POLLUTANT GASES: LEAK DETECTION AND REPAIR

Summary

The following guidance outlines the key steps that should be taken to mitigate fugitive emissions to enhance the resilience of biogas plants. It supports Module 5: Maintaining Equipment and Facilities from the Anaerobic Digestion and Certification Scheme International published by the World Biogas Association (WBA).

Leak Detection and Repair (LDAR) is essential for maintaining site integrity while minimising the risk of harmful and potentially explosive gas leaks. This process helps prevent environmental contamination and ensures the safety of personnel by identifying and fixing leaks before they become hazardous.

An LDAR programme is a systematic approach designed to identify, monitor, and fix leaks of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) from equipment. To complete this task successfully and meet the requirements of national Environmental Regulations, operators must ensure the competency and use of the correct procedures and equipment of the personnel undertaking the LDAR survey.

If the task is completed in a timely, competent and correct manner, the level of risk to plant and personnel will be mitigated to a safe and acceptable level.

The success of an effective LDAR programme is dependent on multiple factors listed below and covered into this OGN:

- The quality of the record keeping system
- The competency of the operator
- The type of monitoring equipment used
- The amount and type of components monitored
- The frequency of surveys over an annual period
- How quickly repairs are being made.

The Regulatory Position

Most countries have environmental regulations that address fugitive emissions and LDAR is a commonly recommended or required practice for industrial processes like biogas plants, oil and gas, petrochemicals, and chemical manufacturing. These can be specific regulations, as found in the US, EU and UK, or encapsulated in wider regulation covering greenhouse gas and pollution control.

Environmental regulators like the US Environmental Protection Agency or UK Environment Agency require LDAR programmes to be in place. For example, multiple regulations enforce AD plants to conduct LDAR surveys, such as the UK Statutory Guidance SR2021 No6 of the Environmental Permitting, aligned to the European Union's BAT (best available technique) Conclusion 14 in the BREF (best available technique reference document) for Waste Treatment and the US Environmental Protection Agency (EPA) Protocols.

Where LDAR has historically been less uniformly enforced pressure is increasing to adopt the requirement through international agreements and foreign investment standards.

When the regulations are enforced, AD plants must carry out LDAR surveys based on stipulations imposed by their national requirements (frequency, limits and others). Plants that do not submit a LDAR programme to the relevant agency might not be allowed to carry their activities.

WBA strongly advises biogas operators to carry out LDAR inspections on a regular basis, even where there is currently no specific requirement to do so. The systematic approach to monitoring plant performance will reduce overall emissions of methane and other gases and improve the integrity of the AD plant, and ultimately, bottom line.

You must produce a LDAR programme using the techniques included in the following standards:

- 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.
- 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.
- ISO 15259:2023, Air Quality – Measurement of stationary source emissions – Requirements for measurement sections and sites and for the measurement objective, plan, and report.

Your LDAR programme must link to your regular monitoring, maintenance and relevant "explosive atmosphere regulations" or "hazardous area compliance". You must use it to quickly identify and carry out repairs, or to replace plant and equipment.

Most industrialised countries have developed dedicated regulations, such as: OHSA (Occupational Safety and Health Administration) in the US, ATEX (Atmosphères Explosibles) in the EU, DSEAR (Dangerous Substances and Explosive Atmospheres Regulations) in the UK. Where dedicated safety regimes have not been developed, most countries adopt or adapt standards from either ATEX or the International Electrochemical Commission, known is ICEx standards.

Case Studies

The National Physical Laboratory conducted a study on *Methane Emissions from Anaerobic Digestion,* finding that 85% of plants suffer from gas leaks and could lose 1m^3 of methane per hour, resulting in economic losses of approximately £5,000 a year.

A second Danish study from Ramboll and the Danish Energy Agency on *Methane Loss from Biogas Plants* revealed that emissions from plants could lead to losses averaging 2.5%. These leaks could be significantly mitigated through the implementation of appropriate procedures in accordance with the Anaerobic Digestion Certification Scheme International (ADCS Intl.), complemented by a well-structured Leak Detection and Repair (LDAR) programme.

LDAR Reporting

Based on the best practice guidance for LDAR, the following methodology is recommended and should be covered in your LDAR reports. A range of all emissions from plant operations must be considered (ammonia, hydrogen sulphide (H2S), methane, biogas, volatile organic compounds (VOCs) and others).

The following measures only apply to:

- anaerobic digestion (AD) (mesophilic and thermophilic digestion)
- mechanical-biological treatment (MBT)
- thermophilic anaerobic digestion (TAD) – (thermally accelerated, usually associated with Biofuels and thermal process).

1. A LDAR programme must include:

- A map of the site and inventory that identifies locations (point and area sources) for potential emissions, including valves, seals and housings, pumps, connectors, and compressors, and a description/characterisation of the potential emissions at each location.
- The methods for locating unknown emission sources: e.g., audio, olfactory, visual, OGI static camera survey, drones, satellite, etc.
- Estimates of the type, concentration and quantity of gas release from each leak location.
- Prioritised locations from highest to lowest risk based on potential release quantity, environmental impact, and compliance with explosive atmosphere or hazardous area regulations.
- Mitigation measures (implementation of repair protocols and monitoring methodologies, to prevent leaks and facilitate effective post-leak remediation).
- Proposed frequency of the LDAR. As a minimum, the programme must be in line with regulatory guidelines. (Increasing the frequency of whole site surveys to a quarterly basis can reduce fugitive emissions by 80%, says the UK EA.)
- Review and compare expected performance from the design stage with real-life data from SCADA monitoring to track efficiency changes or identify an increase in leaks over time.

2. Your LDAR programme must account for all potential leak sources, including but not limited to:

- double membrane roofs (air blower vent)
- roof and cover fixings
- pressure relief valves and vents
- feeding and digestate separation units
- gas pipes
- conveyors and presses
- compressors
- combined heat and power units (methane slippage)
- gas upgrading plant
- grid injection units
- reception storage

- digestate storage
- pits and sumps, for example condensate pits
- building containment
- bio-filters.

Note that each site is unique, and leaks could come from different point sources on each plant, emphasising the need for routine, professionally conducted LDAR surveys.

3. Consideration for LDAR Recording, Findings and Review

For findings:

- Organic source material used: storage capabilities and handling procedures
- Environmental factors: consideration of the weather conditions (fog, rain, high wind) and nearby receptors
- Design of plant and operational monitoring management: from pressure monitoring to times of feeds and others
- Use of suitable equipment.

For recording and review:

- LDAR must be part of the maintenance plan and detection, and repair must be recorded and kept for a minimum of 3 years.
- Evidence of repairs completion, following a Leak detection must be presented with a suitable action plan (from as simple as nuts and bolts to bigger jobs such as membrane replacement or others).
- Records of Year-on-Year comparisons of LDAR reports should be kept for at least 3 Years. This is to show "good practice" in maintaining site equipment and the improvement of the table emissions on a continuous basis.

4. You must identify and reduce emissions of greenhouse gases and other pollutant gases to air.

Recommended routine methods for identifying leaks:

- Daily inspection routines, with a focus on audio, visual or olfactory assessments by site operators, to ensure extra and effective monitoring is occurring. Sniffing equipment could be considered at this stage.
- Train staff to detect leaks using their senses (sight, sound, and smell) and apply maintenance protocols and in the use of monitoring tools like SCADA, to help identify anomalies in the gas production. Scotland EPA advise tests should be undertaken with gas storage at 90%. Consider further LDAR if no reasonable operating changes occurred, and yet the gas volume reduced.

Required inspections as part of the LDAR survey, performed by a certified and competent person:

- Sniffing, using an organic compound analysers and bag sampling, carried out to the requirements of EN15446 standards and the **US Environmental Protection Agency (EPA) Protocol for Equipment Leak Emission Estimates**.
- Optical Gas Imaging (OGI) cameras used to enable visualisation of gas leaks (this can be hand-held, drone mounted or other). This equipment will allow the work to be carried from a distance, removing the access and atmosphere risks to an operator during the inspection (will still require risk assessment procedures (RAMS) to effectively conduct LDAR).

Methods for quantifying emissions include but are not limited to:

- OGI Cameras, able to both detect and quantify leaks
- Flame Ionisation Detection (FID)
- Differential Absorption Lidar (DIAL, rarely used and expensive methods)
- Non-Dispersive Infrared Detection (NDIR).

To quantify the emission leakage that has been identified, the use of appropriate technologies to quantify emissions is recommended. Please refer to the ISO 14064 standard for quantifying and reporting greenhouse gas emissions.

EN 17628 and the **GGSS Guidance for Calculating Greenhouse Gas Emissions** provide guidance on the selection and use of multiple monitoring techniques of VOCs for LDAR programmes and how to report fugitive emissions.

Additional information on methane leakage from AD plants is available from the UK Department of Business, Energy and Industrial Strategy's **Methodology to assess methane leakage from anaerobic digestion plants** and the International Energy Agency's **Methane emissions from biogas plants**.

5. You must include the following LDAR survey details in your LDAR programme.

Details of the site where the LDAR survey was carried out, conditions at the time of the survey, and measurement objectives, including but not limited to:

- site name
- operator name
- permit number if available
- site processes (under normal operating conditions)
- date of the survey
- site operation on the date of the survey (for example, operating at full capacity or reduced load due to X and Y)
- weather conditions (including temperature, wind speed and wind direction)
- measurement objectives (for example: targeted processes, compounds or site areas).

Details of the organisation and personnel carrying out the LDAR survey, including:

- name and address of the monitoring organisation
- names, experience and qualifications of the personnel carrying out the monitoring
- accreditation status of the monitoring organisation
- documented procedures used for the LDAR survey and reporting
- quality assurance or quality control criteria
- the signature of the person approving the report.

Details of the detection equipment used for the survey, including:

- manufacturer, model and serial number of the detection equipment used for the survey
- surveyed gases (methane, VOCs...) detection limit of the detection equipment (for example, ≤60g/hr (OGI cameras), <10ppm (sniffer devices))
- details of equipment used (for example if an OGI camera is used, the spectral range of the camera in micrometer (μm)
- certification or verification status of the OGI camera (for example, to US EPA OOOO a specifications) (if applicable)
- calibration certificates for the equipment (where applicable).

Details of the survey carried out, including:

- areas of the site that were surveyed
- areas of the site that were not surveyed – including a reason why those areas were not surveyed
- leak definition used for the survey (for example, 500ppm, or detectable by the OGI camera at specified distances)
- duration of measurements, at individual components and specified site areas.

Details of the results, including:

- list of leaks identified during the survey
- annotated plan of site (or piping and instrumentation diagram) showing the precise locations of the identified leaks
- time when each leak was identified
- a description of each leaking component identified (for example, valve, flange and so on) – include the component reference number where available.
- a photograph of the leaking component showing the leak location
- severity of the leak – the measured methane concentration or leak rate, or the risk posed due to the component type and location (or both)
- emission estimate in kg/h for each component surveyed
- total site emission rate in kg/h, including uncertainty
- any non-conformities against the quality assurance or quality control procedures
- repairs to be conducted on faulty components and repair schedule. The repair schedule must include a proposed timescale for repairing the identified leaks, with justification (based on the severity of the leak or potential risk). This must be followed up by a post-repair report and/or evidence of remedial action taken.

LDAR Inspectors

It is imperative that inspectors have experience in the use of the emissions' monitoring equipment and experience of inspecting sites. Where applicable, they should have certified training competency, delivered from the equipment manufacturers. For instance, OGI cameras - the most used equipment to conduct LDAR surveys - require a minimum qualification for inspectors in the form of a certification of competence from the camera manufacturers.

This should also be accompanied by a full operational CV or proof of competencies for all LDAR staff (e.g.: competency programme certification, proof of following agencies and ISO guidelines, citation, records of previous jobs). This proof of competence must be defined and assured by the employer.

Further information on recommended technical requirements for suitable Inspectors can be found on the **EPA report**.

It is recommended that inspections are undertaken by an independent auditor and the report is submitted to the operator who has the responsibility to submit the LDAR report to their designated regulator. A **Demo report** is linked to this OGN to further assist you.

Conclusion

LDAR programmes are now a critical part of industrial operations, balancing environmental responsibility, regulatory compliance and economic benefits. As climate change concerns grow and regulations tighten, their importance will only continue to increase.

LDAR programmes help reduce emissions of volatile organic compounds (VOCs), methane, and other hazardous air pollutants (HAPs), which contribute to air pollution, climate change and smog formation. Aside from the critical environmental benefits, reducing leaks improves overall process efficiency, leading to lower operational costs.

New technologies, such as infrared cameras, drone-based sensors and artificial intelligence, have made leak detection more efficient and cost-effective. These advancements allow for faster and more accurate leak identification, reinforcing the importance of LDAR programs.

References

www.gov.uk/government/publications/environment-agency-methane-action-plan/environment-agency-methane-action-plan-2024-to-2026

Calculating greenhouse gas emissions on the Green Gas Support Scheme - GOV.UK

https://assets.publishing.service.gov.uk/media/66018aa3a6c0f7bb15ef920e/CD7.4.N_GR13___Best_Available_Techniques__BAT__Reference_Document_for_Waste_Treatment.pdf

Biological waste treatment: appropriate measures for permitted facilities - 11. Emissions control - Guidance - GOV.UK

www.gov.uk/guidance/control-and-monitor-emissions-for-your-environmental-permit

www.ofgem.gov.uk/sites/default/files/2024-03/EA%20response%20attach.%20Fugitive%20Emissions%20Strategy%20-%202022%2006%2001.pdf

www.ofgem.gov.uk/publications/green-gas-support-scheme-guidance

www.gov.uk/guidance/biological-waste-treatment-appropriate-measures-for-permitted-facilities/11-emissions-control

www.ofgem.gov.uk/sites/default/files/2024-03/EA%20response%20attach.%20Fugitive%20Emissions%20Strategy%20-%202022%2006%2001.pdf

Commission Implementing Decision (EU) 2018/1147 of 10 August 2018 establishing best available techniques (BAT) conclusions for waste treatment, under Directive 2010/75/EU of the European Parliament and of the Council (notified under document C(2018) 5070) (Text with EEA relevance)

CD2.2.A_BAT_14_Document_dated_22_February_2022.pdf

https://assets.publishing.service.gov.uk/media/6790fadecf977e4bf9a2f15f/mead-study.pdf

www.epa.gov/system/files/documents/2023-12/technical-fact-sheet.-using-optical-gas-imaging-in-leak-detection-appendix-k_0.pdf

https://demo.ossldar.com/demo-report/

Acknowledgements

The World Biogas Association (WBA) would like to thank our members for the input and support in developing this operational guidance note. We would also like to thank the ADBA (UK association) and other regulators from the UK for their valuable input and support during the development of the OGN.

Disclaimer

The information presented in this publication of the WBA Operational Guidance Note is made available for general information purposes without charge. It presents information to enable operators to comply with operational requirements. It is an advisory notice and not a comprehensive guide. Any reliance you place on this publication is strictly at your own risk. We disclaim all liability and responsibility arising from any reliance placed on this publication by you or anyone who may be informed of its contents.

WORLD BIOGAS ASSOCIATION
Fifth Floor, Riverside Building, County Hall,
Westminster Bridge Road, London, SE1 7PB
worldbiogasassociation.org | info@worldbiogasasscoiation.org
| @WBAtweets
| World Biogas Association
| https://tinyurl.com/fr28c4am