

Infinis Energy Services Limited

Periodic monitoring of raw landfill gas

Lamby Way Landfill Site

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| Report | LSO150412-TG |
| Date | 15 May 2015 |
| Version | 1 |





PERIODIC MONITORING OF RAW LANDFILL GAS

LAMBLY WAY LANDFILL SITE

Report prepared for

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Issue history

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| First issue | | | |

1 Introduction

Infinis Energy Services Limited (Infinis) contracted Environmental Scientifics Group (ESG) to undertake monitoring of the landfill gas supply to its combustion operations at the Lamby Way Landfill site.

2 Test methodology

Infinis requested that duplicate samples of landfill gas be collected and analysed for the priority trace components (LFGTGN08, Table 1.1) specified in Environment Agency guidance (Guidance for monitoring trace components in landfill gas – LFGTGN08 v3.0, 2010). The test methodology should be in accordance with that specified within LFGTGN08.

Based on LFGTGN08 the priority trace gas components are sampled using a combination of four sampling media as shown in Table 1.

Table 1 Sampling media and analytical methods

| Trace component | CAS number | Sampling method | Analytical method |
|---------------------------------|------------|---------------------|-------------------|
| 1,1-dichloroethane | 75-34-3 | Dual solid sorbent | ATD-GC-MS |
| 1,2-dichloroethane | 107-06-2 | Dual solid sorbent | ATD-GC-MS |
| 1,1-dichloroethene | 75-35-4 | Dual solid sorbent | ATD-GC-MS |
| 1,2-dichloroethene | 540-59-0 | Dual solid sorbent | ATD-GC-MS |
| 1,3-butadiene | 106-99-0 | Dual solid sorbent | ATD-GC-MS |
| 1-butanethiol | 109-79-5 | Dual solid sorbent | ATD-GC-MS |
| 1-pentene | 109-67-1 | Dual solid sorbent | ATD-GC-MS |
| 1-propanethiol | 107-03-9 | Dual solid sorbent | ATD-GC-MS |
| 2-butoxyethanol | 111-76-2 | Dual solid sorbent | ATD-GC-MS |
| Arsenic (as As) | 7440-38-2 | Charcoal | ICP-MS |
| Benzene | 71-43-2 | Dual solid sorbent | ATD-GC-MS |
| Butyric acid | 107-92-6 | Dual solid sorbent | ATD-GC-MS |
| Carbon disulphide | 75-15-0 | Dual solid sorbent | ATD-GC-MS |
| Chloroethane | 75-00-3 | Dual solid sorbent | ATD-GC-MS |
| Chloroethene (vinyl chloride) | 75-01-4 | Dual solid sorbent | ATD-GC-MS |
| Dichloromethane | 75-09-2 | Dual solid sorbent | ATD-GC-MS |
| Dimethyl disulphide | 624-92-0 | Dual solid sorbent | ATD-GC-MS |
| Dimethyl sulphide | 75-18-3 | Dual solid sorbent | ATD-GC-MS |
| Ethanal (acetaldehyde) | 75-07-0 | Silica gel/2,4 DNPH | HPLC-DAD |
| Ethanethiol | 75-08-1 | Dual solid sorbent | ATD-GC-MS |
| Ethyl butyrate | 105-54-4 | Dual solid sorbent | ATD-GC-MS |
| Furan (1,4-epoxy-1,3-butadiene) | 110-00-9 | Dual solid sorbent | ATD-GC-MS |
| Hydrogen sulphide | 7783-06-4 | Charcoal | IC |
| Methanal (formaldehyde) | 50-00-0 | Silica gel/2,4 DNPH | HPLC-DAD |
| Methanethiol | 74-93-1 | Dual solid sorbent | ATD-GC-MS |
| Styrene | 100-42-5 | Dual solid sorbent | ATD-GC-MS |
| Tetrachloromethane | 56-23-5 | Dual solid sorbent | ATD-GC-MS |
| Toluene | 108-88-3 | Dual solid sorbent | ATD-GC-MS |
| Trichloroethene | 79-01-6 | Dual solid sorbent | ATD-GC-MS |

ATD – automated thermal desorption

GC-MS – gas chromatography and mass spectrometry

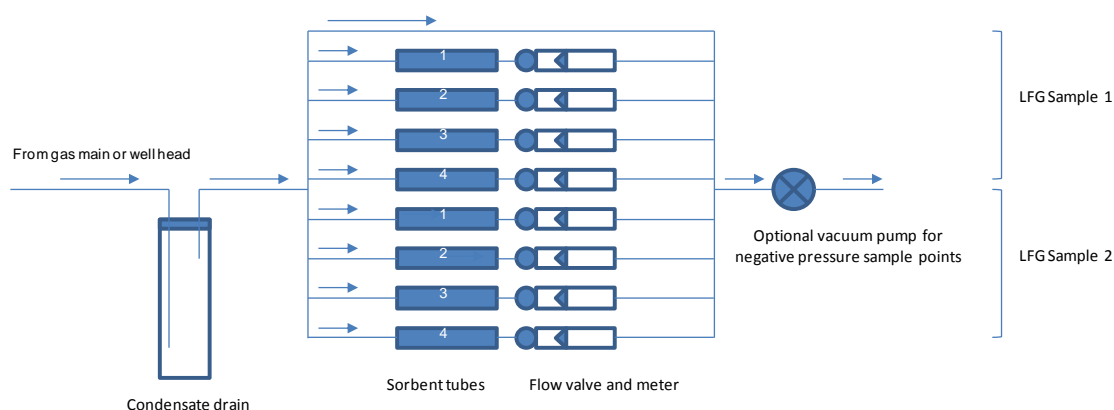
ICP-MS – inductively couple plasma/mass spectrometry

HPLC-DAD – high performance liquid chromatography and diode array detection

IC – ion chromatography

Sampling for all components is undertaken simultaneously using a multiple stream sampler as shown in Figure 1.

Figure 1 Landfill gas sampling arrangement



A sample is taken from either the gas main or well head and passed through a condensate drain to remove excess moisture. The sample gas is then split to pass through a series of eight regulated rotameters arranged in two banks of four. There is also a bypass stream for excess sample. This allows the duplicate simultaneous sampling at regulated flow rates onto four sampling media. The flow rates and sampling duration are set in accordance with LFGTGN08 requirements as summarised in Table 2.

Table 2 Sampling media and analytical methods

| Media | Target species | Sampling rate (ml/min) | Sampling duration (min) | Sample volume (l) |
|---------------------------------------|-------------------|------------------------|-------------------------|-------------------|
| Dual solid sorbent (Tenax/Sulficarb) | VOCs | 20 | 10 | 0.2 |
| Silica gel and 2,4 DNPH (SKC 226-119) | Aldehydes | 20 | 50 | 1.0 |
| Activated carbon 1 (SKC 226-09) | Arsenic | 100 | 50 | 5.0 |
| Activated carbon 2 (SKC 226-09) | Hydrogen sulphide | 100 | 50 | 5.0 |

In the case of negative pressure sources it is necessary to employ a vacuum pump at the sampler's common outlet. This is not normally required with positive pressure systems

This results in two duplicate samples of landfill gas with each sample comprising the four sub-samples above covering all of the priority trace components within Table 1.

The samples are subject to the analytical procedures described in Table 1 to provide a mass on the collected sample which can then be related to the volume of gas sampled to provide a component concentration in the sampled landfill gas.

The sampling followed internal procedure GAS15 and is accredited under test certificate 1015.

3 Site information

| Sample point details | | | |
|----------------------------|----------------------|--|-------------------------|
| Date | 15 April 2015 | Site | Lamby Way landfill site |
| Ambient temperature | 11 °C | Atmospheric pressure | 102.2 kPa |
| Monitoring organisation | ESG UKAS 1015 | Analytical laboratory | ESG UKAS 1015 |
| Location of sampling point | Gas main to compound | Area of influence of collection system sampled | All |
| Type of sample point | 1/4" Tefen | Temperature of gas | 12°C |
| Vacuum on sample point | 1022 mb | Type of waste | Not recorded |
| Status of gas system | Active | Age of waste | Not recorded |

4 Preliminary checks and field measurements

| Parameter | | Concentration |
|--------------------------|------|---------------|
| Methane | % | 60 |
| Carbon dioxide | % | 33 |
| Oxygen | % | 0.1 |
| Nitrogen (by difference) | % | 6.9 |
| Hydrogen sulphide | ppmv | 75 |
| Carbon monoxide | ppmv | 2 |

*carbon monoxide is measured with a hydrogen sulphide filter in the sampling line.

Preliminary bulk gas measurements were undertaken using a Gasdata LMSxi electrochemical cell analyser (no 1227). Reported measurements are spot readings following gas sampling for a period of 5 minutes.

5 Results of landfill gas analysis

The results of the sampling and analysis are summarised in Table 3 below.

Table 3 Priority trace component measurement results

| Parameter | | Concentration ($\mu\text{g}/\text{m}^3$,STP) |
|-------------------------|---|---|
| 1 Pentene | | 2681 |
| 1,1-Dichloroethane | | 137 |
| 1,1-Dichloroethylene | | 137 |
| 1,2-Dichloroethane | * | 172 |
| 1,2-Dichloroethylene | | 378 |
| 1,3-Butadiene | | <24 |
| 1,4 epoxy 1,3 butadiene | | 206 |
| 1-Propanethiol | | <69 |
| 2-butoxyethanol | | <69 |
| Benzene | * | 2922 |
| Butyric acid | | <137 |
| Carbon disulphide | | 2647 |
| Carbon tetrachloride | * | <34 |
| Chloroethane | | <34 |
| Dichloromethane | * | 15811 |
| Dimethyl disulphide | | <34 |
| Dimethyl sulphide | | 69 |
| Ethyl butyrate | | 206 |
| Ethyl mercaptan | | <103 |
| Methyl mercaptan | | <344 |
| N-Butyl mercaptan | | <103 |
| Styrene | * | 172 |
| Toluene | * | 10655 |
| Trichloroethylene | * | 103 |
| Vinyl chloride monomer | | <103 |
| Arsenic | * | 3 |
| Hydrogen sulphide | * | 329962 |
| Acetaldehyde | * | 72 |
| Formaldehyde | * | 206 |

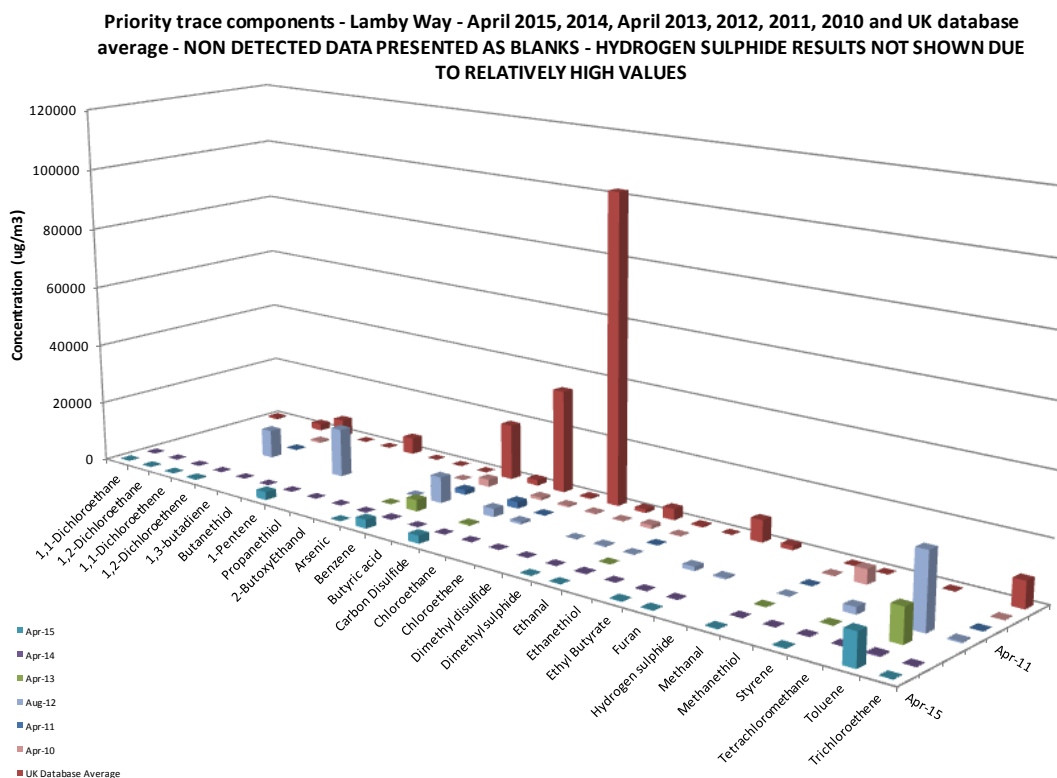
* indicates result is UKAS accredited

< indicates result is below the method limit of detection

The above reported results are the maximum concentrations measured for each parameter in two samples.

The maximum results of the current analyses are compared with historical data and the UK database average in Figure 2.

Figure 2 Historical priority trace component analysis results at Lamby Way



6 NOTES

Sampling of landfill gas was undertaken in accordance with ESG procedure GAS15 and is UKAS accredited under certificate 1015.

Analysis of collected samples was undertaken by ESG's Bretby laboratory. The analytical results which fall within ESG's scope of accreditation under certificate 1015 are identified in Table 3.

The priority component measurements which can be considered to be within the scope of UKAS accreditation are identified in Table 3.

Any interpretations and opinions expressed are outside of the scope of UKAS accreditation.

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