate, lb/hr	ER(C3H8)	8.61E-05	9.32E-05	8.48E-05	8.81E-05
Ethylbenzene Emission Rate, kg/hr	ER(C3H8)	3.91E-05	4.23E-05	3.85E-05	3.99E-05
Xylene Concentration, ppmvd	C(C8H10)	0.046	0.045	0.044	0.045
Xylene Emission Rate, lb/hr	ER(C4H10)	2.5E-04	2.7E-04	2.4E-04	2.5E-04
Xylene Emission Rate, kg/hr	ER(C4H10)	1.1E-04	1.2E-04	1.1E-04	1.1E-04

Location Energy Transfer - Howell, MI
 Source Dehydration Unit
 Project No. 2021-2950

Run Number		Run 1	Run 2	Run 3	Average
Date		12/16/21	12/16/21	12/16/21	--
Start Time		10:25	12:17	14:24	--
Stop Time		11:25	13:17	15:24	--
Calculated Data - Outlet					
O ₂ Concentration, % dry	C _{O₂}	3.52	4.26	3.51	3.76
CO ₂ Concentration, % dry	C _{CO₂}	10.13	9.77	10.25	10.05

Location: Energy Transfer - Howell, MI
 Source: Dehydration Unit
 Project No.: 2021-2950
 Date: 12/16/21

Time Unit Status	O ₂ - Outlet % dry Valid	CO ₂ - Outlet % dry Valid
10:25	13.09	4.51
10:26	3.98	9.98
10:27	4.78	9.46
10:28	4.91	9.48
10:29	6.55	8.53
10:30	14.35	3.86
10:31	20.59	0.21
10:32	15.45	3.18
10:33	5.46	9.10
10:34	3.69	10.20
10:35	3.47	10.18
10:36	3.99	9.90
10:37	4.02	9.88
10:38	3.79	10.00
10:39	4.58	9.57
10:40	4.01	9.90
10:41	3.89	9.97
10:42	3.30	10.24
10:43	2.90	10.55
10:44	2.12	10.96
10:45	1.27	11.50
10:46	1.53	11.41
10:47	2.22	10.95
10:48	2.18	10.97
10:49	1.49	11.31
10:50	2.56	10.82
10:51	1.35	11.35
10:52	0.60	11.75
10:53	1.66	11.27
10:54	2.20	10.92
10:55	0.87	11.64
10:56	0.39	11.75
10:57	0.68	11.62
10:58	0.93	11.60
10:59	1.03	11.51
11:00	0.77	11.71
11:01	0.93	11.64
11:02	0.48	11.67
11:03	0.44	11.72
11:04	0.69	11.65
11:05	2.00	11.00
11:06	1.42	11.29
11:07	0.81	11.70
11:08	1.64	11.27
11:09	0.86	11.63
11:10	1.45	11.33
11:11	1.04	11.48
11:12	0.93	11.58
11:13	0.48	11.74
11:14	2.07	10.98
11:15	1.46	11.44
11:16	1.62	11.24
11:17	1.67	11.25
11:18	2.08	10.97
11:19	2.56	10.81
11:20	6.46	8.44
11:21	7.92	7.52
11:22	7.37	7.93
11:23	7.03	8.06
11:24	6.89	8.15

Parameter	O ₂ - Outlet	CO ₂ - Outlet
Uncorrected Run Average (C _{obs})	3.5	10.1
Cal Gas Concentration (C _{MIA})	11.0	11.0
Pretest System Zero Response	0.00	0.00
Posttest System Zero Response	0.00	0.00
Average Zero Response (C ₀)	0.0	0.0
Pretest System Cal Response	10.98	11.03
Posttest System Cal Response	10.97	11.06
Average Cal Response (C _M)	11.0	11.0
Corrected Run Average (Corr)	3.5	10.1

Location: Energy Transfer - Howell, MI
 Source: Dehydration Unit
 Project No.: 2021-2950
 Date: 12/16/21

Time Unit Status	O ₂ - Outlet % dry Valid	CO ₂ - Outlet % dry Valid
12:17	3.44	10.20
12:18	3.50	10.27
12:19	4.09	9.83
12:20	4.93	9.37
12:21	4.46	9.65
12:22	5.30	9.13
12:23	4.48	9.65
12:24	3.89	10.00
12:25	3.71	10.08
12:26	3.45	10.19
12:27	4.33	9.72
12:28	4.08	9.79
12:29	4.65	9.44
12:30	3.72	10.07
12:31	3.71	10.05
12:32	3.74	10.12
12:33	3.99	9.88
12:34	5.10	9.24
12:35	4.44	9.71
12:36	4.29	9.74
12:37	4.31	9.83
12:38	4.93	9.39
12:39	5.37	9.10
12:40	4.42	9.77
12:41	3.67	10.06
12:42	4.36	9.69
12:43	3.12	10.47
12:44	3.27	10.42
12:45	3.30	10.37
12:46	4.75	9.52
12:47	6.80	8.27
12:48	6.07	8.67
12:49	4.44	9.63
12:50	4.34	9.81
12:51	3.92	9.93
12:52	4.02	9.91
12:53	3.98	9.99
12:54	5.37	9.07
12:55	4.90	9.42
12:56	4.43	9.54
12:57	3.34	10.29
12:58	3.21	10.44
12:59	3.20	10.35
13:00	3.51	10.22
13:01	3.74	10.13
13:02	3.93	9.94
13:03	5.79	8.79
13:04	5.59	9.05
13:05	4.71	9.45
13:06	4.02	9.87
13:07	3.61	10.14
13:08	3.73	10.05
13:09	4.85	9.39
13:10	4.22	9.82
13:11	3.47	10.30
13:12	3.79	10.13
13:13	4.39	9.74
13:14	5.18	9.16
13:15	3.93	9.94
13:16	3.79	10.13

Parameter	O ₂ - Outlet	CO ₂ - Outlet
Uncorrected Run Average (C _{obs})	4.3	9.8
Cal Gas Concentration (C _{MA})	11.0	11.0
Pretest System Zero Response	0.00	0.00
Posttest System Zero Response	0.00	0.02
Average Zero Response (C ₀)	0.0	0.0
Pretest System Cal Response	10.97	11.06
Posttest System Cal Response	10.96	11.02
Average Cal Response (C _N)	11.0	11.0
Corrected Run Average (Corr)	4.3	9.8

Location: Energy Transfer - Howell, MI
 Source: Dehydration Unit
 Project No.: 2021-2950
 Date: 12/16/21

Time Unit Status	O ₂ - Outlet % dry Valid	CO ₂ - Outlet % dry Valid
14:24	3.96	9.98
14:25	4.01	9.96
14:26	4.40	9.71
14:27	4.15	9.88
14:28	3.46	10.24
14:29	3.74	10.14
14:30	3.80	10.04
14:31	3.50	10.30
14:32	3.18	10.39
14:33	2.81	10.69
14:34	2.78	10.67
14:35	3.28	10.33
14:36	3.19	10.42
14:37	2.77	10.62
14:38	3.10	10.53
14:39	2.91	10.51
14:40	2.64	10.75
14:41	2.75	10.63
14:42	2.88	10.67
14:43	3.33	10.35
14:44	3.54	10.20
14:45	3.94	9.85
14:46	2.80	10.71
14:47	2.52	10.90
14:48	3.59	10.16
14:49	2.91	10.62
14:50	4.12	9.81
14:51	4.07	9.90
14:52	2.87	10.59
14:53	2.73	10.80
14:54	3.22	10.43
14:55	4.43	9.62
14:56	4.79	9.51
14:57	4.45	9.62
14:58	3.95	9.98
14:59	4.67	9.52
15:00	4.40	9.76
15:01	5.47	9.07
15:02	4.18	9.90
15:03	4.27	9.84
15:04	3.45	10.25
15:05	3.25	10.44
15:06	3.42	10.25
15:07	3.31	10.38
15:08	3.07	10.56
15:09	2.96	10.61
15:10	2.50	10.89
15:11	3.06	10.54
15:12	4.39	9.66
15:13	3.95	10.07
15:14	4.45	9.75
15:15	5.29	9.08
15:16	2.61	10.82
15:17	3.03	10.66
15:18	3.91	9.95
15:19	3.02	10.67
15:20	2.61	10.69
15:21	2.60	10.77
15:22	2.73	10.79
15:23	3.01	10.59

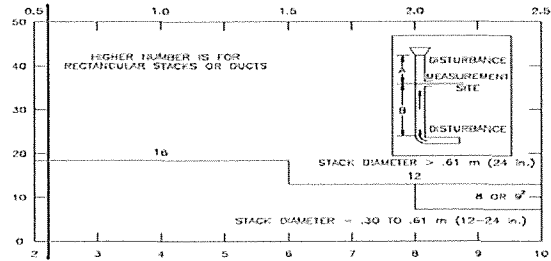
Parameter	O ₂ - Outlet	CO ₂ - Outlet
Uncorrected Run Average (C _{obs})	3.5	10.3
Cal Gas Concentration (C _{MA})	11.0	11.0
Pretest System Zero Response	0.00	0.02
Posttest System Zero Response	0.00	0.01
Average Zero Response (C ₀)	0.0	0.0
Pretest System Cal Response	10.96	11.02
Posttest System Cal Response	10.97	11.05
Average Cal Response (C _N)	11.0	11.0
Corrected Run Average (C _{corr})	3.5	10.3

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Location Energy Transfer - Howell, MI
 Source Dehydration Unit
 Project No. 2021-2950
 Date: 12/15/21

Stack Parameters

Duct Orientation: Vertical
 Duct Design: Circular
 Distance from Far Wall to Outside of Port: 14.00 in
 Nipple Length: 3.00 in
 Depth of Duct: 11.00 in
 Cross Sectional Area of Duct: 0.66 ft²
 No. of Test Ports: 1
 Number of Readings per Point: 1
 Distance A: 13.0 ft
 Distance A Duct Diameters: 14.2 (must be > 0.5)
 Distance B: 2.0 ft
 Distance B Duct Diameters: 2.2 (must be > 2)
 Minimum Number of Traverse Points: 8
 Actual Number of Traverse Points: 8
 Measurer (Initial and Date): ACD 12/15/21
 Reviewer (Initial and Date): TBR 12/15/21



CIRCULAR DUCT

LOCATION OF TRAVERSE POINTS

Number of traverse points on a diameter

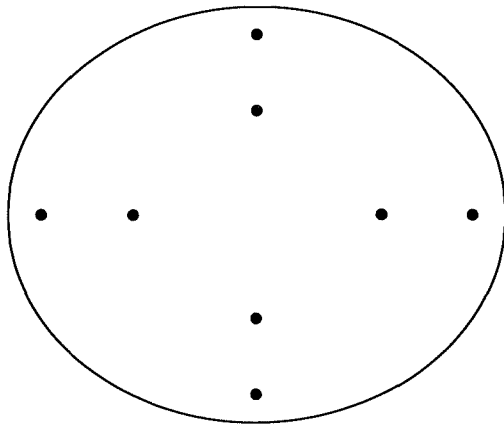
	2	3	4	5	6	7	8	9	10	11	12
1	14.6	--	6.7	--	4.4	--	3.2	--	2.6	--	2.1
2	85.4	--	25.0	--	14.6	--	10.5	--	8.2	--	6.7
3	--	--	75.0	--	29.6	--	19.4	--	14.6	--	11.8
4	--	--	93.3	--	70.4	--	32.3	--	22.6	--	17.7
5	--	--	--	--	85.4	--	67.7	--	34.2	--	25.0
6	--	--	--	--	95.6	--	80.6	--	65.8	--	35.6
7	--	--	--	--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

Traverse Point	% of Diameter	Distance from inside wall	Distance from outside of port
1	6.7	0.74	3.74
2	25.0	2.75	5.75
3	75.0	8.25	11.25
4	93.3	10.26	13.26
5	--	--	--
6	--	--	--
7	--	--	--
8	--	--	--
9	--	--	--
10	--	--	--
11	--	--	--
12	--	--	--

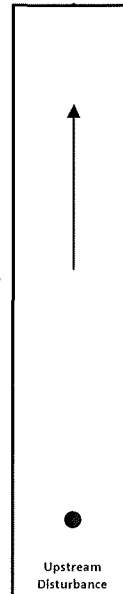
*Percent of stack diameter from inside wall to traverse point.

Stack Diagram
 A = 13 ft.
 B = 2 ft.
 Depth of Duct = 11 in.

Cross Sectional Area



Downstream Disturbance



Location Energy Transfer - Howell, MI
 Source Dehydration Unit
 Project No. 2021-2950
 Date 12/15/21

Sample Point	Angle ($\Delta P=0$)
1	0
2	0
3	0
4	2
5	2
6	1
7	1
8	0
9	1
10	1
11	0
12	1
13	1
14	2
15	2
16	0
Average	0.9

Location Energy Transfer - Howell, MI

Source Dehydration Unit

Project No. 2021-2950

Run No.	1		2		3	
Date	12/16/21		12/16/21		12/16/21	
Status	VALID		VALID		VALID	
Start Time	10:40		12:25		14:52	
Stop Time	10:46		12:32		15:00	
Leak Check	Pass		Pass		Pass	
Traverse Point	ΔP (in. WC)	Ts (°F)	ΔP (in. WC)	Ts (°F)	ΔP (in. WC)	Ts (°F)
A1	0.06	858	0.07	838	0.06	843
2	0.06	900	0.07	875	0.07	897
3	0.08	940	0.09	713	0.09	939
4	0.10	797	0.09	585	0.10	805
B1	0.06	805	0.09	785	0.07	822
2	0.06	895	0.09	836	0.07	889
3	0.09	970	0.09	866	0.09	910
4	0.10	870	0.09	678	0.09	802
Average						
Square Root of ΔP , (in. WC) ^{1/2}	(ΔP) ^{1/2}	0.274	0.290	0.282	0.282	0.282
Average ΔP , in. WC	(ΔP)	0.08	0.08	0.08	0.08	0.08
Pitot Tube Coefficient	(Cp)	0.840	0.840	0.840	0.840	0.840
Barometric Pressure, in. Hg	(Pb)	28.62	28.62	28.62	28.62	28.62
Static Pressure, in. WC	(Pg)	-0.28	-0.25	-0.27	-0.27	-0.27
Stack Pressure, in. Hg	(Ps)	28.60	28.60	28.60	28.60	28.60
Average Temperature, °F	(Ts)	879.4	772.0	863.4	838.3	838.3
Average Temperature, °R	(Ts)	1339.0	1231.7	1323.0	1297.9	1297.9
Measured Moisture Fraction	(BWSmsd)	0.148	0.148	0.147	0.147	0.147
Moisture Fraction @ Saturation	(BWSsat)	437.373	266.736	408.530	370.880	370.880
Moisture Fraction	(BWS)	0.148	0.148	0.147	0.147	0.147
O2 Concentration, %	(O2)	3.5	4.3	3.5	3.8	3.8
CO2 Concentration, %	(CO2)	10.1	9.8	10.3	10.1	10.1
Molecular Weight, lb/lb-mole (dry)	(Md)	29.76	29.73	29.78	29.76	29.76
Molecular Weight, lb/lb-mole (wet)	(Ms)	28.03	28.00	28.06	28.03	28.03
Velocity, ft/sec	(Vs)	25.5	25.8	26.0	25.8	25.8
VFR at stack conditions, acfm	(Qa)	1,008	1,023	1,029	1,020	1,020
VFR at standard conditions, scfh	(Qsw)	22,791	25,137	23,541	23,823	23,823
VFR at standard conditions, scfm	(Qsw)	380	419	392	397	397
VFR at standard conditions, dscfm	(Qsd)	324	357	335	339	339

Location Energy Transfer - Howell, MI
Source Dehydration Unit
Project No. 2021-2950
Parameter(s): VFR
Console Type Meter Box

Run No.	1					2					3				
Date	12/16/21					12/16/21					12/16/21				
Status	VALID					VALID					VALID				
Start Time	10:25					12:17					14:24				
End Time	11:25					13:17					15:24				
Run Time, min	(0) 60					60					60				
Meter ID	T13A					Unit 5					Unit 5				
Meter Correction Factor (Y)	1.029					1.013					1.013				
Orifice Calibration Value (ΔH @)	1.778					1.648					1.648				
Max Vacuum, in. Hg	2					3					3				
Post Leak Check, ft ³ /min (at max vac.)	0.000					0.000					0.000				
Meter Volume, ft ³															
0	0.000					392.290					425.720				
5	2.541					395.070					427.770				
10	5.101					397.900					430.640				
15	7.880					400.300					433.510				
20	10.610					403.000					436.380				
25	12.960					405.910					439.250				
30	14.730					408.640					442.120				
35	17.570					411.430					444.990				
40	20.410					414.200					447.860				
45	23.160					416.890					450.730				
50	26.040					419.620					453.600				
55	29.080					422.330					456.470				
60	31.790					425.600					459.340				
Total Meter Volume, ft ³ (Vm)	31.790					33.310					33.620				
Temperature, °F	Meter	Probe	Filter	Vacuum	Imp. Exit	Meter	Probe	Filter	Vacuum	Imp. Exit	Meter	Probe	Filter	Vacuum	Imp. Exit
0	60	--	--	2	59	59	--	--	3	60	62	--	--	3	52
5	62	--	--	2	50	60	--	--	3	53	62	--	--	3	52
10	60	--	--	2	49	62	--	--	3	52	63	--	--	3	50
15	60	--	--	2	49	62	--	--	3	50	64	--	--	3	48
20	61	--	--	2	51	63	--	--	3	50	65	--	--	3	47
25	61	--	--	2	52	63	--	--	3	50	65	--	--	3	47
30	62	--	--	2	53	63	--	--	3	51	66	--	--	3	47
35	62	--	--	2	53	63	--	--	3	51	67	--	--	3	49
40	62	--	--	2	54	63	--	--	3	51	67	--	--	3	50
45	63	--	--	2	54	64	--	--	3	52	67	--	--	3	50
50	63	--	--	2	54	64	--	--	3	52	67	--	--	3	50
55	64	--	--	2	55	64	--	--	3	53	67	--	--	3	51
60	64	--	--	2	55	64	--	--	3	53	67	--	--	3	51
Average Temperature, °F (Tm)	62	--	--	2	53	63	--	--	3	52	65	--	--	3	50
Average Temperature, °R (Tm)	522	--	--	--	--	522	--	--	--	525	--	--	--	--	--
Minimum Temperature, °F	60	--	--	2	49	59	--	--	3	50	62	--	--	3	47
Maximum Temperature, °F	64	--	--	2	59	64	--	--	3	60	67	--	--	3	52
Barometric Pressure, in. Hg (Pb)	28.62					28.62					28.62				
Meter Orifice Pressure, in. WC (ΔH)	1.000					1.000					1.000				
Meter Pressure, in. Hg (Pm)	28.69					28.69					28.69				
Standard Meter Volume, ft ³ (Vmstd)	31.741					32.693					32.828				
Analysis Type	Gravimetric					Gravimetric					Gravimetric				
Impinger 1, Pre/Post Test, g	H2O	703.0	812.8	109.8		H2O	858.6	854.7	-3.9		H2O	812.8	915.1	102.3	
Impinger 2, Pre/Post Test, g	H2O	758.9	761.6	2.7		H2O	578.4	579.5	1.1		H2O	761.6	771.3	9.7	
Impinger 3, Pre/Post Test, g	Empty	649.7	649.8	0.1		Empty	730.8	736.2	5.4		Empty	649.8	649.2	-0.6	
Impinger 4, Pre/Post Test, g	Silica	859.5	863.5	4.0		Silica	747.4	865.3	117.9		Silica	863.5	871.6	8.1	
Volume Water Collected, mL (Vlc)	116.6					120.5					119.5				
Standard Water Volume, ft ³ (Vvstd)	5.499					5.683					5.636				
Moisture Fraction Measured (BWS)	0.148					0.148					0.147				
Gas Molecular Weight, lb/lb-mole (dry) (Md)	29.76					29.73					29.78				
DGM Calibration Check Value (Yqa)	-3.4					-4.2					-3.5				