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1.0 SCOPE

This Leak detection and Repair (LDAR) Programme details the methodology used to locate, identify, and mitigate against fugitive emissions to air of Volatile Organic Compounds (VOC), including methane.

It is a live document that will be updated accordingly throughout the operation of the AD plant. The environmental permit requires that diffuse emissions of VOCs including methane are monitored every 6 months in accordance with the LDAR Programme.

Appropriate Measures for Biological Waste (AMfBT) (Section 11.9) requires that the LDAR programme consider all potential sources of leakage within the LDAR plan which links to regular monitoring and the Site Dangerous Substances and Explosive Atmospheres Regulations (DSEAR Plan). In Section 4 of this report, Table 1 includes the details of the site-specific sources identified and the methodology and frequencies for addressing each source.

The LDAR plan includes:

- a map of the site and an inventory that identifies locations (point and area sources) for potential emissions
- a method for locating unknown emission sources
- estimates of the type and volume of release from each leak location
- prioritised locations (from highest risk to lowest risk) based on the potential quantity of release, its environmental impact, and DSEAR
- monitoring methods and frequency to quantify significant emissions
- mitigation measures

2.0 RESPONSIBILITIES

The Site Manager is responsible for the day-to-day operation of Three Maids AD Plant and will also act as the Technically Competent Manager (TCM), They hold the necessary (WAMITAB) qualification. The Site Manager is supported by the wider operational business, and Company Directors. With specific regard to LDAR work this includes the commissioning and engineering teams, which include several qualified and experienced gas engineers as well as wider team with relevant Anaerobic Digestion construction and operational experience.

It is the responsibility of the **Site Manager** to ensure that monitoring of diffuse emissions of VOCs, including methane, from the sources identified in this programme is carried out in accordance with the schedule. This includes engaging an **external** specialist contractor to undertake **annual monitoring** and ensuring that **internal LDAR checks** are completed at least

once every **six months**. The Site Manager is also responsible for reviewing the results, ensuring timely follow-up of any identified leaks, and maintaining accurate records to demonstrate compliance.

3.0 SUPPORTING DOCUMENTS

ACD 007r Leak Detection Internal Checks
ACD 007x Site Safety, Operational & Equipment Checklist
ACD 007o Compliance Matrix
Site ATEX Plan

4.0 PROCESS DESCRIPTION

This section provides a summary of the treatment process described fully in section 5 of the EMS Manual for the Site.

The Site will treat via anaerobic digestion (AD) feedstock comprising livestock waste (poultry litter and slurry), energy crops and crop residues; as well as dirty water and several non-hazardous liquid wastes to supplement process water use. Biogas will be upgraded on Site into biomethane which will be transported offsite for injection at a central gas to grid injection point or may be used within two combined heat and power (CHP) engines on Site to supply the heat and electricity required to run and maintain the AD process. In addition, carbon dioxide (CO_2) from the biogas will be captured.

Anaerobic digestion process:
There are three Primary digesters which operate in parallel. The two Primary digesters feed into the three Post digesters. The digesters all have pressure and vacuum relief valves (PVRVs) which will release biogas or take in air in the event of an overpressure or under pressure biogas situation respectively. The PVRVs are a necessary safety feature for an AD plant; but will only be used as a contingency to maintain structural integrity of the tank and dome structures. During normal operation the PVRVs will not operate.

Gas Storage:
Th Biogas generated by the digestion process is stored within the double membrane gas holders located above Digesters 1, 2 and 3. The total available gas storage capacity is approximately 5,118 m^3. Based on a theoretical maximum biogas production rate of approximately 2327 Nm^3/hr, this provides more than 2 hours of gas storage capacity, allowing for short-term process balancing and planned maintenance activities associated with the biogas upgrading system. Gas storage levels are managed and monitored via the SCADA control system.

Gas Upgrade Unit :
Raw biogas is also treated within the Biogas upgrade unit (BUU) through a series of steps:

- Biogas cooling to approximately 50C to remove water.
- Carbon filtration (2 No. filters to remove H2S and 1 No. filter for Volatile Organic Compounds (VOCs))
- Compression

- Three-stage membrane filtration which separates the biogas into methane (CH4) and carbon dioxide (CO2). The CO2 is passed to the CO2 capture unit, and the CH4 is injected through Grid entry unit.

Carbon Dioxide Recovery and Storage

The CO2 is treated in the CO2 capture unit via the following:

- Compression;
- Molecular sieve dryer to remove any moisture that may remain;
- Fine filter to remove any impurities;
- Liquefication – traces of non-condensable gases that may contaminate the CO2 remain as gases when the CO2 becomes liquid in the liquefier; and
- Storage in 2. No CO2 storage tanks (100 m3 each). CO2 is stored pending removal off site via a filling station.

Gas and Heat Management

Biogas may also be used in one of the CHPs or in the emergency boiler. Excess biogas and out of specification biomethane is sent to the emergency flare.

5.0 ASSET IDENTIFICATION AND MONITORING FREQUENCY:

The Site's plant and infrastructure have been reviewed to identify potential contributors to fugitive emissions of VOCs, including methane. The assets identified and associated monitoring requirements are described in Table 1 below.

The site currently uses a **Gazomat™** handheld remote methane detector (RMD) routinely. Methane is measured via Tunable Diode Laser Absorption Spectroscopy (TDLAS). The device can be used at a detection distance of 100m and has:

- Sensitivity: 5ppm*m
- Detection range: 0-99,999 ppm*m
- Measurement accuracy: ±10%

The advantages of the RMD are that it can determine the methane level at the leakage spot and has a low detection limit, but the Identification of the leakage spot can be more difficult. This in house device will be used routinely to verify daily visual findings and observations of pipework and structures on site. If detected leaks will be fixed in line with the leak repair programme detailed in this document.

Optical Gas Imaging (OGI) using hand-held cameras to enable visualisation of gas leaks will be carried out by a suitably trained individual in accordance with the Standards listed in the *Monitoring Methodology* of this LDAR Plan. OGI surveys will be conducted **externally at least once every 12 months and internally at least once every six months (ACD 007r Leak Detection Internal Checks).**

A Site Layout detailing all assets detailed within Table 1 is provided as Appendix A. The Permit Boundary & Emission Point Plan is provided as Appendix-B.

A DSEAR Assessment has been undertaken. Appendix C is the Hazardous/Ex Zoning Drawing. This is held on site and made available to all contractors.

Table 1 Potential source, type and risk of leakage from identified assets

Asset	Priority	Priority Rational
2 no. Liquid Feedstock Tank	Medium	Potential for gas production from stored liquid feedstocks. The tank is fully enclosed with a vent which benefits from a carbon filter.
Process water tank	Medium/Low	Potential for low levels of gas production from process water tanks.
Manure Reception Building	Medium/Low	The Manure Reception building is fully enclosed and held under negative pressure with air extracted and treated via the Odour Control Unit (OCU) which is constantly monitored. A6 Emission abatement plant stack
Solid feed systems	Medium	Manure hopper is internal to the Manure Reception Building which benefits from an OCU which is constantly monitored. External feed hoppers are fed only with silage and extruded straw which have low potential to release methane prior to anaerobic digestion. SCADA linked Level sensors installed in the Primary digestors to prevent digestion material falling below feed screw inlet.
Primary Digester 1	High	High volumes of gas generated within the digesters and transferred via pipework. Biogas levels monitored by SCADA. The maintenance of the tanks is captured in the site's **ACD 007x Site Safety, Operational & Equipment Checklist, ACD 007o Compliance Matrix** and with integrity inspections undertaken every 5 years. Integrity of structures routinely checked with methane laser device. PVRV on Primary Digester 1 PVRV on Primary Digester 2 PVRV on Primary Digester 3 PVRV on Secondary Digester 1&2 PVRV on Separated liquid holding tank The PVRVs are a necessary safety feature for an AD plant; but will only be used as a contingency to maintain structural integrity of tank and dome structures. The seating of the PVRVs is checked daily in accordance with the Daily Check Sheet (**ACD 007x Site Safety, Operational & Equipment Checklist**).
Primary Digester 2	High	
Primary Digester 3	High	
Secondary Digester 1 & 2	High	
Separated liquid digestate holding tank	High	
Mixed fittings and pipework	High	Pipework will be checked as part of daily checks (**ACD 007x Site Safety, Operational & Equipment Checklist**). Integrity routinely checked with methane laser device.
Gas pipes	High	

Asset	Priority	Priority Rational
Double membrane roof to Primary Digesters (air blower vent). Roof and cover fixings.	High	High volumes of gas stored within dome. Biogas levels monitored by SCADA, with pressure sensors installed within dome alerting SCADA as to the level of fullness within each storage dome. Integrity of structures will be checked as part of daily checks (**ACD 007x Site Safety, Operational & Equipment Checklist**) and routinely checked with methane laser device.
Biogas flare stack	Medium	Flare usage is minimised; under certain operating conditions (e.g. extended maintenance of the CHP) or malfunctions (e.g. malfunction of the CHP), surplus biogas may be managed in a safe manner. The SCADA system manages the biogas treatment, gas distribution system and emergency flare if required. In the case of off specification biomethane being produced by the BUU, it will be blended back together with the associated CO2, which will also be out of specification, and this pure biogas stream will be returned to the gas storage dome above the Tertiary/Secondary Digester. A3 Emergency flare stack
CHP (methane slippage)	High	2 No. Quanto Dual fuel CHPs with heat exchangers. Frequency of use, high throughput of gas. The CHP is maintained under contract. This is captured on the Maintenance Schedules (**ACD 007x Site Safety, Operational & Equipment Checklist, ACD 007o Compliance Matrix**). The CHP emissions are tested and methane slippage calculated. A1 CHP engine stack 1 A2 CHP engine stack 2
Emergency boiler	High	Treated biogas from the AD plant may be burnt in the Emergency Boiler (500kW for biogas, 560 kW for natural gas) to provide heat for the AD process, if one or more of the CHPs is non-operational. The boiler is maintained under contract. The boiler is for emergency only. A4 Emergency boiler stack
Biogas upgrade unit (BUU)	High	High volumes of gas processed. Under normal operating conditions there will be no emissions from the BUU. There is a PRV on the BUU (**A7**) which will only operate under abnormal operating conditions. If the CO_2 recovery plant is not operating, then CO_2 is released from the CO_2 stack on the BUU (**A8**) as is normal practice when CO_2 capture equipment is not installed. There should not be an increase in methane released under this scenario. Integrity routinely checked with methane laser device.

Asset	Priority	Priority Rational
Compressors	Medium	A11 Compressor PRV 1 A12 Compressor PRV 2 The PRVs are a necessary safety feature for the compressor; but will only be used as a contingency to maintain structural integrity. The seating of the PRVs is checked daily in accordance with the Daily Check Sheet (**ACD 007x Site Safety, Operational & Equipment Checklist**).
2 No. Gas valves/condensate chambers (Condensate sump 1&2)	Medium	Potential for release of diffuse emissions from gas throughput and emissions from condensate within.
Gas booster	Low	Volume of gas contained within pipework. Potential for corrosion of gas carrying pipework and escape at joints worn over time.
Gas carrying pipework	Medium	Volume of gas contained within pipework. Potential for corrosion of gas carrying pipework and escape at joints worn over time.
Gas valves	Medium	Potential for corrosion of valves and for seal leakage.
CO_2 recovery unit and 2 CO_2 storage tanks	Medium	A9 Carbon dioxide recovery plant PRV1 A10 Carbon dioxide recovery plant PRV2 The PRVs are a necessary safety feature for the compressor; but will only be used as a contingency to maintain structural integrity. The seating of the PRVs is checked daily in accordance with the Daily Check Sheet (**ACD 007x Site Safety, Operational & Equipment Checklist**).
Digestate Buffer Tank	Low	Digestate should be stable 71-day hydraulic retention time on process. Buffer tank fully enclosed.
Digestate separation unit	Low	Digestate fibre should be stable 71-day hydraulic retention time on process. Separation carried out within an enclosed bay to reduce potential for emissions.
Digestate storage tank	Medium/ Low	Liquid digestate has been treated within AD process with 54-day retention time so should be stable when stored. PVRV on liquid digestate storage tank is a necessary safety device as gases are captured via pipework back into gas line.

In accordance with the requirements of Table 1, in addition to checks carried out by site operatives using the RMD and internal LDAR checks every six months; a suitably trained individual will carry out 12 monthly leak detection surveys with an OGI Gas Detection Camera

and then quantify any leaks found using specialist Software. A method statement from the contractor must be included with results which summarises the steps taken by during the survey.

In summary, the following steps should be followed:

- View all VOC containing areas specified within Table 1 with the OGI Camera.
- Take Video evidence and number any fugitive emissions viewed by camera.
- Tag and identify all leaking components.
- Capture still image showing tagged up leaking component.
- Fill in Spreadsheet to show details for each leak found.
- Create Video on each leak. Ideal distance from leak point being approx. 2-3m.
- Create report to show all findings (Remote).
- Provide Report and all Video Evidence to Client (Remote).

The LDAR Plan monitoring shall be carried out using the techniques included in the following Standards:

- BS EN 15446:2008, Fugitive and diffuse emissions of common concern to industry sectors – Measurement of fugitive emission of vapours generating from equipment and piping leaks
- BS EN 17628:2022, Fugitive and diffuse emissions of common concern to industry sectors – Standard method to determine diffuse emissions of volatile organic compounds into the atmosphere.
- BS ISO 15259:2023, Air Quality – Measurement of stationary source emissions – Requirements for measurement sections and sites and for the measurement objective, plan and report

Type and quantity of emission

Specialist Quantitative Optical Gas Imaging (QOGI) software is used to facilitate the quantification of hydrocarbon gas leaks recorded during the survey.

The OGI Camera can store the videos taken on Site for later use, allowing the files to be downloaded and assessed, with gases quantified using the QOGI software after the fact.

If further quantification of the size of a leak is required, the RMD will also be used.

7.0 RECORDS

Survey reports will be issued by the monitoring contractor following each survey. These records will be retained and made available to the Environment Agency.

Following any repairs undertaken because of leaks identified within the LDAR survey, results of a follow up survey will be undertaken and recorded to confirm that the repair has been sufficient.

8.0 LEAK REPAIR

LDAR survey reports issued following each survey will detail any leaks identified during the inspection. Plans for repairs for any leaks identified will be initiated immediately and carried out based on a risk targeted approach; with the contractor assigning a level of risk to each leak depending on the scale of the emission and any accompanying risk factor, e.g. proximity to ignition sources, human receptors etc.

Where necessary, temporary repairs may be required to prevent further losses while awaiting permanent repairs by specialist contractors.

All repairs will aim to be undertaken as soon as possible and no later than 6 weeks following the LDAR report being issued and areas of repair will be resurveyed to confirm the repair has been successful once complete.

9.0 REPORTING

Leak Detection and Repair (LDAR) survey reports will be submitted to the Environment Agency annually, in accordance with the requirements of the site permit.