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Pollutant Emissions Test Report
Zink Enclosed Flare Exhaust
(EUENCLOSEDFLARE1-S2)

BFI Waste Systems of North America, LLC
Northville, Michigan
SRN: N2688

May 18, 2016

Prepared for:
Republic Services, Inc.
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EXECUTIVE SUMMARY

Republic Services, Inc. (Republic) retained Air Quality Specialist, Inc. (AQSI) to conduct tests to measure the non-methane organic compound (NMOC), oxides of nitrogen (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen chloride (HCl), and volatile organic compound (VOC) concentrations, and calculate emissions rates, from one enclosed flare exhaust stack located at Advanced Disposal Arbor Hills Landfill in Northville, Michigan.

The purpose of the test program was to measure the pollutant emission rates from the enclosed flare for comparison to the emissions limitations contained in Michigan Department of Environmental Quality (MDEQ) Permit-to-Install (PTI) No. 179-13, and to measure NMOC and diluent concentrations to determine compliance with 40 *Code of Federal Regulations* (CFR), Part 60, Subpart WWW, 60.752(b)(2)(iii)(B), while the flare operated at the current maximum sustainable landfill gas flow rate.

AQSI conducted the fieldwork on March 23, 2016, and in accordance with the test plan, dated January 18, 2016. Mr. Mark Dziadosz with MDEQ reviewed and approved the test plan. Mr. Andrew Secord and Mr. Jeremy Chrobak with AQSI, and Mr. Steve Smith and Mr. Brandon Chase with BTEC, Inc., conducted the field tests. Mr. Dziadosz with MDEQ witnessed the bulk of the field test program. The test results and compliance limits were:

Parameter	Result	Limit	Status
Exhaust NMOC Concentration (ppmv) – dry basis, as hexane, corrected to 3% oxygen	1.1	20.0	PASS
Exhaust NOx Emission Rate (lb/hr)	2.15	20.0	PASS
Exhaust NOx Emission Rate (tpy)	9.41	87.6	PASS
Exhaust CO Emission Rate (lb/hr)	0.08	15.6	PASS
Exhaust CO Emission Rate (tpy)	0.35	68.3	PASS
Exhaust SO_2 Emission Rate (lb/hr)	3.95	14.0	PASS
Exhaust SO_2 Emission Rate (tpy)	17.3	61.3	PASS
Exhaust HCl Emission Rate (lb/hr)	0.16	6.0	PASS
Exhaust HCl Emission Rate (tpy)	0.72	26.1	PASS
Exhaust VOC Emission Rate (lb/hr)	0.14	7.1	PASS
Exhaust VOC Emission Rate (tpy)	0.59	31.2	PASS

ppmv: Parts per million, volume basis
lb/hr: Pounds per hour
tpy: Tons per year

1.0 INTRODUCTION

Republic Services, Inc. retained Air Quality Specialist, Inc. (AQSI) to conduct tests to measure the non-methane organic compound (NMOC), oxides of nitrogen (NOx), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen chloride (HCl), and volatile organic compound (VOC) concentrations, and calculate emissions rates, from one enclosed flare exhaust stack located at Advanced Disposal Arbor Hills Landfill in Northville, Michigan.

The purpose of the test program was to measure the pollutant emission rates from the enclosed flare for comparison to the emissions limitations contained in Michigan Department of Environmental Quality (MDEQ) Permit-to-Install (PTI) No. 179-13, and to measure NMOC and diluent concentrations to determine compliance with 40 *Code of Federal Regulations* (CFR), Part 60, Subpart WWW, 60.752(b)(2)(iii)(B), while the flare operated at the current maximum sustainable landfill gas flow rate.

The test program consisted of 40 CFR 60, Appendix A, United States Environmental Protection Agency (USEPA) Reference Test Methods 1, 2B, 2C, 3A, 3C, 4, 6C, 7E, 10, 25A, 25C, 26, and 205.

AQSI conducted the fieldwork on March 23, 2016, and in accordance with the test plan, dated January 18, 2016. Mr. Mark Dziadosz with MDEQ reviewed and approved the test plan. Mr. Andrew Secord and Mr. Jeremy Chrobak with AQSI, and Mr. Steve Smith and Mr. Brandon Chase with BTEC, Inc., conducted the field tests. Mr. Dziadosz with MDEQ witnessed the bulk of the field test program. Mr. Chris Glover with Monitoring, Control, and Compliance, Inc. supported flare operations, on behalf of Republic.

The name, address, and telephone number of the primary contact for further information about the tests and this test report is:

Name and Title	Company	Telephone
Mr. Andrew Secord Environmental Scientist	Air Quality Specialist, Inc. 672 N. Milford Road, Suite 152 Highland, Michigan 48357	(248) 887-7565

The name, address, and telephone number of the primary contact for further information about the enclosed flare is:

Name and Title	Company	Telephone/Fax
Ms. Christina Pearse Environmental Manager	Republic Services, Inc. 5011 S. Lilley Road Canton, Michigan 48188	(734) 397-2790

2.0 SUMMARY OF RESULTS

AQSI measured pollutant emissions from the Zink enclosed flare exhaust stack (EUENCLOSEDFLARE1-S2) on March 23, 2016.

AQSI (BTEC) performed a verification of the calibration gas divider on March 22, 2016, in accordance with USEPA Method 205. The gas divider produced gas concentrations with less than 1% variability between triplicate gas dilutions, and generated a gas concentration that was accurate to within 1% of a Protocol 1 gas standard. The method criteria is less than 2% difference between dilutions, and less than 2% difference between the average dilution response and the Protocol 1 gas standard. The results demonstrate that the gas divider met the validation requirements of USEPA Method 205.

AQSI conducted preliminary measurements of the enclosed flare exhaust stack on the afternoon of March 22, 2016. The purpose of the preliminary tests was to obtain baseline concentrations to verify instrument spans, conduct a stratification test, and conduct the NOx analyzer converter check. The flare operated at a combustion chamber set-point temperature of 1,640 °F, and no changes were made to the flare temperature.

AQSI conducted pollutant (NMOC, NOx, CO, SO_2, HCL, and VOC) emission rate tests required by PTI 179-13 on March 23, 2016. Republic operated the enclosed flare at the current maximum sustainable landfill gas flow rate (approximately 2,160 scfm per USEPA Method 2 measurements, or 2,470 scfm per the installed process flow meter), and at a combustion chamber set-point temperature of 1,640 °F, as measured off the top of three installed thermocouples, for this series of tests.

The test results and compliance limits were:

Parameter	Results	Limits	Status
Exhaust NMOC Concentration (ppmv) – dry basis, as hexane, corrected to 3% oxygen	1.1	20.0	PASS
Exhaust NOx Emission Rate (lb/hr & tpy)	2.15 & 9.41	20.0 & 87.6	PASS
Exhaust CO Emission Rate (lb/hr & tpy)	0.08 & 0.35	15.6 & 68.3	PASS
Exhaust SO_2 Emission Rate (lb/hr & tpy)	3.95 & 17.3	14.0 & 61.3	PASS
Exhaust HCl Emission Rate (lb/hr & tpy)	0.16 & 0.72	6.0 & 26.1	PASS
Exhaust VOC Emission Rate (lb/hr & tpy)	0.14 & 0.59	7.1 & 31.2	PASS

ppmv:	Parts per million, volume basis
lb/hr:	Pounds per hour
tpy:	Tons per year

The test results demonstrate that the enclosed flare meets the permitted pound per hour (lb/hr) and ton per year (tpy) emission limits for all pollutants.

In addition, the average exhaust NMOC concentration was 1.1 parts per million (ppm), dry basis as hexane corrected to 3 percent oxygen. The emissions limit is an exhaust concentration less than 20 ppm by volume, dry basis as hexane, at 3 percent oxygen [40 CFR 60.752(b)(2)(iii)(B)]. The test results demonstrate that the enclosed flare meets the emission limit of 60.752(b)(2)(iii)(B) while operating at the current, maximum sustainable flow rate, and temperature controlled at 1,640 °F by the top thermocouple.

3.0 SOURCE DESCRIPTION

Advanced Disposal Arbor Hills Landfill is an active municipal solid waste (MSW) landfill. Anaerobic bacteria decompose the emplaced waste. By-products of decomposition are methane (~45-55%, typical) and carbon dioxide (~30-40%, typical), with minor amounts of nitrogen (~15%, typical) and oxygen (<2%, typical), and trace amounts of other volatile organic compounds.

Republic employs a gas collection and control system to meet the requirements of Subpart WWW. Gas collection wells are installed in a grid pattern about the landfill. The wells are connected to a common header system. A blower produces a vacuum on the well field. Collected gas is routed to a third-party landfill gas-to-energy (LFGTE) plant. The Zink enclosed flare (EUENCLOSEDFLARE1-S2) serves as a back-up control device.

The enclosed flare exhaust stack is 120 inches inside diameter, and approximately 50 feet tall. The test ports are approximately 42 feet above ground level, and approximately 30 feet downstream from the nearest disturbance or bend (burner tips).

The enclosed flare is designed to meet the requirements of 60.753(b)(2)(iii) at a flow rate up to 2,600 scfm. The combustion chamber temperature and landfill gas flow to the burner of the enclosed flare is monitored and recorded at least once every 15 minutes. The enclosed flare is equipped with an automatic shutdown that activates if the minimum combustion chamber set-point temperature cannot be maintained.

The enclosed flare flow rate data recorded from process flow meter panel data, for March 23, 2016, is presented in Appendix A.

4.0 SAMPLE AND ANALYTICAL PROCEDURES

AQSI performed measurements in accordance with procedures specified in USEPA *Standards of Performance for New Stationary Sources* Reference Test Methods. The sample collection and analytical methods used in the test program are indicated in the table below.

Sample Method	Parameter	Analytical Method
USEPA Method 1 & 2C	Velocity and flow rate (inlet)	Field Data
USEPA Method 2B	Velocity and flow rate (exhaust)	Mass Balance
USEPA Method 3A	Oxygen and carbon dioxide	Instrument Analyzer(s)
USEPA Method 3C	Landfill gas composition and inlet moisture content	Gas Chromatography / Thermal Conductivity Detector (GC/TCD)
USEPA Method 4	Exhaust moisture content	Field Data
USEPA Method 6C	Sulfur dioxide	Ultra-violet (UV) Analyzer
USEPA Method 7E	Oxides of nitrogen	Chemiluminescence Analyzer
USEPA Method 10	Carbon monoxide	Non-dispersive Infrared (NDIR) Analyzer
USEPA Method 25A	Non-methane organic compounds (as total hydrocarbons – methane) and volatile organic compounds	Flame Ionization Analyzer (FIA)
USEPA Method 25C	Organic carbon (inlet)	Gas Chromatography / Flame Ionization Detector (GC/FID)
USEPA Method 26	Hydrogen chloride	Ion Chromatography
USEPA Method 205	Gas divider verification	Precision and repeatability

AQSI used USEPA Method 1, *"Sample and Velocity Traverses for Stationary Sources,"* to determine the appropriate number and location of traverse points at the enclosed flare inlet. AQSI calculated the traverse point locations by dividing the stack cross-section into equal areas (one traverse point for each area). The number of traverse points were determined by the distance to the nearest upstream and downstream flow disturbance, in equivalent stack diameters from the sample ports.

AQSI used USEPA Method 2C, *"Determination of Stack Gas Velocity and Volumetric Flow Rate in Small Stacks and Ducts (Standard Pitot Tube),"* to measure velocity pressures and temperatures at each traverse point. AQSI used a standard pitot tube, with a coefficient of 0.99, positioned at each inlet traverse point. The velocity pressure and gas temperature were measured and recorded. Velocity pressure measurements were read from an inclined water-column manometer with increments of 0.01 inch of water. Temperature measurements were made with a pyrometer and thermocouple probe.

The average stack gas velocity is a function of the average velocity pressure, absolute stack gas pressure, average stack gas temperature, molecular weight of the wet stack gas, and pitot tube coefficient. The derivation of the average stack gas velocity was calculated using the equations stipulated in this test method. The actual stack gas flow rate was calculated using the average stack gas velocity and the cross-sectional area of the stack.

AQSI used USEPA Method 2B, *"Determination of Exhaust gas Volume Flow Rate from Gasoline Vapor Incinerators,"* to calculate the enclosed flare exhaust flow rate. The ratio of total carbon at the flare inlet and outlet was multiplied by the inlet volume to determine the exhaust volume flow rate. This method is applicable because at the low landfill gas flow rate (inlet), there is not sufficient exhaust gas volume on the flare outlet to register a differential pressure on an inclined manometer. The exhaust volume flow rate data was used to calculate pollutant emission rates.

AQSI used Method 3C, *"Determination of Carbon Dioxide, Methane, Nitrogen, and Oxygen from Stationary Sources,"* and Method 25C *"Determination of Non-methane Organic Compounds in Landfill Gases,"* to determine the landfill gas composition and organic carbon (OC) concentrations. AQSI collect three, 60-minute, integrated samples of landfill gas from the Zink enclosed flare inlet. AQSI submitted the samples to Triangle Environmental Services, Inc. (TES), Durham, North Carolina, to analyze each sample for carbon dioxide, (CO_2), methane (CH_4), nitrogen (N_2), and oxygen (O_2), and NMOC concentration. The OC concentration data was used for Method 2B exhaust volume flow rate calculations.

AQSI used USEPA Method 3A, *"Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrument Analyzer Procedure),"* to measure exhaust gas O_2 and CO_2 concentration. The O_2 data was used for the correction of the measured NMOC concentration to dry basis, as hexane at 3 percent oxygen, per 60.752(b)(2)(iii(B). The CO_2 data was used for Method 2B exhaust volume flow rate calculations.

AQSI used USEPA Method 4, *"Determination of Moisture Content in Stack Gases,"* to measure exhaust gas moisture content. The moisture data was used to correct the exhaust gas NMOC concentration to dry-basis, and to correct the Method 2B exhaust scfm to dry standard cubic feet per minute (dscfm) for the other pollutant emission rates.

AQSI collected the Method 4 samples in triplicate, concurrent with the Method 26 HCl sample collection.

AQSI used USEPA Method 6C, *"Determination of Sulfur Dioxide Emissions from Stationary Sources (Instrument Analyzer Procedure),"* to measure exhaust gas SO_2 concentration, Method 7E, *"Determination of Nitrogen Oxides Emissions from Stationary Sources (Instrument Analyzer Procedure),"* to measure exhaust NO_x concentration, and Method 10, *"Determination of Carbon Monoxide Emissions from Stationary Sources,"* to measure exhaust gas CO concentration.

The Method 3A / 6C / 7E / 10 sample train consisted of a stainless steel probe, a Teflon® sample line maintained at ~275°F, a non-contact thermoelectric sample conditioner to remove moisture, a sample pump, a bypass manifold, and the four (O_2 & CO_2, SO2, NOx, and CO) instrument analyzers.

AQSI had estimated the approximate maximum average pollutant gas concentrations, in parts per million (ppm) as each respective pollutant, that met the emission limit criteria of the PTI by back-calculation from the lb/hr limit, and the estimated exhaust gas flow rate. AQSI operated each analyzer in the lowest fixed instrument range that provided both the best data resolution, and also preserved any short-term and intermittent concentration spikes.

AQSI calibrated the 3A / 6C / 7E / 10 analyzers with three gases in the 0 – 100 percent of span for O_2 (range: 0 – 20 percent), CO_2 (range: 0 – 20 percent), SO2 (range: 0 – 90 ppm), NOx (range: 0 – 90 ppm), and CO (range: 0 – 190 ppm).

AQSI used an Environics computerized multi-gas calibrator ('gas divider') to dilute an available parameter-specific USEPA Protocol I calibration gas standard to produce gas concentrations that represent 80 – 100 percent and 40 – 60 percent of the selected instrument span for the pollutant and diluent measurement ranges. AQSI used a "Nitrogen Zero Air" (99.99% nitrogen) gas standard that represented less than 0.25 percent of each instrument span as the "zero air" and dilution gas.

AQSI conducted a Stratification Test in accordance with Section 8.1.2 of Method 7E on the afternoon of March 22, 2016. The stratification results demonstrated that the stack was minimally stratified (i.e., <10% stratified, per diluent (O_2) results, and Compliance Run Nos. 1, 2, and 3 were collected along a 3-point traverse from the south test port.

The O_2 / CO_2 / SO_2 / NOx / CO concentration measurement system met the analyzer calibration error, sample system bias, and drift error requirements of Method 7E (i.e., Sections 8.2.3, 8.2.5, and 8.5).

AQSI used USEPA Method 25A, *"Determination of Total Gaseous Organic Concentration and Methane Concentration Using a Flame Ionization Analyzer (FIA),"* to measure the exhaust gas NMOC and VOC concentration.

AQSI used a methane/non-methane hydrocarbon analyzer to measure stack gas total hydrocarbon and methane concentrations. The analyzer is equipped with dual flame ionization detectors. The first detector ionizes all hydrocarbons (including methane) in the sample stream, and produces a voltage signal proportional to the hydrocarbon concentration. The second detector is equipped with a catalyst that removes all hydrocarbons except methane. NMOC is the arithmetic difference between the total hydrocarbon concentration and the methane-only concentration.

AQSI intended to have both FIA detectors calibrated with four gases in the 0 – 100 ppm range methane: "Hydrocarbon Free Air" (<0.1 ppm methane), and three USEPA Protocol 1 methane gas standards that represent 80 – 90 percent, 45 – 55 percent, and 25 – 35 percent of the analyzers 0 – 100 ppm range, respectively. However, the instrument technician calibrated the total hydrocarbon detector with four gases in the 0 – 100 ppm range, with propane.

AQSI planned to report the NMOC concentration as the instantaneous difference between the total hydrocarbons (as methane), minus the methane, concentration. AQSI has chosen to report NMOC as total hydrocarbons, as propane, in accordance with good engineering practice, since 1) the total hydrocarbon detector was calibrated with propane, and 2), the total hydrocarbon and methane signals were relatively indistinguishable from each other, due to very low in-stack concentrations.

AQSI reports NMOC exhaust concentration, corrected to dry basis as hexane, at 3 percent oxygen, for comparison to 60.752(b)(2)(iii)(B) of the NSPS.

The NMOC sample system met all calibration error, linearity, and drift error requirements of Section 8.4 of Method 25A. Section 6.1.1 of Method 25A requires the instrument detector be operated at a temperature of >120°C (>250°F). AQSI maintained the FID detector block at a temperature of 190° ± 5°C (~375°F), per manufacturer guidelines. Section 6.1.3 of Method 25A requires the heated sample line to be operated at a temperature >110°C (230°F). AQSI operated and maintained all heated sample lines at 275°F (or higher) to prevent condensation of NMOC.

The pollutant and diluent concentrations from each instrument analyzer, as an analog (voltage) signal, were sent to the data acquisition system (DAS), where the signal output was recorded at 4-second intervals. The pollutant and diluent concentration results were averaged based on the overall duration of the test.

AQSI subcontractor (BTEC) imported the raw text files produced by the DAS into Microsoft® Excel, and then broke out test run and calibration drift data into individual sheets (tabs). AQSI used Excel to reduce the raw run data into 1-minute averages, per MDEQ request.

AQSI drift-corrected the average pollutant and diluent concentrations (except NMOC / VOC) to carry out pollutant emission rate calculations.

AQSI used USEPA Method 26, "*Determination of Hydrogen Halide and Halogen Emissions from Stationary Sources (Non-Isokinetic Method)*," to measure exhaust gas HCl mass. AQSI modified the method by use of standard-size Method 4 impingers in lieu of the midget impingers in Method 26. This modification was stated in the Intent-to-Test Notification, dated January 18, 2016.

AQSI obtained moisture content and HCl concentration from these samples. The first two impingers were loaded with 100 milliliters (mL) of 0.1 N H_2SO_4, the third and fourth impingers were loaded with 100 mL of 0.1 N NaOH, and the last impinger was loaded with silica gel.

The Method 26 sample train (Figure 5) consisted of an unheated glass probe, a heated quartz-fiber filter, the impingers, a sample umbilical line, a calibrated dry-gas meter, and pump. The gas sample was extracted from the stack at a fixed sample rate.

AQSI measured the impinger contents and re-weighed the silica gel, for moisture content calculation, after each test. The contents of the first two impingers were placed into a sample container. The back-half of the filter holder, the first two impingers, and the first impinger U-tube were rinsed with de-ionized water. The rinses were placed in the same container as the first two impinger catch contents. The sample container was sealed, labeled, and the liquid level marked. The samples were sent to Maxxam Analytics International Corporation for HCl analysis.

The third and fourth impinger contents were measured (for moisture content), but were not retained or analyzed (the only analyte of interest, HCl, was obtained from the first two impingers' contents); the use of NaOH in these impingers in this program was solely to protect the dry-gas meter from any potential halogens.

The Method 4 / 26 sample train was leaked-check prior to, and immediately after each HCl sample run in accordance with Method 5, Sections 8.4.2 and 8.4.4, respectively.

The laboratory reported HCl results in units of mass (micrograms, μg). AQSI converted the reported mass to a concentration, milligrams per cubic meter (mg/m^3), by division of the reported mass by the corrected sample volume.

AQSI used USEPA Method 205, "*Verification of Gas Dilution Systems for Field Instrument Calibrations,*" to demonstrate that the gas divider accurately and repeatedly provides known concentrations of calibration gas by controlled dilution of a known Protocol 1 gas standard.

AQSI validated the gas divider by initial calibration of one instrument analyzer in a selected span range with blended gas standards, and then challenged the analyzer with a known Protocol 1 concentration, in accordance with USEPA Method 205. The challenge was repeated three times with the same generated concentrations for the initial verification. The measured concentrations were averaged.

The gas dilution system was deemed acceptable since no single response differed by more than 2 percent from the average instrument response, and, the average instrument response was within 2 percent of the predicted response.

The gas dilution system met the precision and accuracy requirements of Method 205.

5.0 RESULTS AND DISCUSSION

AQSI demonstrated the gas dilution system performance on March 23, 2016. AQSI chose to demonstrate the gas divider with the Method 25A FID, due to the inherent linearity of the FID. AQSI zeroed the FID with the "Hydrocarbon Free Zero Air" standard, and set the instrument span with a 89.2 ppm generated propane gas standard. The instrument span was set at 89.8 ppm. Controlled dilutions of 49.5 and 29.7 ppm, respectively, were directed to the analyzer to demonstrate linearity; the instrument response was 49.5 ppm, and 29.6 ppm, respectively.

AQSI then challenged the FID, in triplicate, with the generated dilutions. The instrument response to the triplicate 49.5 ppm dilutions was 49.6 ppm, 49.6 ppm, and 49.5 ppm, respectively. The average instrument response to the 49.5 ppm dilution was 49.6 ppm. The results demonstrate that all individual injections agree to within 0.5 % of the average response to the 49.5 ppm dilution, and that the average response (49.6 ppm) agreed within 1 % to the 49.5 ppm dilution. The acceptance criteria are within 2 % for both parameters.

The FID was then alternatively challenged with a zero gas and a 90.5 ppm Protocol 1 propane gas standard to check the accuracy of the dilution. The instrument response to the triplicate zero gas injections was 1.2 ppm, 1.2 ppm, and 1.4 ppm, respectively. The instrument response to the triplicate 90.5 ppm Protocol 1 propane standard was 90.1 ppm, 90.4 ppm, and 90.5 ppm, respectively. The average instrument response to the 90.5 ppm Protocol 1 gas standard was 90.3 ppm. The results demonstrate that all individual injections agree to within 0.5 % of the average response to the 90.5 ppm standard, and that the average response (90.3 ppm) was within 1.0 % of the 90.5 ppm standard. The acceptance criterion is within 2% agreement.

The results demonstrate that the gas divider met the verification criteria of Method 205.

AQSI performed an O_2 Stratification Test on the afternoon of March 22, 2016. The stratification test was conducted in accordance with Method 7E, 8.1.2. AQSI measured the diluent (O_2) concentration at each of 6 points in the enclosed flare exhaust, and from two (2) accessible test ports (east and south), for a total of 12 points.

AQSI compared the individual points' average diluent (O_2) results to the mean value. The results show that the average concentration data from point to point varied only slightly (11.6 to 12.3 % O_2) on the east to west traverse, and all points average concentration was within the ±5 % of mean concentration criteria to substantiate "no stratification." The stratification results from on the south port showed more variability (11.3 to 13.4% O2), such that all points were within ±10 % of mean concentration, and therefore the stack was "minimally stratified." As the south port exhibited both the highest (and lowest) pollutant and diluent concentrations, the Compliance Test Run Nos. 1, 2, and 3 were collected from the 3-point traverse, representing 16.7, 50.0, and 3.3 percent of the measurement line, of the south port on March 23, 2016.

AQSI conducted NMOC concentration and NOx, CO, SO_2, HCl, and VOC emissions rate tests required PTI No. 179-13 on March 23, 2016.

Republic operated the enclosed flare at an approximate average landfill gas flow rate of 2,470 scfm as measured by the installed process flow meter (approximately 2,160 scfm as measured by Method 2), and at a combustion chamber set-point temperature of 1,640 °F, for this series of tests.

Per agreement between AQSI and MDEQ, all exhaust mass emission rates were calculated from the higher inlet flow rate (i.e., flow meter data), as this produces the highest exhaust gas flow rate and emission rates.

On March 23, 2016, the average NMOC exhaust concentration was 1.1 ppm, dry basis as hexane, corrected to 3 percent oxygen. The emission limit [40 CFR 60.752(b)(2)(iii)(B)] is an exhaust concentration less than 20 ppm by volume, dry basis as hexane, at 3 percent oxygen. The test results demonstrate that the enclosed flare meets the emission limit of 60.752(b)(2)(iii)(B) at the tested landfill gas flow rate and combustion chamber temperature.

On March 23, 2016, the average NOx emission rate was 2.15 lb/hr, or 9.41 tpy, at a calculated average exhaust gas flow rate of 18,235 dscfm. The NOx results meet the limits (20.0 lb/hr and 87.6 tpy, respectively) established by PTI No. 179-13.

On March 23, 2016, the average CO emission rate was 0.08 lb/hr, or 0.35 tpy, at a calculated average exhaust gas flow rate of 18,235 dscfm. The CO results meet the limits (15.6 lb/hr and 68.3 tpy, respectively) established by PTI No. 179-13.

On March 23, 2016, the average SO_2 emission rate was 3.95 lb/hr, or 17.3 tpy, at a calculated average exhaust gas flow rate of 18,235 dscfm. The SO_2 results meet the limits (14.0 lb/hr and 61.3 tpy, respectively) established by PTI No. 179-13.

On March 23, 2016, the average HCl emission rate was 0.16 lb/hr, or 0.72 tpy, at a calculated average exhaust gas flow rate of 18,235 dscfm. The HCl results meet the limits (6.0 lb/hr and 21.6 tpy, respectively) established by PTI No. 179-13.

On March 23, 2016, the average VOC emission rate was 0.14 lb/hr, or 0.59 tpy, at a calculated average exhaust gas flow rate of 19,676 scfm. The VOC results meet the limits (7.1 lb/hr and 31.2 tpy, respectively) established by PTI No. 179-13.

AQSI notes that there were variations or anomalies in normal sample collection procedures:

1. Test No. 1 was started at 10:12 on March 23, 2016. All test trains were stopped approximately 5 minutes later due to a loose filter head on the continuous emissions monitoring system (CEMS) probe. The CEMS test was re-started a few minutes later, and the HCl and inlet NMOC trains were re-started at 10:25, when the CEMS had "caught-up." At approximately 10:45, all sample trains were again stopped due to a vacuum problem in the HCl train. The problem was traced to a collapsed glass probe. A new, shorter (quartz) liner was cut and fitted to a sheath. CEMS and HCl Test No. 1 were scrapped, and Test No. "1B" was started at 12:04. The inlet NMOC train was also re-started at this time. Test No. 1B (Test No. "1") CEMS and HCl were completed at 13:05. The inlet 3C/25C train ran an extra 5 minutes as there was still sufficient vacuum in the sample tank to do so; subsequent inlet test were run at a slightly higher flow rate (30 cc/min).

2. At the conclusion of Test No. 2, the HCl train failed the post-test leak check. Investigation revealed that the probe tip had likely cracked after removal of the air-cooled probe sheath from the stack, due to differential cooling of the sheath and quartz liner. Per agreement with Mr. Dziadosz with MDEQ, the post-test leak-check was repeated from the filter holder inlet. This leak-check was successful. The quartz liner was cut and shortened again for Test No. 3, and both pre- and post-test No. 3 leak-checks were conducted from the filter holder inlet due to an unclean cut at the quartz probe tip.

3. AQSI and MDEQ acknowledged the above issues with the HCl trains. MDEQ elected to allow the continuation of testing, but reserved the right to request subsequent tests of the inlet for chloride ion concentration and re-calculation of HCl mass emission rate. AQSI notes that the HCl concentration trends with the moisture concentration. In addition, AQSI notes that the HCl blank was high. AQSI did not use "blank-corrected" HCl concentration to carry out emission rate calculations.

4. The total hydrocarbon concentration (as propane), and the methane concentration (as methane), were less than 1 ppm for the duration of most tests, and the average THC and CH_4 concentrations were also less than 1 ppm. As stated in the test plan, in the event that THC / CH_4 concentrations were low or indistinguishable from one another, AQSI would report NMOC/VOC as THC. Therefore, AQSI did not perform any "methane-subtraction" for this project; the reported NMOC/VOC concentration is the THC concentration, and since the average THC concentration was less than 1 ppm, all calculations were carried out using 1 ppm.

5. The CO concentration was less than 1 ppm for the duration of most tests, and the average CO concentrations were also less than 1 ppm. Similar to the THC above, since the average CO concentration was less than 1 ppm, all calculations were carried out using 1 ppm.

The exhaust gas flow rates and emission rates presented on Tables 1 through 7 are calculated from the inlet flow rate, as recorded from the installed process flow meter, as the process flow meter yielded higher flow rates than Method 2. Table 1 presents a summary of the results of the pollutant emissions rate tests on the enclosed flare exhaust stack. Table 2 presents the results of the enclosed flare exhaust NMOC concentration, dry basis as hexane, corrected to 3 percent oxygen. Tables 3, 4, 5, and 6 present run-specific results of the NOx, SO_2, CO, HCL, CO, and VOC emission rate tests, respectively.

Analyzer Run Data for Test Nos. 1, 2, and 3 present the 1-minute average and 1-hour average of the enclosed flare exhaust uncorrected pollutants: NOx, CO, SO2 and NMOC/VOC (as THC) and diluent (O_2 and CO_2) concentrations vs. time over the course of each 60-minute sample run conducted on March 23, 2016. All test result average concentrations are consistent and repeatable.

Figure 1 depicts the flare inlet duct traverse points. Figure 2 depicts the USEPA Method 3C/25C landfill gas composition sample train. Figure 3 depicts a representative enclosed flare exhaust stack. Figure 4 depicts the flare exhaust stack CEMS test traverse points. Figure 5 depicts the USEPA Method 3A / 6C / 7E / 10 pollutant and diluent sample train. Figure 6 depicts the USEPA Method 25A NMOC/VOC sample train. Figure 7 depicts the USEPA Method 4 / 26 moisture / hydrogen chloride sample train.

There was no major maintenance performed on the enclosed flare in the last 3 months.

Mr. Mark Dziadosz with MDEQ witnessed the bulk of the compliance test program.

AQSI quality assurance (QA) procedures included pre-test analyzer calibration error, linearity, system bias, and post-test drift error demonstrations on the Method 3A / 6C / 7E / 10 sample system, and pre-test analyzer calibration error, linearity, and post-test drift error demonstrations on the Method 25A sample system. All instrument analyzer systems passed these QA checks.

AQSI leak checked both the positive- and negative – pressure legs of the Method 2C apparatus (pitot tube, pitot lines, and manometer) before each velocity traverse. The inlet Method 3C/25C sample train was leak checked prior to each sample run. The moisture / hydrogen chloride sample train was leak-checked before and after each test, in accordance with USEPA Method 4. All measurement systems passed their respective leak checks, except as noted, above.

Raw field and computer-calculated data used in the determination of the enclosed flare exhaust velocities and moisture content, field notes, and enclosed flare process data is presented in Appendix A.

The laboratory analytical reports for the landfill gas composition and hydrogen chloride sample analysis is presented in Appendix B.

Equipment and analyzer calibration data sheets and computer-generated calibration sheets are presented in Appendix C. These sheets also include the Method 205 validation test data.

Sample calculations are presented in Appendix D.

Copies of the Microsoft® Excel spreadsheets used to produce the pollutant and diluent concentration results, CEMS test run data, CEMS post-cal data, and other ancillary files, are included on the compact disk located in the back-cover pocket.

This report prepared by: ______________________
Andrew D. Secord
Environmental Scientist

This report reviewed by: ______________________
Dana A. Oleniacz
President

May 18, 2016

Table 1

Summary Pollutant Emissions Rate Test Results
Republic - Arbor Hills
Zink Flare Exhaust
Northville, Michigan
March 23, 2016

Pollutant		**NMOC Exhaust Concentration**	
(units)	**(ppm CH_4)**	**(ppmv - dry basis, as hexane)**	**ppmv - limit**
NMOC (ppmv)	**1.0**	**1.1**	*20.0*

Pollutant		**Average Emission Rates**		
(units)	**(lb/hr)**	**(limit)**	**(tpy)**	**(limit)**
NOx (ppmv)	**2.15**	*20.0*	**9.41**	*87.6*
CO (ppmv)	**0.08**	*15.6*	**0.35**	*68.3*
SO2 (ppmv)	**3.95**	*14.0*	**17.3**	*61.3*
HCl (mg/m^3)	**0.16**	*6.0*	**0.72**	*26.1*
VOC (ppmv)	**0.14**	*7.1*	**0.59**	*31.2*

ppmv:	parts per million (volume), in equivalents of the calibration gas, and corrected for zero- and span- drift, as applicable.
lb/hr:	pounds per hour
tpy:	tons per year

Table 2

Non-methane Organic Compound Concentration Test Results
Republic - Arbor Hills
Zink Flare Exhaust
Northville, Michigan
March 23, 2016

Test No.	NMOC (ppm C_3H_8)	Stack Gas O_2 (%)	Moisture (%)	NMOC - corrected (ppm as hexane)
1	1.0	12.21	9.2	**1.1**
2	1.0	11.99	4.7	**1.1**
3	1.0	12.25	8.0	**1.1**
Averages:	**1.0**	**12.15**	**7.3**	**1.1**

NMOC: Non-methane organic compounds, as total hydrocarbons
ppm: parts per million (volume), averages < 1 ppm reported as 1 ppm
C_3H_8: propane
O_2: oxygen, drift-corrected concentration
%: percent
B_{ws}: % moisture / 100

Equation: $NMOC_{(hexane)} = [NMOC_{(propane)} * 17.9 / (20.9 - \%O_2)] / [2 * (1 - B_{ws})]$

Table 3

Oxides of Nitrogen Emissions Rate Test Results
Republic - Arbor Hills
Zink Flare Exhaust
Northville, Michigan
March 23, 2016

Test No.	Molecular Weight	Concentration (ppmv)	Flow Rate (dscfm)	Emission Rates (lb/hr)	Emission Rates (tpy)
1	46.01	16.33	18,057.4	2.11	9.26
2	46.01	16.84	18,327.1	2.21	9.69
3	46.01	16.15	18,318.1	2.12	9.29
Averages:		**16.4**	**18,234.2**	**2.15**	**9.41**

ppmv: parts per million (volume), in equivalents of the calibration gas, and corrected for zero- and span- drift.

dscfm: dry, standard cubic feet per minute

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = ppmv * molecular weight * dscfm * Constant

Constant = 60 minutes/hour / (24.04 liters/gram-mole * 453,600 milligrams/pound * 35.31 ft^3/m^3)
= $1.558*10^{-7}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

Table 4

Carbon Monoxide Emissions Rate Test Results
Republic - Arbor Hills
Zink Flare Exhaust
Northville, Michigan
March 23, 2016

Test No.	Molecular Weight	Concentration (ppmv)	Flow Rate (dscfm)	Emission Rates (lb/hr)	(tpy)
1	28.01	1.0	18,057.4	0.08	0.35
2	28.01	1.0	18,327.1	0.08	0.35
3	28.01	1.0	18,318.1	0.08	0.35
Averages:		**1.0**	**18,234.2**	**0.08**	**0.35**

ppmv: parts per million (volume), in equivalents of the calibration gas, and corrected for zero- and span- drift. Run averages were <1 ppm; reported as 1 ppm.

dscfm: dry, standard cubic feet per minute

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = ppmv * molecular weight * dscfm * Constant

Constant = 60 minutes/hour / (24.04 liters/gram-mole * 453,600 milligrams/pound * 35.31 ft^3/m^3)
$= 1.558*10^{-7}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

Table 5

Sulfur Dioxide Emissions Rate Test Results
Republic - Arbor Hills
Zink Flare Exhaust
Northville, Michigan
March 23, 2016

Test No.	Molecular Weight	Concentration (ppmv)	Flow Rate (dscfm)	Emission Rates (lb/hr)	Emission Rates (tpy)
1	46.01	27.94	18,057.4	3.62	15.84
2	46.01	30.59	18,327.1	4.02	17.61
3	46.01	32.00	18,318.1	4.20	18.41
Averages:		**30.2**	**18,234.2**	**3.95**	**17.29**

ppmv: parts per million (volume), in equivalents of the calibration gas, and corrected for zero- and span- drift.

dscfm: dry, standard cubic feet per minute

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = ppmv * molecular weight * dscfm * Constant

Constant = 60 minutes/hour / (24.04 liters/gram-mole * 453,600 milligrams/pound * 35.31 ft^3/m^3)
= $1.558*10^{-7}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

Table 6

Hydrogen Chloride Emissions Rate Test Results
Republic - Arbor Hills
Zink Flare Exhaust
Northville, Michigan
March 23, 2016

Test No.	Molecular Weight	Concentration (mg/m^3)	Flow Rate (dscfm)	Emission Rates (lb/hr)	(tpy)
1	36.46	3.23	18,057.4	0.22	0.96
2	36.46	1.61	18,327.1	0.11	0.48
3	36.46	2.40	18,318.1	0.16	0.72
Averages:		**2.41**	**18,234.2**	**0.16**	**0.72**

mg/m^3: milligrams per cubic meter

dscfm: dry, standard cubic feet per minute

lb/hr: pounds per hour

tpy: tons per year

Equations

lb/hr = mg/m^3 * dscfm * Constant

Constant = 60 minutes/hour / (453,600 milligrams/pound * 35.31 ft^3/m^3)
= $3.746*10^{-6}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

Table 7

Non-methane Organic Compound Emissions Rate Test Results
Republic - Arbor Hills
Zink Flare Exhaust
Northville, Michigan
March 23, 2016

Test No.	Molecular Weight	Concentration (ppmv)	Flow Rate (scfm)	Emission Rates (lb/hr)	(tpy)
1	44.10	1.0	19,887.0	0.14	0.60
2	44.10	1.0	19,231.0	0.13	0.58
3	44.10	1.0	19,911.0	0.14	0.60
Averages:		**1.0**	**19,676.3**	**0.14**	**0.59**

ppmv: parts per million (volume), in equivalents of the calibration gas (proane), wet-basis
Note: Run averages were <1 ppm; reported as 1 ppm.

scfm: standard cubic feet per minute (wet)

lb/hr: pounds per hour

tpy: tons per year

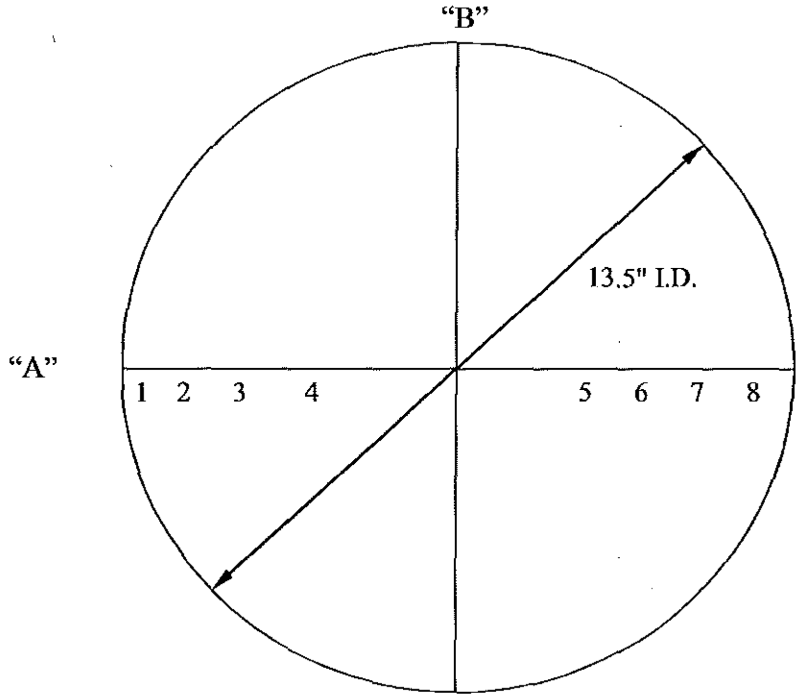
Equations

lb/hr = ppmv * molecular weight * scfm * Constant

Constant = 60 minutes/hour / (24.04 liters/gram-mole * 453,600 milligrams/pound * 35.31 ft^3/m^3)
= $1.558*10^{-7}$

tpy = lb/hr * 8,670 hours/year * 1 ton/2,000 pounds

AQS Inc.



Traverse Point Number	Distance From Wall (inches)
1	0.50
2	1.42
3	2.62
4	4.36
5	9.14
6	10.88
7	12.08
8	13.00

Figure 1
Traverse point numbers and locations, Zink enclosed flare inlet
Arbor Hills Landfill, Northville, Michigan.

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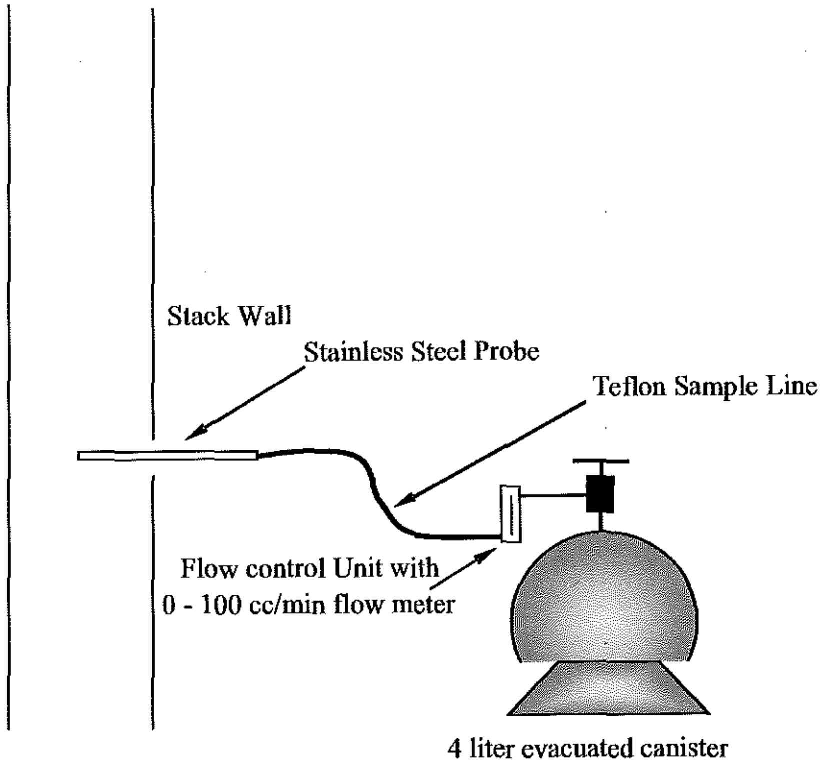

Figure 2
USEPA Method 3C/25C sample train for the enclosed flare inlet duct at Arbor Hills Landfill, Northville, Michigan.

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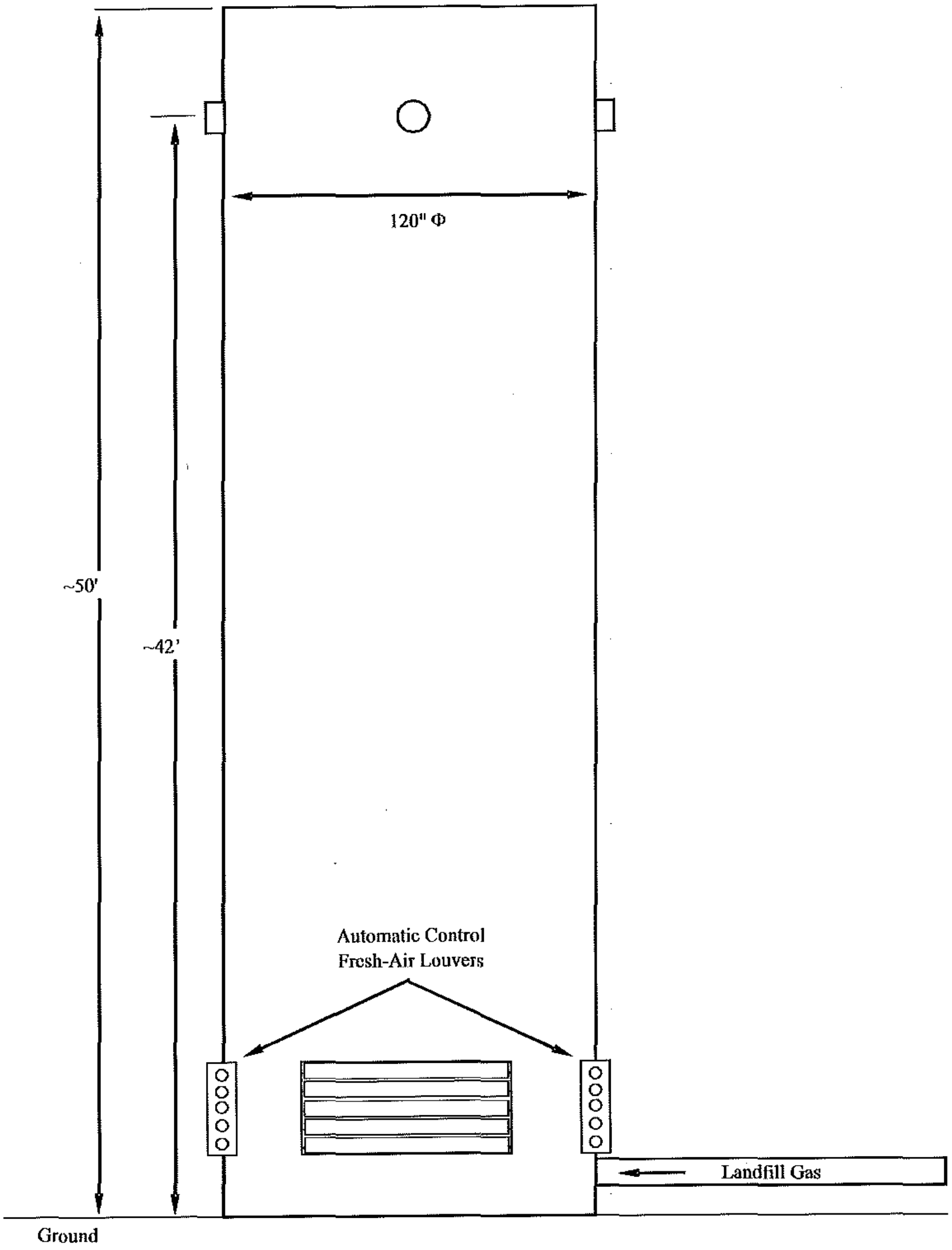

Figure 3
Representative enclosed flare and approximate exhaust sample port locations at Arbor Hills Landfill, Northville, Michigan.

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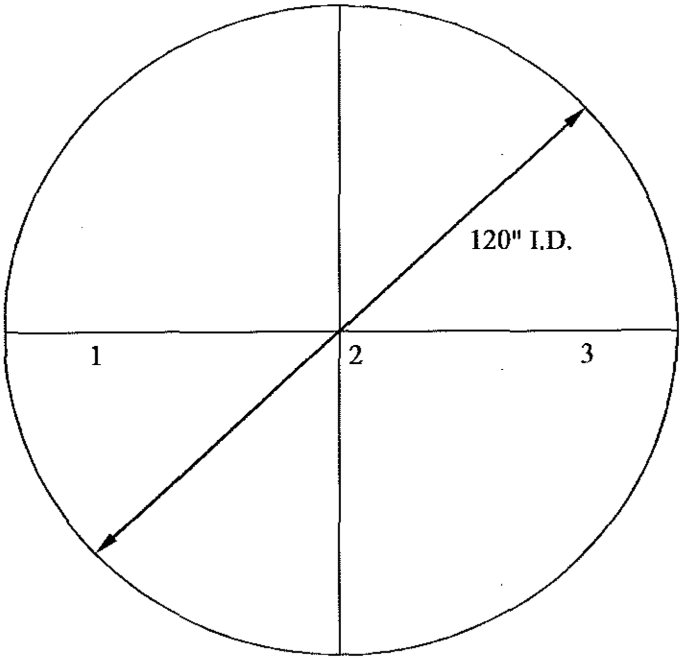

Stratification Point Number	Distance from Wall (inches)
1	20
2	60
3	100

Figure 4
Exhaust CEMS traverse point numbers and locations, enclosed flare exhaust, Arbor Hills Landfill, Northville, Michigan.

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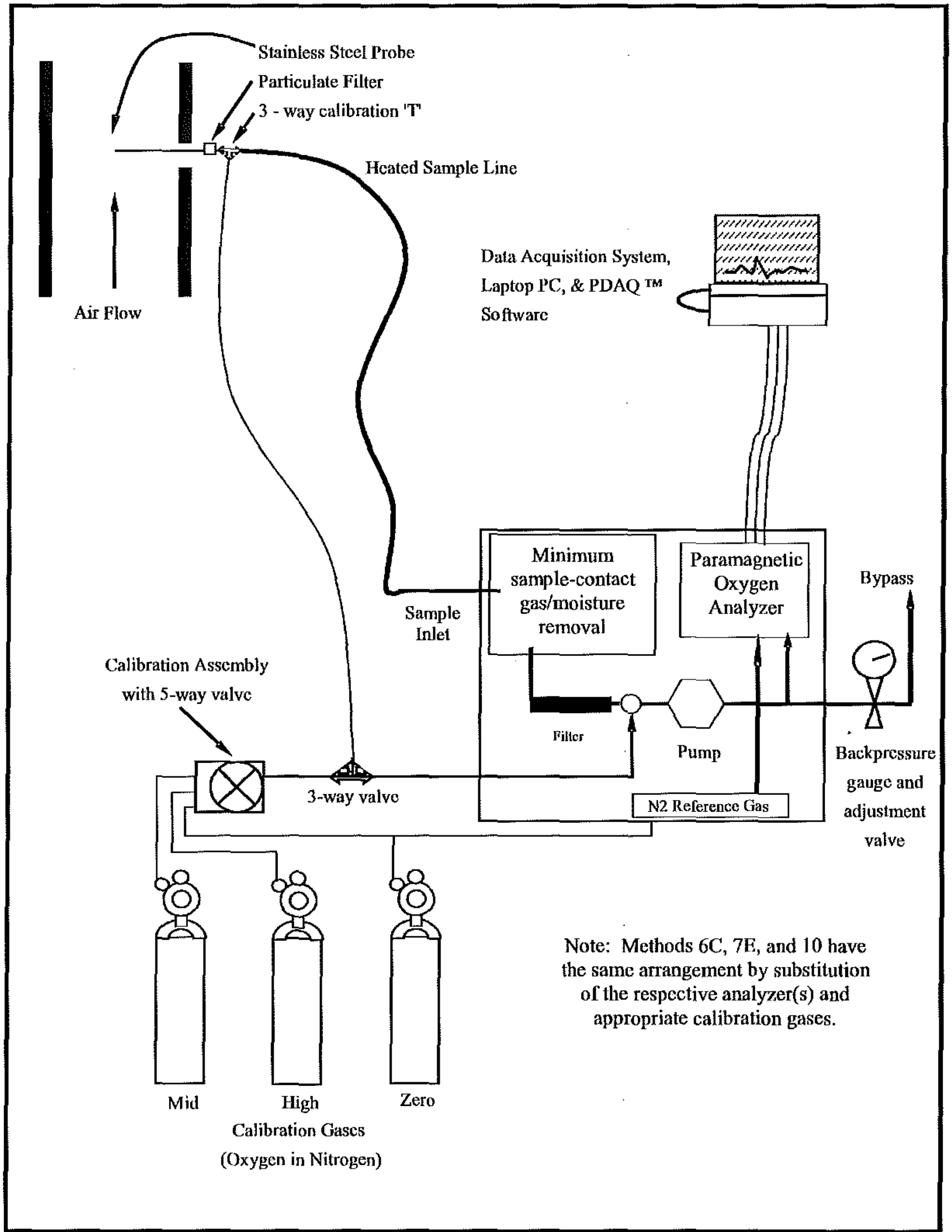

Figure 5
USEPA Method 3A / 6C / 7E / 10 sample train for the enclosed flare exhaust stack at Arbor Hills Landfill, Northville, Michigan.

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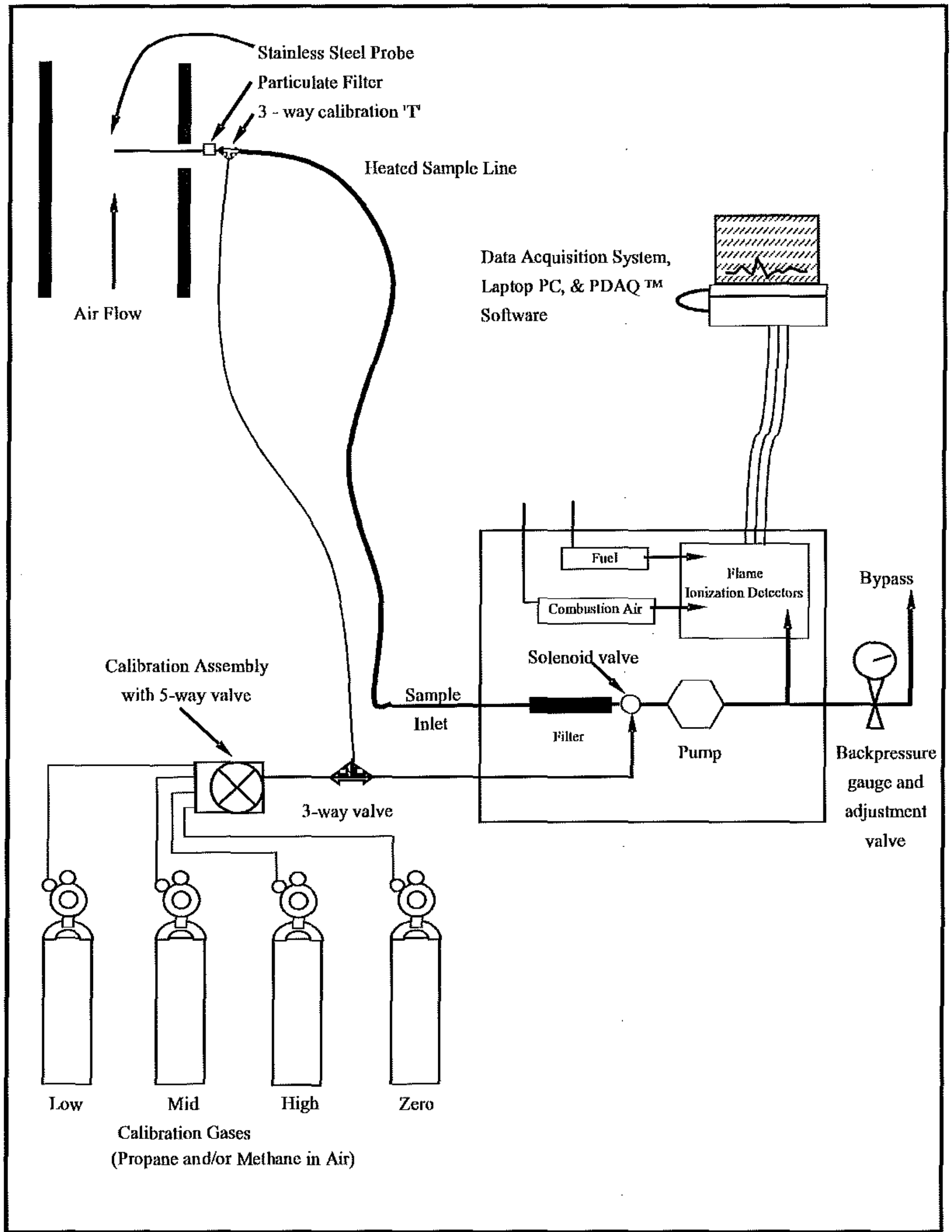

Figure 6
USEPA Method 25A sample train for the enclosed flare exhaust stack at Arbor Hills Landfill, Northville, Michigan.

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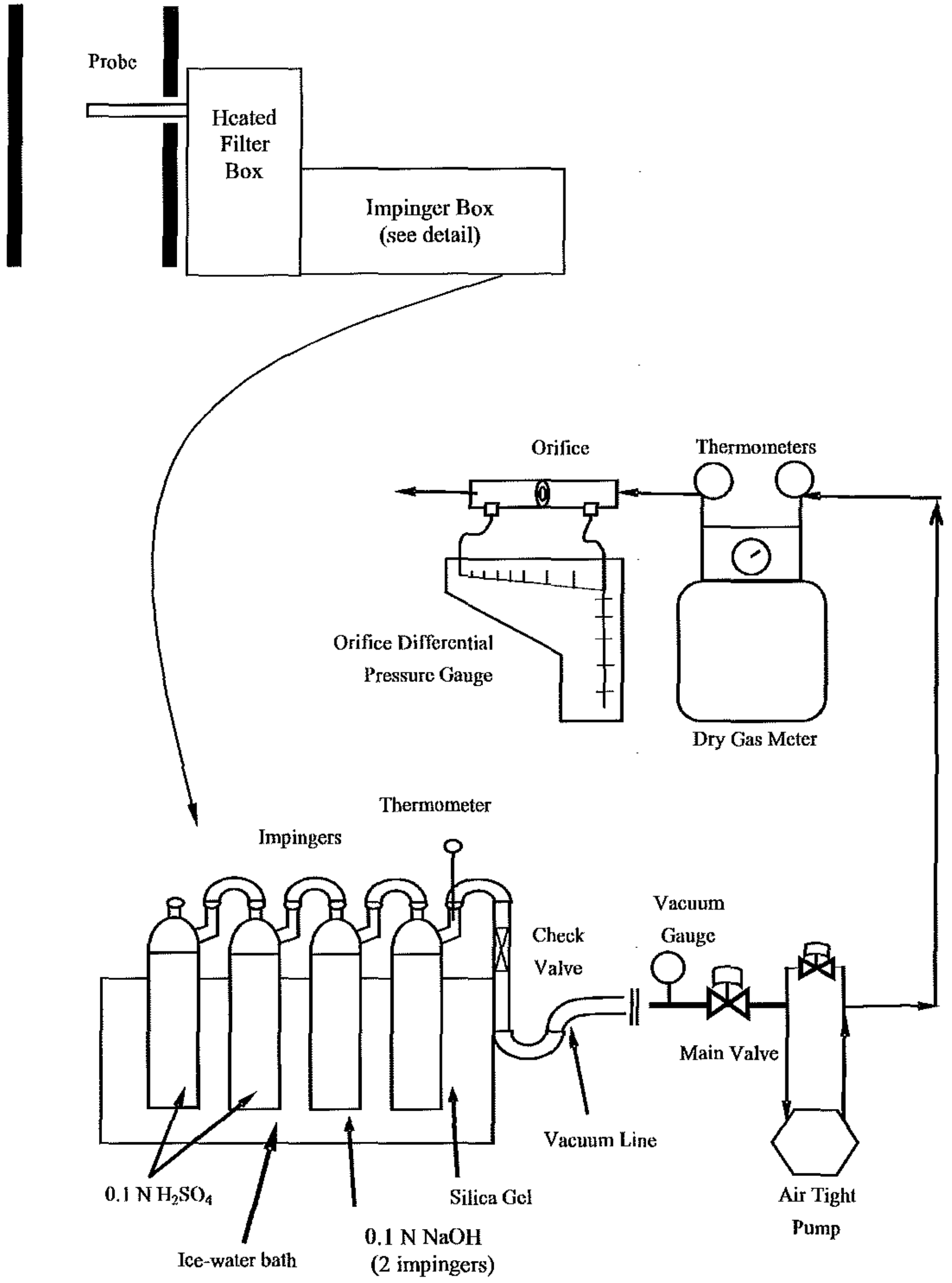

Figure 7
USEPA Method 4 / 26 sample train for the enclosed flare exhaust stack at Arbor Hills Landfill in Northville, Michigan.

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