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BRE Global Client Report

DSEAR Assessment of Guy & Wright Ltd AD Plant

Prepared for: **Wiser Environment**

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Version History

Version	Date	Status	Changes Overview
1	13/06/2016	Second Issue	Updated with Gas Bag 1

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1 Introduction

This risk assessment and area classification exercise forms part of the legal requirements of the UK legislation covering fires and explosions from the presence of dangerous substances in the workplace. The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)[1] came into force on the 1st July 2003 and implements the European Union ATEX Directive[2]. In workplaces where potentially dangerous substances are present it is a requirement that the employer undertakes a risk assessment and also a hazardous area classification exercise.

The requirements of DSEAR must be applied to all workplaces where explosive atmospheres may occur. Where appropriate, workplaces shall be classified into hazardous area zones and, where necessary, marked with the specified sign. The basis of the technique is that areas where combustible vapours or gases are present are split into three zones: 0, 1, or 2, depending on the persistence and frequency of the flammable atmosphere. Areas where combustible dusts are present are similarly split into three zones, 20, 21 or 22, depending on the persistence and frequency of the dust cloud. This then enables the correct equipment to be used within the different zones to minimise the risk of the equipment causing an ignition of the flammable atmosphere.

This report details the results of the DSEAR assessment carried out on the 23rd March 2016 for Guy and Wright Ltd on behalf of Wiser Environment, following a site visit and information supplied by the client.

The risk assessment and area classification report is intended to be a “living” document, as part of the requirements under DSEAR and EU ATEX 137 Directive. Changes made to the areas will need to be documented and assessed in relation to its effect on the risk assessment and whether this will change the area classification designated for the areas where the change has occurred. This applies whether the change is physical, e.g. change of materials handled; or operational, e.g. certain processes used less frequently.

2 Dangerous substances handled

The first part of the risk assessment is to identify all the materials handled in the work-place covered in this report that have the potential to cause explosions.

2.1 Flammable Gases

Biogas is a mixture of methane and carbon dioxide in the ratio of approximately 55:45.

In addition, there is some production of hydrogen sulphide gas, which although flammable, is not produced in anywhere near the quantities required for it to reach its Lower Explosion Limit (4%) since typical quantities measured are less than 1000ppm.

Name	**Boiling point (°C)**	**Relative Density (Air = 1)**	**Auto-ignition temp (°C)**	**Flashpoint (°C)**	**Explosive limits (LEL-UEL %)**
Methane	-164	0.717	537	-221	5 –15
Hydrogen Sulphide	-60.2	0.92	270	-82.4	3.9 – 45.5

3 General Recommendations

- Strictly enforce a no smoking policy on site
- Ensure all equipment is adequately earth bonded (earth resistance less than 10 ohms) in accordance with PD CLC/TR 60079-32-1:2015 Explosive atmospheres. Electrostatic hazards, guidance, available from BS.
- All electrical and mechanical equipment in the Zone 2 areas to be ATEX certified category 3 equipment for gas atmospheres (Ex IIB 3G) and category 2 (Ex IIB 2G) for Zone 1 areas and category 1 (Ex IIB 1G) for Zone 0 areas.
- Place Ex warning signs on entrances to areas which are hazardous areas.
- All equipment in the zoned areas must be ATEX certified for gas atmospheres and the certificates kept on file. Repairs to such equipment can only be undertaken by suitably trained (Compex training) personnel to ensure the explosion safety protection systems are not compromised.
- Staff and contractors operating and undertaking works on the plant must be provided with adequate training and information of the explosion hazards and risks from biogas plants to meet the requirements of Regulation 9 of DSEAR.

4 Feedstock Intake

4.1 Description

Food waste is inspected in the lorry prior to being unloaded into the open storage area. The food waste is then loaded into the intake hopper using a small loader vehicle where it is dropped onto a conveyor belt. Instead of a metal detector, a person monitors the waste as it passes underneath the inspection house, where metal and plastic is removed. The food waste is then broken down into smaller pieces by choppers and stored at ambient temperature in two large silver tanks at the rear of the intake yard.

Photograph 1 – Food waste open storage area, silver storage tank can be observed in the distance

4.2 Existing explosion prevention/protection

The basis of safety for the feedstock intake is a lack of a flammable atmosphere as the waste will not be producing any methane at this stage of the process. A source of ignition is also unlikely.

4.3 Potential ignition sources

Hot surfaces

No hot surfaces are expected in this area.

Electrical equipment

There are motors for the conveying equipment and the compactor. Electric vehicles are also present.

Mechanical equipment

Conveyors and compactors are present.

Cutting/welding

One of the main causes of explosions is during maintenance work involving cutting and welding activities "hot working" which can cause sparks and localised hot spots, and hence any work of this nature must be subject to a hot work permit system. No welding or cutting is expected during normal operations.

Static

Static could build up from operative clothing as personnel do not wear anti-static PPE. All equipment should be earthed.

Naked flames

No naked flames are expected during normal operation.

4.4 Area Classification

The feed intake area and the buffer tanks are not considered to require a hazardous area due to the lack of methane being produced.

Zone classification: No zone

4.5 Evaluation of risk

The risk evaluation outlined in this section only concerns the hazards from a fire/and or explosion, directly as a result of the ignition of a gas or dust. The likelihood value is assessed from the likely presence of a flammable atmosphere in conjunction with a source of ignition, assuming there is significant oxygen present.

Risk Value matrix

LIKELIHOOD (L)	*VALUE*	*SEVERITY OF OUTCOME (S)*
Negligible	1	Negligible
Low	2	Slight damage to property
Medium	3	Moderate damage to property Injury to occupants, medical attention required
Significant	4	Large scale damage to property Occupants require hospitalisation
High	5	Major loss of property Major loss of life

Likelihood

Severity

1	**2**	**3**	**4**	**5**
2	**4**	**6**	**8**	**10**
3	**6**	**9**	**12**	**15**
4	**8**	**12**	**16**	**20**
5	**10**	**15**	**20**	**25**

Note: Beware of low likelihood but high severity

Risk Rating	*Action*
1 - 5	Record findings, review in twelve months
6 - 12	Risk should be reduced where reasonably practicable.
15 - 25	Stop! Implement additional controls.

Hazard	**Likelihood**	**Severity**	**Risk Factor**	**Comments**
Ignition of methane from feedstock intake area and buffer tanks	1	4	4	No biogas production due to lack of biological enzymes required and temperatures too low. Personnel could be present.

4.6 Recommendations

- See General Recommendations in Section 3.

5 Digester 1

5.1 Description

The chopped waste stored in the silver tanks is then transported into six small digester cell approximately 300m^3 in volume using flow meters which deliver roughly 0.5m^3 of food waste every 2 hours. The digesters are located inside a concrete enclosure, each with a sight glass and gas monitor. The digesters are around 3 m deep into the ground and had no visible pressure relief.

The digesters are heated via a concrete slab underneath the digester and there is a feed and return pipe on each digester cell so recirculation is possible.

Mechanical agitators are used to stir the slurry and the motors for the agitators are located externally to the digester. The paddles of the agitators are located below the liquid level.

Photograph 2 – Gas monitor

Photograph 3 – Agitator motor

Photograph 4 – Flow meters used to transport the food waste to the digesters.

5.2 Existing explosion prevention/protection

The basis for safety inside the tanks is a lack of flammable atmosphere due to the low levels of oxygen and lack of ignition sources. Such small amounts of feedstock are transported to the digester that over feeding is very unlikely.

Temperature and pressure sensors are found on the outside of the digesters and flammable gas monitoring is located within the digesters themselves. Temperature, pressure and oxygen levels are monitored via the control system located in the plant room next to the digesters.

5.3 Potential ignition sources

Hot surfaces

The digester cells are heated through a concrete slab.

Electrical equipment

Each digester cell has metal agitators used to stir the slurry. The motors are located externally to the digester, so do not come into contact with the biogas.

There is a gas sensor present outside the digester.

Mechanical equipment

The agitators may be a source of friction if they malfunction; however they are located within the liquid substrate and not in the gas layer above the liquid level and move at relatively slow speeds due to the density of the substrate.

Cutting/welding

One of the main causes of explosions is during maintenance work involving cutting and welding activities "hot working" which can cause sparks and localised hot spots, and hence any work of this nature must be subject to a hot work permit system. No welding or cutting is expected during normal operations.

Static

Static could build up from operative clothing as personnel do not wear anti-static PPE. All equipment should be earthed.

Naked flames

No naked flames are expected during normal operation.

Lightning

As the digester cells are located underground and below the level of the highest building then lightning is not expected to be an issue.

5.4 Area Classification

External area around the cells

Zone 2 for 1m above and around the sight glass.

Inside the cells

Inlet pipework transports the waste material and air into the digesters. This could raise the oxygen content locally close to the valves due to the incoming air which could permeate through to raise the oxygen content to a level where combustion is possible. For this reason it would be prudent to allocate a zone 1 internally above the liquid level to account for potential conditions of increased oxygen.

See Appendix A for schematic drawings showing the zoned areas.

5.5 Evaluation of risk

The comments highlight the main reasons taken into account in allocating the likelihood and severity score.

Hazard	Likelihood	Severity	Risk factor	Comments
Ignition of biogas inside cells	2	4	8	Ignition sources are possible though there should not be a flammable atmosphere in the cells. Solid roof construction and lack of pressure relief would not allow the pressure wave that results from an explosion to escape. Personnel could be present close to the tanks. If there was an ignition personnel could be affected by the roof venting the explosion.
Ignition of biogas external to the cells	2	2	4	Ignition sources are unlikely but possible. Any ignition would result in a fire ball at high level due to the unconfined area limiting potential for injuries to personnel. Personnel could be present around the tanks.

5.6 Measures required for compliance and/or to reduce risk

- Consider fitting pressure relief valves on the digesters to ensure excess biogas is vented to prevent overpressure.
- Restrict and control access around the digester roof areas and around pressure relief points.
- Ensure mechanical equipment such as the agitators are serviced and maintained regularly.
- Ensure the oxygen concentration sensor is calibrated regularly.
- See General Recommendations in Section 3.

6 Desulphurisation

Due to the high sulphur content in the biogas it is necessary to reduce the sulphur content to enable direct combustion in a gas engine. The sulphur cleaning of the biogas takes place in a biological desulphurisation tower.

Air is added to the gas to make it weaker, the process aims to get the content of the biogas to approximately 60% methane. As the feedstock is mainly vegetable matter the concentration of H_2S doesn't reach very high levels normally; 140-200ppm and at most 500ppm. The gas and accompanying odour is removed via water traps and carbon filters.

Photograph 5 – Gas Cleaning Tower

Photograph 6 – Carbon Filter Trap

Photograph 7 – Chiller

Photograph 8 – Water Trap

A gas chiller is provided in order to dry the gas before engine combustion. The chillers are serviced by Edina.

6.1 Existing explosion prevention/protection

The basis of safety for the gas cleaner is a lack of ignition sources and a reduced oxygen concentration of 0.8 – 1.2%.

The electric heat condenser chiller has a level sensor which is Ex1/2G T3 rated this means it is suitable for a zone 0 gaseous atmosphere and can exist and operate safely in an environment with a maximum surface temperature of 200 °C. A blower/compressor is Ex 1G IIC T6 rated this means it is suitable for a zone 0 gaseous atmosphere, and temperatures of 85 °C.

6.2 Potential ignition sources

The following potential ignition sources are possible:

Hot surfaces

No hot surfaces were observed or are expected to be present.

Electrical equipment

Various electrical equipment is present within the hazardous areas and should be confirmed as suitably rated for the appropriate flammable gas atmosphere.

Mechanical friction and impact sparks

Possible from the gas blower fans if they malfunction.

Cutting/welding

One of the main causes of explosions is during maintenance work involving cutting and welding activities "hot working" which can cause sparks and localised hot spots, and hence any work of this nature must be subject to a hot work permit system. No welding or cutting is expected during normal operations.

Static

Gas pipelines are assumed to be earthed.

Naked flames

No naked flames were observed to be present in close proximity to the plant.

Lightning

There is no lightning strike protection.

6.3 Area classification

Gas outlet measuring: zone 1 above and around with a radius of 3m surrounded by a zone 2 above and around for 2m.

Gas test valves: zone 1 above and around for 1m surrounded by a zone 2 above and around for 3m.

Gas blower fan: zone 2 above and around for 3m.

Gas safety valve: zone 1 above and around for 1m surrounded by zone 2 above and around for 3m.

The gas cleaning tower and the chiller will be required to be zoned internally as a zone 2 to account for possible oxygen ingress leakage increasing the oxygen concentration to a value that could support combustion.

6.4 Evaluation of risk

The comments highlight the main reasons taken into account in allocating the likelihood and severity score.

Hazard	Likelihood	Severity	Risk factor	Comments
Ignition of methane inside cleaner tower.	1	4	4	Very unlikely for internal sources of ignition to be present. Personnel could be present.
Ignition of methane externally around cooler plant	2	3	6	External ignition sources most likely from chiller unit if equipment is not ATEX rated. Flammable atmosphere expected rarely and in localised area around flanges, valves and fittings. Personnel could be present.

6.5 Measures required for compliance and/or to reduce risk

- All equipment in the zoned areas must be ATEX certified for gas atmospheres and the certificates kept on file. Repairs to such equipment can only be undertaken by suitably trained (Compex training) personnel to ensure the explosion safety protection systems are not compromised.
- Undertake regular servicing and maintenance of the biogas blower fans and associated equipment on the plant.
- Fit lightning strike protection to gas cleaner tower

7 Flare Stack

7.1 Description

There is one flare stack located on site. The flare stack is used to burn off any excess biogas that cannot be utilised by the CHP engines. No electrical equipment is present inside the stack, the air valve is ATEX rated Ex II 2G T3-T6.

Photograph 9 – Flare stack

Photograph 10 – Air valve on flare stack

7.2 Existing explosion prevention/protection

The basis of safety is a controlled burning of the biogas supplied by biogas pipelines located underground.

BRE Global assume the flare stack equipment has been installed to suitable gas industry codes and statutory requirements for gas burning appliances. No installation details have been supplied.

7.3 Potential ignition sources

BRE Global assume there will be piloted ignition of any biogas being pumped to the flare stack for burning. The potential ignition sources below assume possible leaks from pipework flanges and joints.

Hot surfaces

Hot surfaces from equipment are not expected to be of such a high temperature that will cause any methane gas to auto-ignite.

Electrical equipment

There is no electrical equipment present within the hazardous areas.

Mechanical equipment

The air valve is Ex II 2G T3-T6 rated.

Cutting/welding

One of the main causes of explosions is during maintenance work involving cutting and welding activities "hot working" which can cause sparks and localised hot spots, and hence any work of this nature must be subject to a hot work permit system. No welding or cutting is expected during normal operations.

Static

Static could build up from operative clothing as personnel do not wear anti-static PPE. All equipment and gas pipelines should be earthed.

Naked flames

Pilot flame is present to ignite the biogas when required. During use there will also be the flame from the flare.

7.4 Area classification

It is possible for flammable gas leaks to occur around the biogas pipe joints and flanges that feed the flare, although these will be mostly underground the pipework close to the stack is above ground.

The release is expected to be secondary and at a relatively small rate, based on values given in BS EN 60079-10-1.

Molecular mass of methane	16.05(kg/kmol)
Estimated release, $(dG/dt)_{max}$ (see Appendix B & C)	4.46×10^{-5} kg/s
LEL_m	$0.033 kg/m^3$ (5% vol)
Safety factor, *k*	0.5
Ambient temperature, T	293K
Calculated value of $(dV/dt)_{min}$	2.7×10^{-3} m^3/s
Estimated number of air changes, C	100/h ($2.87 \times 10^{-2} s^{-1}$)
Calculated volume V_k	0.097 m^3
Quality factor, f, in reducing the ventilation	2
Calculated hypothetical volume, V_z	$0.19m^3$
Volume of free space V_o (outside)	$3400m^3$

Hence as V_z is $>0.1m^3$ and $<V_0$ the degree of ventilation is said to be medium

Using Table B1 in BS EN 60079-10-1:2009[5]:

Grade of release:	Secondary
Degree of ventilation:	Medium
Availability of ventilation:	Good
Zone:	2

The extent of the hazardous zone is limited to a 0.2m around each of the gas pipework flanges, connections and valves.

7.5 Evaluation of risk

The comments highlight the main reasons taken into account in allocating the likelihood and severity score.

Hazard	**Likelihood**	**Severity**	**Risk factor**	**Comments**
Unwanted ignition of methane leaks from biogas supply pipework to flare	2	3	6	Flammable atmospheres unlikely but possible from leaks of biogas from flanges/joints. Pilot flame or flare stack flame present. Appropriate gas appliance safety systems assumed to be used, e.g. to account for extinguishment of pilot flame. Ventilation is good as outside. Personnel could be present.

7.6 Measures required for compliance and/or to reduce risk

- Ensure the gas flare safety systems are checked and serviced regularly by appropriate competent gas engineers.
- If there is no flame arrestor on the biogas supply pipeline feeding the flare stack then it is recommended that one is installed.
- See General Recommendations in Section 3.

8 CHP Engines 1 & 2

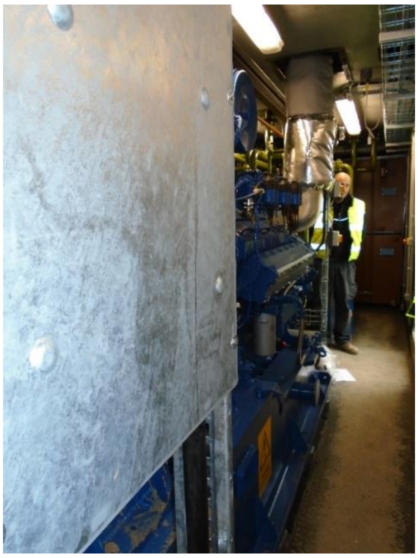
8.1 Description

There are two CHP engines on site, CHP engine 2 is not in use yet. The CHP engines are identical and are located in storage containers in the middle of the site. There is a fire alarm system on each engine which is linked to a slam shut valve on the outside of the engine container. A booster fan for the primary CHP (Engine 1) is located just outside the CHP containers, the secondary CHP (Engine 2) is fed from the combibag and gas bag. The fan is ATEX rated II2G c IIB T3 which means it is suitable for methane and temperatures no higher than 200 °C

Photograph 11 – Internal and external booster fan

Photograph 12 – Extraction Fans

Photograph 13- CHP Container Interior



8.2 Existing explosion prevention/protection

The container layout design is such that that as many ignition sources as practicable are removed from the engine space.

There are two methane detectors; one is located to the side of the gas inlet pipework at ceiling level and the other is close to the air outlet. A single smoke detector is situated at ceiling level. The activation of these shut down the main gas supply and stops the engine.

If the ventilation fails at any point, the CHP shuts down.

One of the methane detectors is placed close to the outlet and set to alarm as low a level as possible, normally 20% LEL. At no point will there be a gas/air mixture within the flammable range, except when a sudden, major release occurs that overwhelms the ventilation system.

8.3 Potential ignition sources

The potential ignition sources below assume possible leaks from pipework flanges and joints.

Hot surfaces

Some hot surfaces from equipment are present but not to such a high temperature that will cause any methane gas to auto-ignite.

Electrical equipment

All electrical equipment in the containers is non-Ex rated.

Mechanical equipment

Mechanical extraction is present in the engine room.

Cutting/welding

One of the main causes of explosions is during maintenance work involving cutting and welding activities "hot working" which can cause sparks and localised hot spots, and hence any work of this nature must be subject to a hot work permit system. No welding or cutting is expected during normal operations.

Static

Static could build up from operative clothing as personnel do not wear anti-static PPE. All equipment should be earthed.

Naked flames

No naked flames were seen to be present in the engine rooms.

8.4 Area classification

The engine rooms are not currently regarded as a zoned area. If this is to remain the case there needs to be good ventilation of this room to ensure there is no build-up of flammable gas from any leaks around the biogas pipe joints and flanges.

Possible sources of release could be from leaking valves or flanges on the pipework. The release is expected to be secondary and at a relatively small rate, based on values given in BS EN 60079-10-1.

30m^3 Engine Room (Engine 1)

Molecular mass of methane	16.05(kg/kmol)
Estimated release, $(dG/dt)_{max}$ (see Appendix B & C)	4.01×10^{-5} kg/s
LEL_m	0.033kg/m^3 (5% vol)
Safety factor, *k*	0.5
Ambient temperature, T	293K
Calculated value of $(dV/dt)_{min}$	$2.4\text{x}10^{-3}$ m^3/s
Calculated number of air changes, C	97.2/h ($2.7 \times 10^{-2} s^{-1}$)
Calculated volume V_k	0.09 m^3
Quality factor, f, in reducing the ventilation	1
Calculated hypothetical volume, V_z	0.09m^3
Volume of free space V_o (given)	30m^3

Hence as V_z is >0.1m^3 and <V_0 the degree of ventilation is said to be High

Using Table B1 in BS EN 60079-10-1:2009[5]:

Grade of release:	Secondary
Degree of ventilation:	High
Availability of ventilation:	Good
Zone:	2NE

35m³ Engine Room (Engine 2)

Molecular mass of methane	16.05(kg/kmol)
Estimated release, $(dG/dt)_{max}$ (see Appendix B & C)	4.01×10^{-5} kg/s
LEL_m	0.033kg/m^3 (5% vol)
Safety factor, *k*	0.5
Ambient temperature, T	293K
Calculated value of $(dV/dt)_{min}$	$2.4\text{x}10^{-3}$ m^3/s
Calculated number of air changes, C	96.7/h ($2.98 \times 10^{-2}s^{-1}$)
Calculated volume V_k	0.09 m^3
Quality factor, f, in reducing the ventilation	1
Calculated hypothetical volume, V_z	0.09m^3
Volume of free space V_o (given)	35m^3

Hence as V_z is >0.1m^3 and <V_0 the degree of ventilation is said to be high

Using Table B1 in BS EN 60079-10-1:2009[5]:

Grade of release:	Secondary
Degree of ventilation:	High
Availability of ventilation:	Good
Zone:	2NE

Zoning schematics can be found in Appendix A. Release rate calculations can be found in Appendix B.

The extent of the hazardous zone is limited to a 0.5m around each of the gas pipework flanges, connections and valves.

Zoning schematics can be found in Appendix A. Release rate calculations can be found in Appendix B.

8.5 Evaluation of risk

The comments highlight the main reasons taken into account in allocating the likelihood and severity score.

Hazard	Likelihood	Severity	Risk factor	Comments
Ignition of methane inside CHP engine rooms	2	5	10	Flammable atmospheres unlikely but possible from leaks of biogas from flanges/joints. Ignition sources possible inside the room as some equipment may not be ATEX rated. Confirm low level ventilation is adequate to remove any leaked vapours. Personnel could be present.

8.6 Measures required for compliance and/or to reduce risk

- Ensure the flammable gas detector is checked and serviced regularly, and it is calibrated appropriately for methane.
- Ensure ventilation system is regularly checked and maintained.
- See General Recommendations in Section 3.

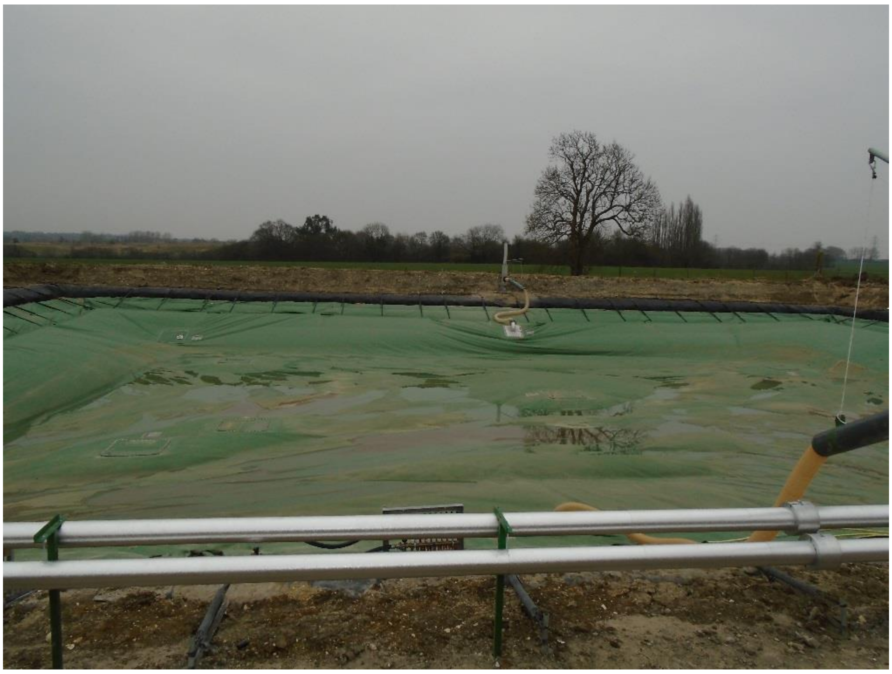
9 Digester 2 (Combibag)

9.1 Description

The digestate from Digester 1 (six cells) is pumped to Digester 2 (combibag) where it stays for 3-4 months before being pumped out to the lagoon. As a result, more gas is produced and captured in Digester 2, reducing odour emission from the lagoon. Gas produced within Digester 2 is pumped out periodically to prevent excess build-up. Digester 2 is heated using residual heat from the CHP.

Digester 2 is located within original Lagoon 1, it has been replaced with a flexible gas-tight cover known as a combibag. Digester 2 is connected to the gas dome with a biogas pipeline main. All gas that is still produced from the digestate in Digester 2 will flow to the gas dome via this pipeline. A biogas blower ensures the continuous biogas flow from Digester 2 to the gas dome, to overcome the pressure drop. The gas blower is ATEX rated 2G IIB T3 which means it's suitable for a zone 1 and 2 gaseous environment and surface temperatures up to 200°C.

Photograph 14 - Combibag



9.2 Existing explosion prevention/protection

The basis for safety is the lack of flammable atmosphere. The outdoor location provides substantial natural ventilation should a release of gas occur. The gas tight cover is flexible, depending on the gas levels within the lagoon, this prevents pressure from building up.

9.3 Potential ignition sources

The following potential ignition sources are possible:

Hot surfaces

Hot surfaces are not expected to be present.

Electrical equipment

There is no fixed electrical equipment in the area. Portable equipment could be present.

Mechanical equipment

There is a biogas blower which is Ex 2G IIB T3

Cutting/welding

One of the main causes of explosion is during maintenance work involving cutting and welding activities "hot working" which can cause sparks and localised hot spots and hence any work of this nature must be subject to a hot work permit system where it occurs within or close to the designated hazardous areas. Welding equipment was not seen and is not expected to be used in the area.

Static

Possible from operative clothing as anti-static PPE is not worn and equipment that is not earth bonded.

Naked flames

Naked flames are not expected in the area.

9.4 Area classification

Zone	2
Extent	1m externally above and around the combibag.
Zone	1
Extent	Between the membrane and the liquid level underneath.

9.5 Evaluation of risk

Hazard	Likelihood	Severity	Risk Factor	Comments
Ignition of gas leaks within the combibag	1	3	3	The combibag is outside, away from personnel, though personnel could be in close proximity A source of ignition is unlikely.

9.6 Measures required for compliance and risk reduction

- An 'Ex' and "Flammable substances" warning signs should be placed on the entrance to the area.
- Restrict access to the combibag area.
- See General Recommendations in Section 3.

10 Gas Bag 1

10.1 Description

The membrane gas holder (Gas Bag 1) is used to store gas and to provide a constant pressure into the gas utilisation system which feeds hot water boilers, CHP generators, surplus gas flares etc. The outer air membrane is designed to withstand wind loadings of 150km/hr and snow loadings of 250kg/m^2, the storage capacity (external to digester cells) is 300m^3.

Gas Safety Relief Valve

The safety relief valve is fitted remotely and connected by flexible pipe 1no spring loaded gas pressure relief valve provides a mechanical means of easily setting and adjusting the relief pressure of the gas bag. Set at 15mbar.

Viewing Window

2 no 230mm diameter inspection windows are mounted on the side of the air membrane.

Gas Bag Connections

2no 125mm flanged gas inlet/outlet connections are provided on the Gas Holder above the concrete base.

Photograph 15 – Gas Bag 1

10.2 Existing explosion prevention/protection

Although a flammable atmosphere is present the basis of safety is a lack of ignition sources.

10.3 Potential ignition sources

The following potential ignition sources are possible:

Hot surfaces

Hot surfaces are not expected to be present.

Electrical equipment

There is no fixed electrical equipment in the area. Portable equipment could be present.

Mechanical equipment

There is an overpressure valve but this is located outside of the dome.

Cutting/welding

One of the main causes of explosion is during maintenance work involving cutting and welding activities "hot working" which can cause sparks and localised hot spots and hence any work of this nature must be subject to a hot work permit system where it occurs within or close to the designated hazardous areas. Welding equipment was not seen and is not expected to be used in the area.

Static

Possible from operative clothing as anti-static PPE is not worn and equipment that is not earth bonded.

Naked flames

Naked flames are not expected in the area.

10.4 Area classification

Zone	2
Extent	1m above and around the membrane
Zone	0
Extent	Inside the gas bag
Zone	1 & 2
Extent	Zone 1 for 3m above and around then Zone 2 for 2m above and around

10.5 Evaluation of risk

Hazard	**Likelihood**	**Severity**	**Risk Factor**	**Comments**
Ignition of gas within the dome.	1	3	3	The bag contains a pressure valve, which controls the pressure within the bag. A source of ignition is unlikely though ignition would result in a major fireball.

Ignition of gas from leak	1	3	3	Flammable atmospheres unlikely due to outdoor location. Any flammable atmospheres that do occur due to a leak will only persist for a short period of time. Ignition sources unlikely.

10.6 Measures required for compliance and risk reduction

- See General Recommendations in Section 3.

11 Gas Bag 2

11.1 Description

A booster fan delivers biogas to a storage dome which is pressure controlled. Next to the gas bag there is an overpressure valve. The bag is made from a gas impermeable material, which can handle temperatures up to 70 °C and is flame retardant.

The biogas blower is ATEX rated 2G IIB T3 which means it's suitable for a zone 1 and 2 gaseous environment and surface temperatures up to 200 °C.

Photograph 15 – Gas Bag 2

Photograph 16 – Overpressure valve

11.2 Existing explosion prevention/protection

Although a flammable atmosphere is present the basis of safety is a lack of ignition sources.

11.3 Potential ignition sources

The following potential ignition sources are possible:

Hot surfaces

Hot surfaces are not expected to be present.

Electrical equipment

There is no fixed electrical equipment in the area. Portable equipment could be present.

Mechanical equipment

There is an overpressure valve but this is located outside of the dome.

Cutting/welding

One of the main causes of explosion is during maintenance work involving cutting and welding activities "hot working" which can cause sparks and localised hot spots and hence any work of this nature must be subject to a hot work permit system where it occurs within or close to the designated hazardous areas. Welding equipment was not seen and is not expected to be used in the area.

Static

Possible from operative clothing as anti-static PPE is not worn and equipment that is not earth bonded.

Naked flames

Naked flames are not expected in the area.

11.4 Area classification

Zone	2
Extent	1m above and around the membrane
Zone	0
Extent	Inside the gas bag
Zone	1 & 2
Extent	Zone 1 for 3m above and around then Zone 2 for 2m above and around

11.5 Evaluation of risk

Hazard	**Likelihood**	**Severity**	**Risk Factor**	**Comments**
Ignition of gas within the dome.	1	3	3	The bag contains a pressure valve, which controls the pressure within the bag. A source of ignition is unlikely though ignition would result in a major fireball.

Ignition of gas from leak	1	3	3	Flammable atmospheres unlikely due to outdoor location. Any flammable atmospheres that do occur due to a leak will only persist for a short period of time. Ignition sources unlikely.

11.6 Measures required for compliance and risk reduction

- See General Recommendations in Section 3.

12 Diesel storage

There are a number of vehicles which operate on site, outside there is a diesel storage area with a number of storage containers.

Photograph 17 – Diesel storage

12.1 Existing explosion prevention/protection

The basis of safety is a lack of a flammable atmosphere due to the relatively high flash point of diesel and also the outside location.

12.2 Potential ignition sources

The following potential ignition sources are possible:

Hot surfaces

Hot surfaces are not expected to be present.

Electrical equipment

No electrical equipment present

Mechanical equipment

No mechanical equipment present

Cutting/welding

One of the main causes of explosion is during maintenance work involving cutting and welding activities “hot working” which can cause sparks and localised hot spots and hence any work of this nature must be subject to a hot work permit system where it occurs within or close to the designated hazardous areas. Welding equipment was not seen and is not expected to be used in the area.

Static

Possible from operative clothing as anti-static PPE is not worn and equipment that is not earth bonded.

Naked flames

Naked flames are not expected in the area.

12.3 Area classification

No hazardous area is required as the diesel is not heated to anywhere near its flashpoint.

12.4 Evaluation of risk

Hazard	Likelihood	Severity	Risk Factor	Comments
Ignition of diesel fuel vapour	1	2	2	No flammable atmosphere expected as no heat source present. Ignition sources very unlikely Personnel could be present

12.5 Measures required for compliance and risk reduction

- See General Recommendations in Section 3.

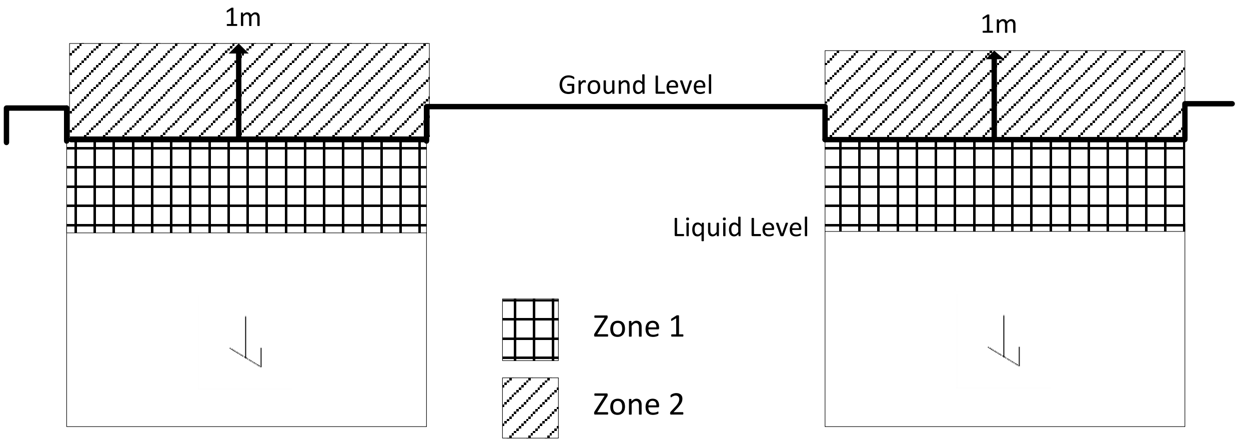
14 Reference

- Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002.
- European Union Directive ATEX 137.
- BS EN 60079-10-1:2015. Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres
- PD CLC/TR 60079-32-1:2015 Explosive atmospheres. Electrostatic hazards, guidance, available from BS

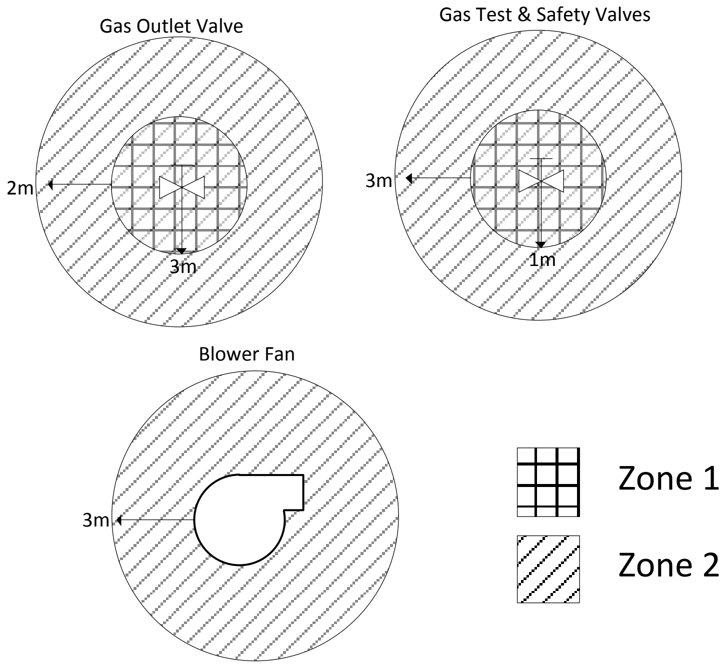
bre

Appendix A Zoning Schematics

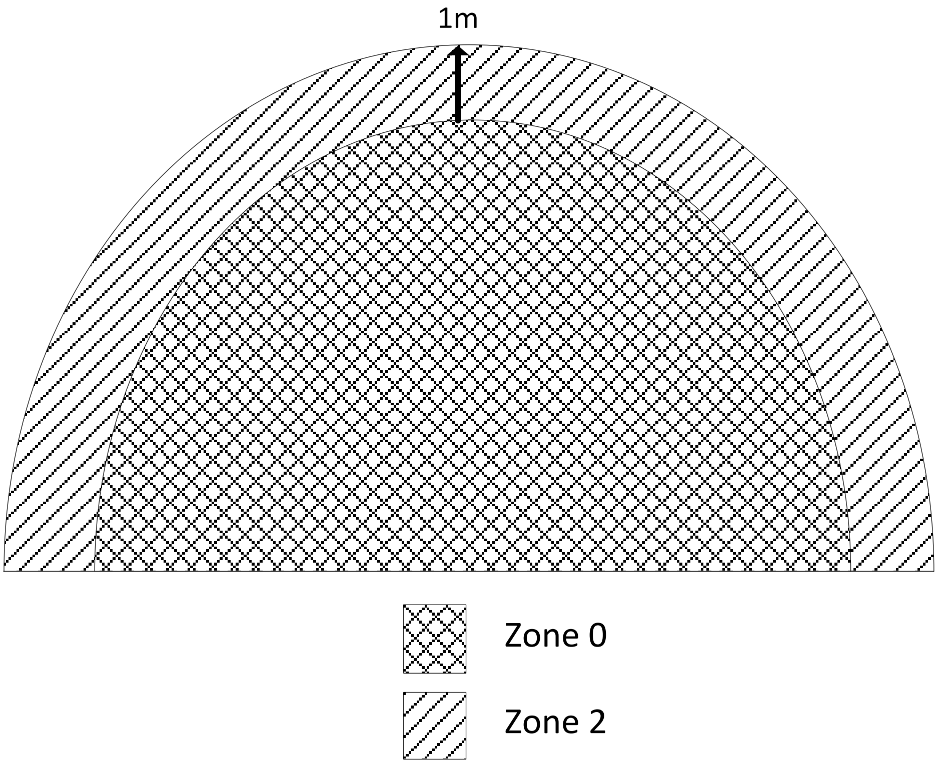
Digesters



Outlet valves and blowers



Gas Bags



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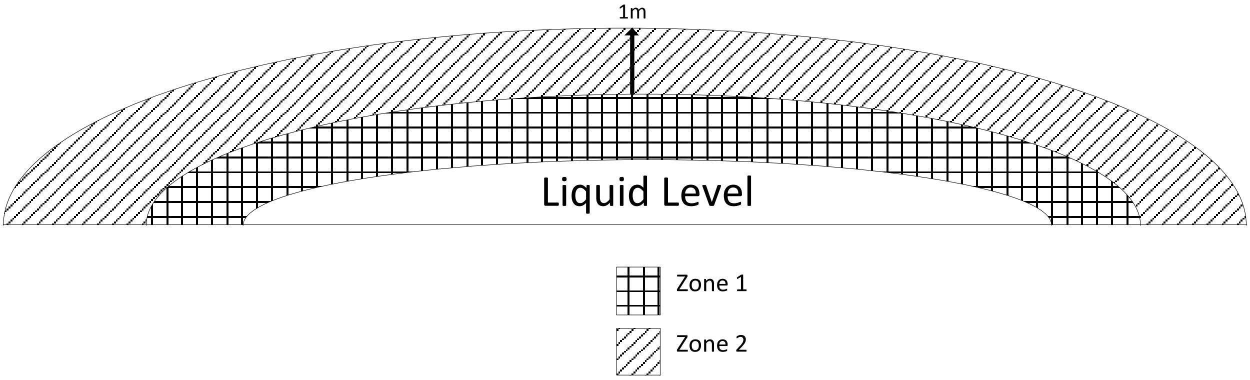

Appendix B Release rate calculation

Biogas (methane)

This procedure follows guidance in BS EN 60079-10-1:2009.

The discharge is taken to be from a leak through a hole of cross section 0.25mm², with a gas pressure of 200 mbar gauge (1.2 bar absolute) which has been confirmed as the maximum pressure in this particular pipeline at a temperature of 20° C. 0.25mm² follows industry guidance for estimating leaks from low pressure gas pipeline fittings and valves.

$p = 1.20 \times 10^5$ Pa	pressure in pipeline
$p_0 = 10^5$ Pa	pressure outside pipeline
T = 293K	absolute temperature
$M = 16.05$ kg/kmol	molecular mass of methane
$S = 2.5 \times 10^{-7}$ m²	hole cross section
$Y = 1.32$	polytropic index of adiabatic expansion for methane gas

p_c = critical pressure (given below)

R = 8314 J kmol^{-1} K^{-1} Universal gas constant

$p_c = p_0 \{(Y+1)/2\}^{y/(y-1)}$

$p_c = 10^5 \{(1.32+1)/2\}^{1.32/(1.32-1)} = 1.8 \times 10^5$ Pa

Velocity of release of gas is non-choked because $p < p_c$

Using the non-choked release rate equation:

$dG/dt = S.p.(M/RT \times 2y/y\text{-}1 \times [1\text{-} (p_0/p)^{(y-1)/y}])^{1/2} (p_0/p)^{1/y}$

dG/dt = 4.01 x 10^{-5} kg/s

Methane calculation of LEL_m

RMM methane = 16.05

LEL used is 5%

$LEL_m = 0.416 \times 10^{-3} \times 16.05 \times 5$= **0.033kg/kmol**

Appendix C Determination of gas zones and ventilation calculations

Estimation of hypothetical volume, V_z

$$(dV/dt)_{min} = \frac{(dG/dt)_{max}}{kLEL_m} \times \frac{T}{293} \qquad (1)$$

where:

$(dV/dt)_{min}$ is the minimum volumetric flowrate of fresh air (volume per time, m^3/s)

$(dG.dt)_{max}$ is the maximum rate of release at source (mass per time, kg/s)

LEL_m is the lower explosion limit (mass per volume, kg/m^3)

k is a safety factor applied to the LEL_m ; typically:

> *k* = 0.25 (continuous and primary grades of release)
>
> *k* = 0.5 (secondary grades of release)

T is the ambient temperature (Kelvin, K)

V_o is the actual volume of the area/building.

The relationship between the calculated value of $(dV/dt)_{min}$ and the actual ventilation rate within the volume under consideration (V_o) in the vicinity of the release can be expressed as a volume (V_k). Thus for ideal flow conditions:

$$V_k = \frac{(dV/dt)_{min}}{C} \qquad (2)$$

where

C is the number of fresh air changes per unit time (s^{-1})

For non-ideal conditions the effective air exchange will be lower than that given by C, leading to an increased volume (V_z). An additional correction (quality) factor, *f* is added to equation (2):

$$V_z = \frac{f\,(dV/dt)_{min}}{C} \qquad (3)$$

where f = 1 (ideal situation) to 5 (impeded air flow)

Degree of ventilation

High : $V_z < 0.1m^3$ or < 1% of V_o

Low : $V_z > V_o$

Medium: all other condition.