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DSEAR Assessment (Interim Phase 1)
Biodynamic UK Ltd
Nottingham (Anaergia)

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Document Control

Report Produced for.

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APPENDICES

FIGURES

1 EXECUTIVE SUMMARY

- *FBW Engineering Ltd* have been commissioned by *Anaergia Ltd* to conduct a risk assessment as required by Regulation 5 of the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) on the bioenergy facility operated by Biodynamic Ltd located in Nottingham, UK

- A remote assessment was carried out between July-October 2021 with this document forming an Interim Assessment for temporary arrangements for preliminary operations in February 2022

- It was not possible to visit site however design documentation and input was provided by the client, which forms the basis of this document, with accuracy of data assumed

- Temporary ventilation and extraction have been installed on several vessels for initial plant operations. FBW assumes the total fan ventilation rates provided (1,600 Nm3/hr) are accurate and assume that the extraction rates can be balanced by the client to maintain the criteria established in this DSEAR assessment

- Based on the DSEAR assessment, FBW would recommend balancing the individual extraction rates of the quoted 1,600 Nm3/fan to:

    - 950 Nm^3/hr from Feed Buffer Tank
    - 100 Nm^3/hr from each Pasteuriser Tank
    - 100 Nm^3/hr from Depackaging Balance Tank
    - 350 Nm^3/hr from Liquid Reception Tank

- This DSEAR should be considered a temporary document suitable for initial start-up and operations utilising the temporary arrangements and will not be valid should plant operations or design deviate from that assessed.

- This assessment is based on assumptions of ventilation rates from the supplied Odour Control Unit (OCU) should these ventilation rates change, the assessment may change in terms of hazardous zone classification and extent

- Multiple areas requiring hazardous zoning have been determined. In some cases, only the vapour space or headspace within a vessel/structure has been assessed. All equipment installed within these zones must be suitable for inclusion within a hazardous zone with appropriate electrical and thermal protection.

- Training of staff in relation to DSEAR and personnel is paramount to the safe operation of a DSEAR assessed facility

- This report does not deal with the detail of task risk assessment of how Anaergia will risk assess activities that may occur or impact a hazardous zone resulting from this DSEAR assessment. There therefore is a requirement for Anaergia to take the detail contained within this DSEAR assessment and generate a specific risk assessment.

- Hazardous area drawings should be commissioned as addenda to this assessment

- Two key design aspects will further mitigate/reduce the classification and extent of hazardous zones as an improvement on certain hazards detailed in this assessment, and could be considered by the client

    - Introduction of dependant power supply for the OCU this will increase the assessed availability of ventilation
    - Methane stripping of dissolved gases from digestate will reduce the hazard of said material

- Site cleanliness and remove of feed organics and digestate is critical to prevent local concentration and emission of hazardous gases

- A suggested action list has been generated and can be found in Appendix 3

2 INTRODUCTION

The Dangerous Substances and Explosive Atmosphere Regulations 2002 (DSEAR) stipulate that risk assessments be undertaken for potentially explosive atmospheres and require a minimal standard of compliance. The requirements of DSEAR are such that in any workplace where there is a risk of an explosion occurring, hazardous zones are classified and are protected from sources of ignition by selecting appropriate equipment and safety systems.

Anaergia Ltd requested that FBW Engineering Ltd undertake a DSEAR risk assessment for their Anaerobic Digestion facility, Biodynamic UK Ltd, Colwick Industrial Estate, Nottingham, NG4 2JT.

For initial operations Anaergia will be installing a 1,600 Nm^3/hr ATEX rated fan to provide temporary ventilation on the Temporary Buffer Tank, both Pasteuriser tanks, liquid reception tank and depackaging tank.

The assessment was carried out remotely based on relevant information and data supplied by the client. Information was obtained from observations and discussion with site personnel as appropriate.

The following approach was taken:

- The plant was divided into unit operations
- The risk of an explosive atmosphere forming, persisting, and igniting was evaluated. See the aim of DSEAR.
- A risk assessment was generated
- Existing and suggested mitigation measures were evaluated

The DSEAR zone classification and hazardous zone classification summary can be found in section 6 and summarised in Appendix 1.

Hazardous area calculations are summarised in Appendix 2.

A Summary of recommendations from the DSEAR assessment can be found in Appendix 3 which will act as mitigation measures.

A general risk assessment detailing the transference of information from the DSEAR into tangible practical onsite mitigation actions cannot be created at this time and will require the clients input on design details and operation to complete.

2.1 THE AIM OF DSEAR

The principal objectives of the DSEAR assessment are to identify/define:

- Hazardous properties
- Storage method and quantities
- The likelihood of explosive/ flammable atmospheres forming through use
- Potential ignition sources
- Non-routine activities such as maintenance work
- Adverse conditions and unplanned events such as exceeding the limits of control temperature or other settings
- Measures to prevent or mitigate risks as far as is reasonably practicable
- Provision of equipment and procedures to deal with accidents and emergencies
- Provision of information, instruction, and training for staff

On receipt of this DSEAR assessment report Anaergia Ltd should action the measures highlighted to prevent or mitigate risk. Where doubts exist as to the contents in the report and how this may be achieved, please contact FBW Engineering Ltd.

3 METHOD AND TERMINOLOGY

The methodology used in the DSEAR assessment is defined in the widely recognised industrial British Standard BSEN 60079-10-1 (2015)[1] which is the UK implementation of EN 60079-10-1:2015. Note that this standard supersedes the withdrawn BS EN 60079-10-1:2009.

DSEAR put into effect requirements from two European Directives: The Chemical Agents Directive (98/24/EC) and the Explosive Atmospheres Directive (99/92/EC). It also replaced several older regulations dealing with flammable substances safety. Within the United Kingdom the agency responsible with regulatory compliance of DSEAR is the Health and Safety Executive (HSE)[2].

In DSEAR, an explosive atmosphere is defined as a mixture of dangerous substances with air, under atmospheric conditions, in the form of gases, vapours, mist or dust in which, after ignition has occurred, combustion spreads to the entire unburned mixture.

The classification of a hazardous zone associated with a potentially explosive atmosphere is based on:

- The Grade of Release
- Nature of Ventilation
- Effectiveness of Ventilation/Dilution – Degree of Dilution
- Availability/Robustness of Ventilation

A hazardous area or zone is an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment.

A non-hazardous area or zone of negligible extent is an area which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment.

The following figure shows the overall basis of zonal classification used in BSEN 60079-10-1 (2015) for explosive gas, using the parameters defined above:

[1] *BS EN 60079-10-1:2015 BSI Standards Publication Explosive Atmospheres Part 10-2: Classification of areas – Explosive Gas Atmospheres*

[2] https://www.hse.gov.uk/fireandexplosion/dsear-background.htm

Figure 1: Classification of a Hazardous Zone[3]

Grade of release	Effectiveness of Ventilation						
	High Dilution			Medium Dilution			Low Dilution
	Availability of ventilation						
	Good	Fair	Poor	Good	Fair	Poor	Good, fair or poor
Continuous	Non-hazardous (Zone 0 NE)[a]	Zone 2 (Zone 0 NE)[a]	Zone 1 (Zone 0 NE)[a]	Zone 0	Zone 0 + Zone 2	Zone 0 + Zone 1	Zone 0
Primary	Non-hazardous (Zone 1 NE)[a]	Zone 2 (Zone 1 NE)[a]	Zone 2 (Zone 1 NE)[a]	Zone 1	Zone 1 + Zone 2	Zone 1 + Zone 2	Zone 1 or zone 0[c]
Secondary[b]	Non-hazardous (Zone 2 NE)[a]	Non-hazardous (Zone 2 NE)[a]	Zone 2	Zone 2	Zone 2	Zone 2	Zone 1 and even Zone 0[c]

[a] Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone which would be of negligible extent under normal conditions.

[b] The zone 2 area created by a secondary grade of release may exceed that attributable to a primary or continuous grade of release; in this case, the greater distance should be taken.

[c] Will be zone 0 if the ventilation is so weak and the release is such that in practice an explosive gas atmosphere exists virtually continuously (i.e. approaching a 'no ventilation' condition).

'+' signifies 'surrounded by'.

Availability of ventilation in naturally ventilated enclosed spaces shall never be considered as good.

3.1 GRADE OF RELEASE

The characterisation of a release depends upon temperature, pressure, physical and chemical attributes of an individual species for mixture.

A release of a flammable substance above its flashpoint will give rise to a flammable vapour or gas cloud with varying buoyancy.

The following categories are used in the DSEAR assessment:

source of release a point or location from which a flammable gas, vapour, mist, or liquid may be released into the atmosphere so that an explosive gas atmosphere could be formed

continuous grade of release which is continuous or is expected to occur frequently or for long periods. Typically, >1000hrs per year.

Both "frequently" and "long" are the terms which are intended to describe a very high likelihood of a potential release. In that respect, those terms do not necessarily need to be quantified.

primary grade of release: release which can be expected to occur periodically or occasionally during normal operation. Typically, between 2-1000hrs per year.

secondary grade of release: release which is not expected to occur in normal operation and, if it does occur, is likely to do so only infrequently and for short periods. Typically, <2 hours per year.

release rate: quantity of flammable gas, liquid, vapour, or mist emitted per unit time from the source of release

[3] *BS EN 60079-10-1:2015 Table D2.1 Annex D*

3.2 VENTILATION AND DILUTION – EFFECTIVENESS/AVAILABILITY

Gas or Vapour releases can be diluted through mixing with air, until the gas disperses, and the concentration drops to below the lower flammability limit.

Air movement can be through natural or artificial means.

Appropriate ventilation can therefore reduce/eliminate hazardous zones by reducing the concentration and persistence of a hazardous zone.

Natural ventilation in buildings arises from pressure differences induced by the wind and/or by temperature gradients.

Artificial Ventilation can also be provided by artificial means e.g., Fans. This can be used in open air where for example natural ventilation is limited by walls or other structures

The degree of dilution is the ability of ventilation to dilute a release to a safe level.

High Dilution – The concentration near the source of release reduces quickly and there will be virtually no persistence after the leak has stopped

Medium Dilution - The concentration is controlled in a manner which produces a stable zone near the source of release and there will be no undue persistence after the leak has stopped

Low Dilution – There is significant concentration while the leak is in progress and/or a significant persistence of a flammable atmosphere after the release has stopped

Availability of ventilation is defined as:

Good Ventilation – Ventilation is present virtually continuously

Fair Ventilation – Ventilation is expected during normal operation. Cessation of ventilation is permitted for short periods

Poor Ventilation – Ventilation which does not meet the standard of Good or Fair, but discontinuities are not expected for long periods

Systematic methods for determining the dilution and ventilation are defined further in BSEN 60079-10-1 (2015)

3.3 ZONES AND EXTENT OF ZONE

Hazardous area classification is based upon the frequency of the occurrence and duration of an explosive atmosphere, and is classified as:

Zone 0 an area in which an explosive gas atmosphere is present continuously or for long periods or frequently. Both "long" and "frequently" are the terms which are intended to describe a very high likelihood of a potentially explosive atmosphere in the area. In that respect, those terms do not necessarily need to be quantified.

Zone 1 an area in which an explosive gas atmosphere is likely to occur periodically or occasionally in normal operation.

Zone 2 an area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, it will exist for a short period only.

The **extent of zone** distance in any direction from the source of release to where a gas/air mixture will be diluted by air to a concentration below the lower flammable limit.

3.4 SHAPE OF ZONE

Section A.2 of the British Standard[1] defines example shapes of zones that can used. FBW have selected a spherical zone, limited by boundary obstructions of radius equal to the extent of zone.

3.5 SELECTION OF ZONE CALCULATION METHOD

There are several methods in which hazardous area zoning can be carried out:

- Direct Example
- Modified Direct Example
- Risk Based Assessment
- Gas Dispersion
- CFD Modelling

This DSEAR assessment will use the direct example method as defined in the British Standard[1]. This is the preferred standardised approach. Some modified direct method examples where FBW's operational experience of biogas facilities will be used, namely the risk of flammable gas generation in Anaerobic Digestion feed substrate.

3.6 EQUIPMENT PROTECTION LEVEL

The level of protection of equipment required for the various zones when assigned can also be summarised, as seen in the table below:

Figure 2: Relationship Between Ex Zones and Equipment Rating

Relationship between Ex Zones and Equipment Rating						
ATEX Zone			**Equipment**			
Zone: A place where an explosive atmosphere can form	Gases	Dusts	Level of Assured Protection	Category	Marking Gases	Marking Dusts
Continuous - release which is continuous or is expected to occur frequently or for long periods. Typically, >1000hrs per year	0	20	Two Faults occurring Independently	1	Ex II 1G	Ex II 1D
Primary - release which can be expected to occur periodically or occasionally during normal operation. Typically, between 2-1000hrs per year	1	21	One equipment fault	2	Ex II 2G	Ex II 2D
Secondary - release which is not expected to occur in normal operation and, if it does occur, is likely to do so only infrequently and for short periods. Typically, <2 hours per year.	2	22	Normal operation	3	Ex II 3G	Ex II 3D

4 BASIS OF AREA CLASSIFICATION AND SOURCES OF RELEASE

4.1 BASIS OF SAFETY

The term 'basis of safety' includes all preventive and protective measures for the plant.

Preventative measures could include:

- Safety in Design
- Prevention and Minimisation of Gas release
- Inspection and Maintenance of Safety systems
- Minimise source of ignition by use of ATEX equipment
- Maintenance and Operation by competent and suitably trained individuals
- Safe Systems of work such as Permit to Work and Procedures
- Safety systems such as fixed and personal Ex gas alarms

Mitigation could include:

- Reduce/Minimise the number of personnel and public exposed to the hazardous areas
- Measure to reduce/minimise/eliminate the spread of fire and explosions such as alarm system, fire extinguishing measures
- Structural Design
- Emergency Plans

4.2 HAZARDOUS SUBSTANCES

The primary hazardous component on site and within the biogas is Methane (CH_4).

Hydrogen Sulphide (H_2S) can form but this typically would not occur in a level to pose a hazard of explosive atmospheres forming. It is however extremely hazardous to health at relatively low levels and should be eliminated wherever possible.

Digestate (organic residues post anaerobic digestion) can emit ammonia and similar products particularly at elevated pH's. Again, this would be unlikely to be produced at levels where an explosive atmosphere could form and will not be assessed within this study. Ammonia as Hydrogen Sulphide is more of a H&S concern.

This DSEAR study is predicated on their being no potentially hazardous components imported within the liquid imports to site.

Diesel is used onsite for the temporary steam boiler.

The following figure shows the likely hazardous components formed onsite and their subsequent evaluation basis.

Figure 3: Evaluation of Hazardous Components[4]

Component	Biogas	Methane	H_2S	Ammonia	Hydrogen	Diesel EN 590
Location	Produced in facility and undesirable product in feed substrate	Constituent in Biogas	Undesirable by-product in biogas and evolved from feed substrate	Produced primary post digestion	Trace constituent in Biogas	Used as fuel supply for temporary steam boiler
Flashpoint (°C)	N/A Gas @ STP	-188	-82.4	132	N/A Gas @ STP	55
Min Ignition Temperature (°C)	Composition dependent	537	232	651	585	210
Boiling Point (°C)	Composition dependent	-161.5	-60	-33.3	-252.9	n/a
Density (g/l) @ STP	1.15-1.25	0.657	1.363	0.767	0.090	820-845
Lower Explosion Limit %, (LEL)	Composition dependent	4.4	4.3	15	4	0.6
Upper Explosion Limit %, (UEL)	Composition dependent	17	46	28	75	7.5
Temperature Class	T1	T1	T3	T1	T1	T3
Gas Group	IIA	IIA	IIB	IIA	IIB	IIA
EVALUATED?	**YES**		NO – not in a quantity that would form explosive mixtures			**YES**

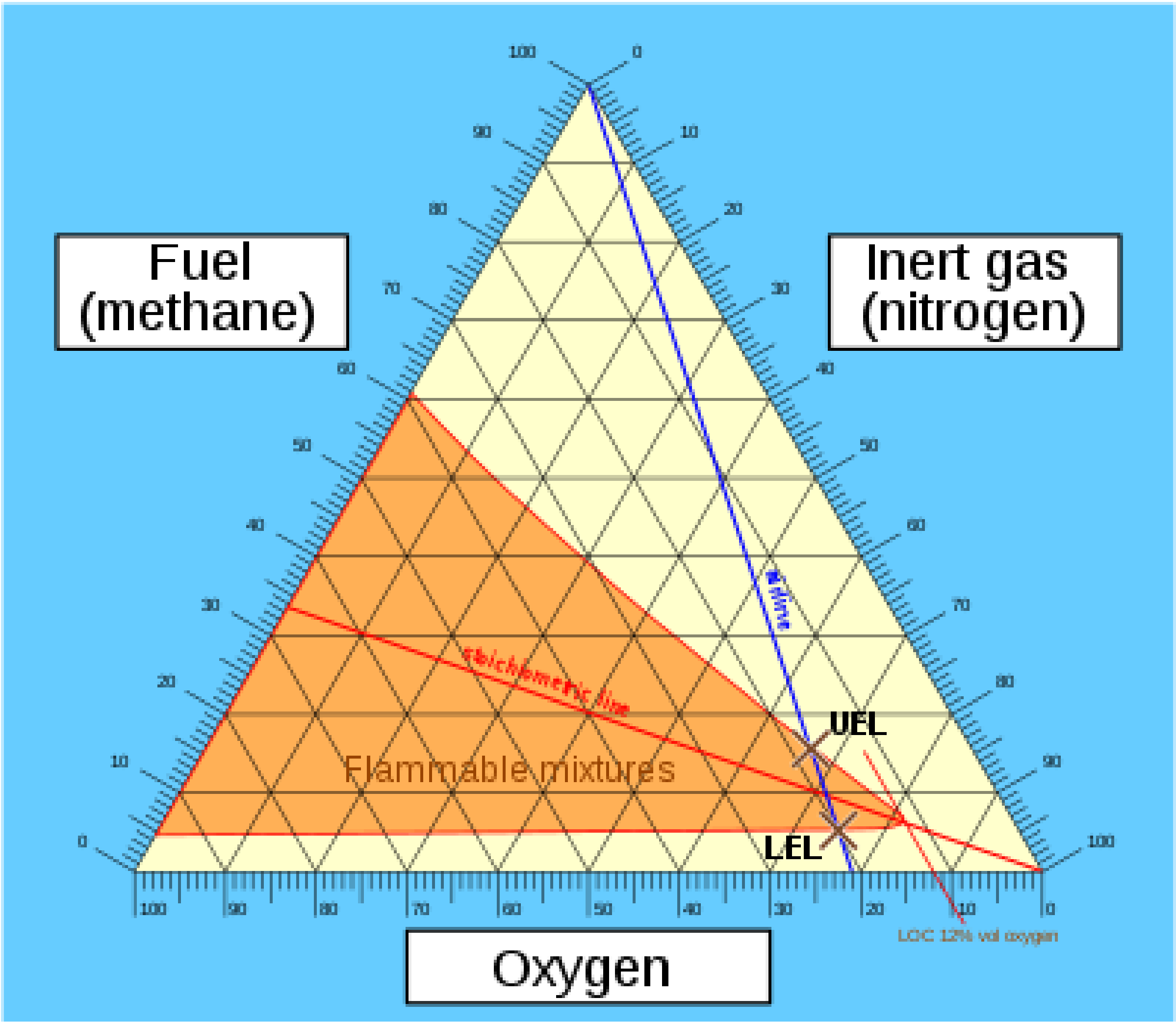
This assessment is based an assumed Biogas mixture of Methane 50-65%, with the balance carbon dioxide. Though Hydrogen sulphide can form in Biogas in typical levels of 1-2000 ppm, it is assumed to play no part in the flammability perspective when substituted by the bulk, more flammable component of methane.

Gas leaks from process areas can result in an explosive mixture when mixed with air and upon contact with a viable ignition source.

The following flammability diagram can be used to determine the lower and upper flammability limits of a methane/inert gas (carbon dioxide mix). Of note, the flammability limits of a methane rich atmosphere with trace oxygen, is different to an explosive mixture of methane in air

[4] *Perry's chemical engineers' handbook, 9th edition (mechanical engineering) hardcover – 23 sept. 2018*

Figure 4: Methane Flammability Diagram



4.3 IGNITION SOURCES

The design, selection, and installation of ATEX rated equipment is the basis of inherent safety in potentially explosive atmospheres.

If a potentially explosive atmosphere cannot be eliminated by suitable design, ATEX rated equipment is the principle means of eliminating sources of ignition.

It is therefore critical that ATEX equipment is installed, maintained, and operated by competent individuals and organisations.

Operator and Organisations must receive training regarding inspection and maintenance.

BS60079-17[5] details the grade of electrical inspections required, the interval between inspections shall be determined taking account the type of equipment, manufacturers guidance and, if any, the factors governing its deterioration. Inspection grades and intervals will need to be established and documented to determine inspection strategy. The interval between periodic inspections shall not exceed three years without seeking expert advice.

The risk/hazard of using any portable or non-permanent equipment in Ex areas/zones **must** be considered. With appropriate classification and testing utilised to maintain safe systems of work.

It is advised that any Permit to Work (PTW) system incorporate the elements within this DSEAR assessment to minimise/control/eliminate the risk of explosion and ignition.

Other key ignition risks that have been considered as part of this assessment are outlined below:

- Mechanical Failure of Plant and Equipment
- Thermal Sources – Hot Flare/CHP Engine
- Static Electricity
- Lightning Strike – Installed by Lightning Strike Ltd
- Sparks – Tools/equipment used in Ex areas should be non-sparking
- Pyrophoric Substances – none identified
- Exothermic reactions – none identified
- Ignition via radio/microwave induction – Use of mobile phones should not be used in Ex areas and Radio's should be Ex rated

[5] Guidelines for managing inspection of Ex electrical equipment ignition risk in support of IEC60079-17

- Secondary Fire from adjacent sites

4.4 NON-STANDARD OPERATION AND PLANT MAINTAINANCE

Section 6 will detail the DSEAR assessment for the plant in operation, however the facility will have stages of operation that introduce new and specific risks.

4.4.1 Start or Seeding of Anaerobic Digesters and Commissioning

Anaerobic Digesters are often "seeded" with external digestate or waste that contains the consortium of bacteria required to anaerobically digest organic substrates.

This is typically delivered in road tankers that are transferred into the process tanks.

During this period, the anaerobic digesters are not fed design levels of substrate, during which the concentration of methane is increased within the gas train.

It is standard practice for the anaerobic digesters to have an inert nitrogen blanket introduced to mitigate any explosion risk through the elimination of oxygen prior to the introduction of organic feed substrate and for intrusive maintenance,

Over time organic substrate is fed in a controlled manner into the digesters, typically called a "ramp-up".

During this commissioning period, it is common for process issues, such as slow feed rates, deviations in gas composition etc.

In conclusion within this commissioning period there is an elevated risk of stagnant material and methane generation and there a general increase in risk of an explosion.

The assessment contained within section 6 will take this period into account during the assessment period

4.4.2 Maintenance

There will be an ongoing requirement for maintenance that may result in intrusive work with an assessed zone.

Each task should be robustly risk assessed for "work" within a potentially explosive environment. Staff should be train with an understanding of working within a hazardous zone with the use of appropriate equipment, Ex equipment and safety equipment.

4.4.3 Shutdown

In a similar manner to start-up the risk of an explosion is increased during a short or long-term shutdown. An accumulation of explosive gases could occur, particularly if cleaning procedures are neglected.

5 PLANT DESCRIPTION AND PROCESS OVERVIEW

Biodynamic Ltd is a biogas plant situated in the Southeast of Colwick Industrial Estate, Nottingham near to the River Trent.

The site is close to other industrial facilities within the industrial estate. Prohibited activities are identified on site signage.

Please refer to P&ID's[6] and Anaergia Process Flow Diagram[7].

5.1 WASTE RECEPTION AND DEPACKAGING

5.1.1 RECEPTION HALL

The site imports food waste across a weighbridge before this deposited in a reception hall contained within an odour-controlled reception building (client has advised three air changes per hour) through a dedicated odour control fan.

With the reception building the food waste is macerated using a "Tiger" depackaging unit (25 tonnes per hour processing rate) which simultaneously macerates and separates non-digestible components (e.g., plastic packaging) for dewatering through a "Runi" press, where the solid non-digestible rejects can be removed from site.

The treated slurry from the "Tiger" is collected in a hopper prior to further processing. A further "Tiger" unit is scheduled for phase 2 which will add another processing stream. There is also potential for digestate to be used to act as a dilution aid.

Any liquid arisings from the "Runi" press or liquid run-off from the reception hall is collected in a sump and can be pumped back to the depackaging process.

Separated feed slurry in the Hopper is pumped via a macerator (32mm) and 50 m^3/hr progressive cavity pump to the external, odour controlled Depackaging Reception Tank (95m^3). An additional macerator-pump set will be installed for the addition of the second, phase 2, "Tiger" unit.

Digestate is pumped into a screw press which will separate a proportion of fibres from the sludge which can be disposed/recycled as appropriate. Collected Filtrate is then stored in a filtrate tank and then can be returned to the digestion process.

Note the use of digestate in the feed process in lieu of harvested rainwater or potable water can introduce anaerobic bacteria into the feed stream, increasing the likelihood of ammonia odours, Hydrogen Sulphide and increase the potential for methane generation.

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[6] *Anaergia Biodynamic Ltd Nottingham – P&ID's by FBW Engineering – Drawing Set 125-A01-01*

[7] *20210422 BFD Notts Additional Item – PP Edit - Confidential*

5.1.2 EXTERNAL RECEPTION

Tankers can connect to a 32mm macerator and 72 m^3/hr progressive cavity pump and transfer liquid or treated slurry (minimal non-digestible content) to an external, odour controlled liquid reception tank. One reception tank is scheduled for phase 1 and two more odour controlled liquid reception tanks for phase 2. Air Extraction pipework with dampers will be installed on this vessel, with extraction to a 1,600 Nm^3/hr ATEX rated fan.

5.2 PRETREATMENT

The liquid reception tank is pumped into two 50 m^3 odour controlled, pasteuriser tanks with vacuum a vacuum pressure relief valve. Where the substrate is heated via steam injection (from boiler) for a minimal of 70^{o}C for 1 hours to comply with APBR regulations.

Pasteurised substrate is then pumped into a large buffer tank at a rate of 50 m^3/hr.

Further plant phases will replace/supplement the steam heating with recovered hot water from the CHP Engines.

Air Extraction pipework with dampers will be installed on this vessel, with extraction to a temporary 1,600 Nm^3/hr ATEX rated fan.

5.3 ODOUR CONTROL

An Odour Control Unit (OCU- carbon filter) treats odourous air streams from storage tanks and processes on site.

A 1,600 Nm3/hr ATEX rated fan extract odourous air from the following tanks:

- Depackaging Reception Tank located externally which collects treated substrate from the depackaging process
- Liquid Reception Tank located externally (and phase 2 – Tanks 2/3) for the storage of pumpable substrate that do not require depackaging
- Pasteuriser 1 & 2 located externally, for the pasteurisation of substrate
- Buffer Tank located externally, collected pasteurised substrate required for fed to the digestion process

The Client has advised the various extraction legs can be balanced via dampers.

5.4 ANAEROBIC DIGESTION PROCESS

Substrate is digested in two, 3700 m^3 anaerobic digesters. Anaerobic bacteria within the liquid contents of the digester convert biodegradable components into a biogas consisting of (50-65% methane, 35-50% Carbon Dioxide, and other trace components such as Hydrogen Sulphide).

Each Digester has an integrated double membrane biogas holder which acts as the roof of the tank and contains the biogas produced. The space between each membrane is inflated using a duty/standby air blower in a relatively standard configuration.

Condensate from the biogas stream can be returned to the Digesters.

Digested sludge from the Primary anaerobic Digesters can undergo further digestion in a single Post Digester (6400 m^3). An integrated double membrane biogas holder for any residual biogas production is connected to the gas system (design as above).

All digesters and post digesters have internal mixing and have two, integrated *Anaergia Service box*[8] *Pro* Pressure Relief Valves (-0.5mbar) with Over pressure (5mbar) and under pressure protection.

Hydrogen Sulphide (H_2S) is a corrosive, hazardous gas. The evolution of H_2S is minimised by microaeration. Duty/Standby blowers independently inject air into all Digesters and Post Digesters into the integral biogas holder, which through oxidation reactions concerts H_2S to Sulphur. The final design has not been finalised but a single gas pipe with non-return valves fitted is proposed. A Gas analyser in the biogas output of each digester will stake a reading once per hour and if the oxygen concentration increases above 1.2vol% the oxygen feed to that specific digester will cease.

5.4.1 PUMP ROOM

Manifold Piping is in place in the Pump Room allowing flexibility to which digester pasteurised sludge is fed. This is important to consider during the DSEAR as there is the design potential to add feed to the digesters in varying proportions and therefore materially affect biogas evolution.

The Microaeration blowers are situated in the Pump Room.

Ventilation is in place for the pump room with a rate of 2,600Nm^3/hr

A sump collects any spillages for return to the Digestion Process.

[8] *Anaergia Service Box – PRV - 301_TDS_Servicebox Pro_R1.1_EN_20210322*

5.5 BIOGAS STREAM AND CONSUMERS

Biogas produced in the Anerobic Digestion process is processed:

1. Individually analysed for Composition in a gas analyser

2. Biogas blowers to increase pressure for downstream processes

3. An optional chiller package will remove water from the biogas steam that hasn't condensed from the system

4. Activated Impregnated Carbon used to remove H_2S from the biogas stream

5. Activated Impregnated Carbon used to remove Volatile Organic Carbon (VOC) from the biogas stream

6. 2 x Flare (2000 Nm^3/hr and 1000 Nm^3/hr) used as an emergency consumer in the event of no processing options of biogas. This provides sufficient processing for 100% of Phase 3 production. This will use biogas for ignition.

7. Biogas Upgrading Unit (BUU) by *Air Liquide* for grid injection (by increasing methane content) with a consumption in phase 1 of 979 Nm^3/hr boosted biogas.

8. 2 x CHP Units (2MW + 0.5 MW) with a consumption in phase 1-2 of 1000 Nm^3/hr boosted biogas moving to circa 3000 Nm^3/hr in phase 3.

Failure to adequately control the volumes of biogas produced either in the process streams or flare could result in the Pressure Relief safety systems activating on the Digestion tanks hence the overpressure relief valves set at 5 mbar.

Biogas pipework is installed at high level, with condensate points, at low points draining to a condensate sump, which allows liquors to be returned and contained in the digestion process.

5.6 UTILITIES

A temporary boiler powered by diesel is used as a heating source for the process and to provide steam injection for the pasteurisation process.

Potable water manifold is distributed from the main, in the pump room.

An air compressor is fitted in the Pump room to provide plant air.

A rainwater harvesting system is installed to reduce the requirement of potable water within the process

5.7 DIGESTATE REMOVAL

A tanker connection is in place on the Post Digestion Tank to remove digestate substrate prior to off-site disposal. The client has indicated that PAS110 could be sought but initially this would be recycled appropriately under permitted spreading for agricultural benefit.

6 AREA CLASSIFICATION

See hazardous area zoning summary in Appendix 1. Sections for infrequent operations such as maintenance, start-up, commissioning, shutdown can be found in section 4.4.

6.1 TIGER HOPPER SLURRY TANK (ID=1)

6.1.1 Basis of Assessment

The tiger slurry tank[9] is a collection vessel for the macerated and screened substrate that ultimately is a source of organic material for anaerobic digestion. It therefore has the potential for generating methane under anaerobic conditions. However, for this to occur, a consortium of microbiological agents would be required. Unless "seeded" from an external source, this slurry is unlikely to generate from the relatively small volume of this intermediate storage tank.

The contents of this tank are much more likely to generate H_2S and malodours. However, in extreme circumstances, levels of the magnitude of 1000's of ppm of H_2S represents a H&S/odour risk and not an explosion/deflagration risk.

Therefore, on this basis it has been determined in normal operating conditions there is **no potential to generate a hazardous atmosphere through the accumulation of methane gas**.

However, it is common in similar anaerobic digestion plants to use recycled digestate as an alternative to potable water as a water/utility saving measure. This material contains active anaerobic bacteria and can "seed" organic materials and introduce the potential for methane generation. This would likely result in a zoning requirement and therefore would render this section of the DSEAR assessment as no longer accurate. **Please note the client has advised that digestate will not be used as a water substitute**.

In addition, within the reception hall, post digestion dewatering operations take place to screen solids from liquid digestate prior to disposal/recover. These materials could seed multiple operations within the reception hall. Therefore, operations should be completely demarcated/separated with appropriate control steps implemented. Note similar steps are also required for management of ABPR regulation.

[9] *https://www.tigerdepack.com/en/*

6.1.2 Recommendations

The following recommendations are made to further mitigate risk:

- Regular clean-outs/flushes (e.g., weekly) of the slurry tank to prevent anaerobic species, H_2S and malodourous species to form

- Daily emptying of the slurry tank (e.g., end of production run/shift) to prevent anaerobic species, H_2S and malodourous species to form

- Installation of local odour extraction, not only will this prevent malodours to spread within the reception hall, but if digestate was introduced this could act as an appropriate control measure to prevent an explosive atmosphere from forming

- Consider installing Ex protected instruments at the design stage to future proof if digestate is introduced

- Segregation of post digestion residues to prevent contamination of substrates

6.2 RECEPTION HALL PIT (ID=2)

6.2.1 Basis of Assessment

Two reception Hall pits act as collection of substrates of recovered/washed organics from the “Runi” press and runoff from drains and leachate from the reception hall. As in section 6.1 this material is a source of organic material for anaerobic digestion. It therefore has the potential for generating methane under anaerobic conditions. However, for this to occur, a consortium of microbiological agents would be required. Unless “seeded” from an external source, this slurry is unlikely to generate from the relatively small volume of these pits.

The contents of this tank are much more likely to generate H_2S and malodours. However, in extreme circumstances, levels of the magnitude of 1000’s of ppm of H_2S represents a H&S/odour risk and not an explosion/deflagration risk.

Therefore, on this basis it has been determined in normal operating conditions there is **no potential to generate a hazardous atmosphere through the accumulation of methane gas**.

However, it is common in similar anaerobic digestion plants to use recycled digestate as an alternative to potable water as a water/utility saving measure. This material contains active anaerobic bacteria and can “seed” organic materials and introduce the potential for methane generation. This would likely result in a zoning requirement and therefore would render this section of the DSEAR assessment as no longer accurate. **Please note the client has advised that digestate will not be used as a water substitute**.

In addition, within the reception hall, post digestion dewatering operations take place to screen solids from liquid digestate prior to disposal/recover. These materials could seed multiple operations within the reception hall. Therefore, operations should be completely demarcated/separated with appropriate control steps implemented. Note similar steps are also required for management of ABPR regulation.

6.2.2 Recommendations

The following recommendations are made to further mitigate risk:

- Regular clean-outs/flushes (e.g., weekly) of the pits to prevent anaerobic species, H_2S and malodourous species to form
- Daily emptying of the pits (e.g., end of production run/shift) to prevent anaerobic species, H_2S and malodourous species to form
- Installation of local odour extraction, not only will this prevent malodours to spread within the reception hall, but if digestate was introduced this could act as an appropriate control measure to prevent an explosive atmosphere from forming
- Consider installing Ex protected instruments at the design stage to future proof if digestate is introduced
- Segregation of post digestion residues to prevent contamination of substrates

6.3 RECEPTION HALL GENERAL – E.G. WASTE RECEPTION, GULLIES, PUMPS, PIPES ETC (ID=3)

6.3.1 Basis of Assessment

In a similar manner to previous sections, consideration should be made with respect to the operation and design of the reception hall. What areas could accumulate, stagnant organic materials?

The contents of this tank are much more likely to generate H_2S and malodours. However, in extreme circumstances, levels of the magnitude of 1000's of ppm of H_2S represents a H&S/odour risk and not an explosion/deflagration risk.

It is assumed that robust operational and housekeeping practices will be carried out to prevent accumulation of organic material, substrates, and leachate run-off in gullies, drains etc and no waste will be allowed to accumulate in process areas. It is also assumed that no leachate or residues from the dewatering process will cross contaminate the reception hall operations.

Therefore, on this basis it has been determined in normal operating conditions there is **no potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.3.2 Recommendations

The following recommendations are made to further mitigate risk:

- Daily cleaning and flushing of process areas, drains and gullies (e.g., end of production run/shift) to prevent anaerobic species, H_2S and malodourous species to form

- Daily turnover of waste "piles" or collection to prevent pockets of explosive gas forming

- Installation of local odour extraction at low level, not only will this prevent malodours to spread within the reception hall, but if digestate was introduced this could act as an appropriate control measure to prevent an explosive atmosphere from forming

- Segregation of post digestion residues to prevent contamination of substrates

6.4 FILTER DEWATERING PRESS (ID=4)

6.4.1 Basis of Assessment

The filter press process digestate, post anaerobic digestion to separate the solid material and fibres from the liquid digestate. Solid material is stored in a bunker with liquid digestate sent to the filtrate tank as an intermediate step (see section 6.5).

It is assumed that robust operational and housekeeping practices will be carried out to prevent accumulation of organic material, substrates, and leachate run-off in gullies, drains etc and no waste will be allowed to accumulate in process areas. It is also assumed that no leachate or residues from the dewatering process will cross contaminate the reception hall operations.

It is assumed that there is minimal liquid hold-up in the press and no material will be left to accumulate when the material is not in operation.

This material is intended to be pumped direct from the post digester, there therefore is the **potential for methane generation and hazardous area forming** through degassing of methane from the liquid substrate.

Note this area is not installed under the current (as of Feb 2022) installation.

6.4.1.1 DSEAR ASSESMENT – INTERNAL TO PRESS

In operation an explosive atmosphere could form in the press.

Grade of Release – deemed to be **CONTINUOUS** when in operation
Degree of Dilution – deemed to be **LOW**
Availability of Ventilation – deemed to be **POOR**

ZONE CLASSIFICATION – ZONE 0
EXTENT OF ZONE – INTERNAL TO PRESS

6.4.1.2 DSEAR ASSESDMENT – EXTERNAL TO PRESS

In operation an explosive atmosphere could form in the press.

As per section C.3.5 BS EN 60079-10-1:2015

Release Rate = 0.6 g/s
Release Characteristic = 0.02 m^3/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.628 kg/m3 @ 38^oC, +5 mbarg internal pressure, 6mm circular opening, coefficient of discharge 0.9]

Assume **minimal** ventilation rate of 0.03 m/s from OCU

Grade of Release – deemed to be **CONTINUOUS** when in operation
Degree of Dilution – deemed to be **HIGH**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 2
EXTENT OF ZONE – EXTERNAL TO PRESS = 0.7m (assume 1.0m)

6.4.2 Recommendations

The following recommendations are made to further mitigate risk:

- Daily drain down at end of production run
- Installation of local odour extraction to maintain ventilation rate across of press
- Internal zone 0 of press external zone 2, 1m spherical zone
- Segregation of post digestion residues to prevent contamination of substrates
- Hazardous classification and therefore zones can be removed by methane stripping the digestate (see section 6.18)
- The use of OCU with independent backup power supply, to prevent non-provision of extraction, on the assessed basis would result in declassification to non-hazardous zone of negligible extent classification.

6.5 FSP FILTRATE COLLECTION TANK (ID=5)

6.5.1 Basis of Assessment

The FST filtrate collection tank collects dewatered filtrate prior to return to the post digestate storage tank.

It is assumed that robust operational and housekeeping practices will be carried out to prevent accumulation of organic material, substrates, and leachate run-off in gullies, drains etc and no waste will be allowed to accumulate in process areas. It is also assumed that no leachate or residues from the dewatering process will cross contaminate the reception hall operations.

This material is intended to be pumped direct from the post digester, with minimal hold-up in the dewatering press there therefore is the **potential for methane generation and a hazardous area forming** through degassing of methane from the liquid substrate.

Note this area is not installed under the current (as of Feb 2022) installation.

6.5.1.1 DSEAR ASSESSMENT – FILTRATE COLLECTION TANK

In operation an explosive atmosphere could form in the headspace of the tank

As per section C.3.5 BS EN 60079-10-1:2015

Release Rate = 5 g/s
Release Characteristic = 0.18 m^3/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.634kg/m3 @ 35C, +1 mbarg internal pressure, 25mm circular opening (vent), coefficient of discharge 0.9]

Assume ventilation rate of 0.01-3 m/s from OCU

Grade of Release – deemed to be **CONTINUOUS** when in operation
Degree of Dilution – deemed to be **MEDIUM**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 0 HEADSPACE AND AT VENT
EXTENT OF ZONE – HEADSPACE OF TANK, 2m Spherical zone from Vent

6.5.2 Recommendations

The following recommendations are made to further mitigate risk:

- Daily empty at end of production run
- Installation of local odour extraction on tank to maintain ventilation rate within the tank
- Installation of Vent to ensure no pressurisation
- Hazardous area classification of Internal zone 0 within in Filtrate Tank and for a 2m zone surrounding Vent
- Hazardous classification and therefore zones can be removed by methane stripping the digestate (see section 6.18)

6.6 DEWATERED SOLID STORAGE BUNKER (ID=6)

6.6.1 Basis of Assessment

The solid digestate has the potential to emit small levels of methane. It will be assumed to be non-hazardous provided sufficient local ventilation is provided.

Note as the material will likely be handled by plant to remove from offsite, hazardous area classification could be detrimental to operations.

Note this area is not installed under the current (as of Feb 2022) installation.

6.6.2 Recommendations

The following recommendations are made to further mitigate risk:

- Minimise storage volumes
- Daily turnover of waste “piles” or collection to prevent pockets of explosive gas forming
- Installation of local odour extraction on tank to maintain ventilation rate
- Ensure sufficient air ventilation rates
- Frequent methane assessments within the locality of the storage area to maintain assumption on non-hazardous assessment. Should methane levels accumulate above 1.3 vol% (approx. 30% of Lower explosion limit) reclassification is advised
- Any risk of hazardous atmosphere forming can be further reduced by methane stripping the digestate (see section 6.18)

6.7 RAINWATER HARVESTING TANKS (ID=7)

6.7.1 Basis of Assessment

The rainwater harvesting tanks are installed to provide dilution water for the Tiger depackaging process and are installed to provide recycled water mitigating the use of potable water

However, it is common in similar anaerobic digestion plants to use recycled digestate as an alternative to potable water as a water/utility saving measure. This material contains active anaerobic bacteria and can "seed" organic materials and introduce the potential for methane generation. If these tanks were converted to a duty of digestate transfer or mixing with water, this would likely result in a zoning requirement and therefore would render this section of the DSEAR assessment as no longer accurate.

Therefore, on this basis it has been determined in normal operating conditions there is **no potential to generate a hazardous atmosphere**.

6.7.2 Recommendations

The following recommendations are made to further mitigate risk:

- Consider installing Ex protected instruments at the design stage to future proof if digestate is introduced

6.8 DEPACKAGING RECEPTION TANK (ID=8)

6.8.1 Basis of Assessment

The depackaging reception tank is located outside the reception hall and acts as bulk storage for the depackaged organic slurry produced in the reception hall. This material following further treatment is then suitable for anaerobic digestion.

Though the tank is mixed via a recirculating pump, stratification of this waste is likely due to the high viscosity/rheology and with significant retention time, local or bulk anaerobic conditions can occur resulting in the production of methane.

The tank is extracted to the odour control unit via temporary ATEX rated fans. No pressure relief valve or breather valve is shown.

The contents of this tank are much more likely to generate H_2S and malodours. However, in extreme circumstances, levels of the magnitude of 1000's of ppm of H_2S represents a H&S/odour risk and not an explosion/deflagration risk.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

Note if recycled digestate is used in the reception hall. The likelihood/risk of methane forming during stagnant conditions. This material contains active anaerobic bacteria and can "seed" organic materials and introduce the potential for methane generation. This would likely result in a change to the zoning requirement and therefore would render this section of the DSEAR assessment as no longer accurate.

6.8.1.1 DSEAR ASSESSMENT – DEPACKAGING RECEPTION TANK

In operation an explosive atmosphere could form in the headspace of the tank

As per section C.3.5 BS EN 60079-10-1:2015

Release Rate = 5 g/s
Release Characteristic = 0.17 m^3/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.656 kg/m^3 @ 25°C, +1 mbarg internal pressure, 25mm circular opening (vent), coefficient of discharge 0.9]

Assume minimal ventilation rate of **3 m/s** from OCU extraction. Diameter of tank = 3.7 m. CSA = 10.7 m^2, there**fore minimal ventilation rate = 32 Nm^3/hr**

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **HIGH**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 2 (NEGLIGIBLE EXTENT) HEADSPACE
EXTENT OF ZONE – N/A

6.8.2 Recommendations

The following recommendations are made to further mitigate risk:

- Internal hazardous area classification of zone 2 Negligible Extent of depackaging reception tank. Note exposure of instruments/equipment of submerged components should be considered.

- Weekly drain/turn over down to minimal levels

- A maximum of 5 days retention in the storage tank

- Consideration for microaeration of the fluid, though this will increase odour carryover into the OCU, the oxygen will inhibit anaerobic conditions from forming and minimise H_2S formation. This would likely result in declassication to Zone 2 NE on the above assessment.

- Ensure sufficient ventilation/ air changes in the headspace of the depackaging reception tank, at minimal operation liquid level, of 6 m/s at surface.

- Consider pressure conditions of headspace PRV/vent arrangements (e.g., tank drawing in), note though these perform a safety function, a hazardous zone requirement will be required based on the above assessment.

- The use of Digestate in the feed would likely result in reassessment though the internal hazardous area zoning would be unlikely to change if the ventilation rate is high.

- The use of OCU with independent backup power supply, to prevent non-provision of extraction, on the assessed basis would result in declassification to non-hazardous zone of negligible extent classification.

6.9 LIQUID RECEPTION TANK(S) (ID=9)

6.9.1 Basis of Assessment

A liquid reception tank (380 m^3) is to be installed in phase 1 with additional tanks installed in further expansion phases. These are located extern to the reception hall and are installed to provide bulk storage for miscellaneous substrates suitable for anaerobic digestion.

The reception tanks are mixed with two side entry mixers and have extraction to the odour control unit. No pressure relief valve or breather valve is shown. No additional vents are shown that would require external zoning.

The nature and composition of these substrates are unknown, but it is assumed as they are suitable for anaerobic digestion, they have the potential to generate methane.

It is assumed in a similar manner to other organic substrates that the contents of this tank are more likely to generate H_2S and malodours. However, in extreme circumstances, levels of the magnitude of 1000's of ppm of H_2S represents a H&S/odour risk and not an explosion/deflagration risk.

Therefore, on the above variability and unknown composition of the substrate it has been assumed in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.9.1.1 DSEAR ASSESSMENT – LIQUID RECEPTION TANK(S)

In operation an explosive atmosphere could form in the headspace of the tank

Release Rate = 5 g/s
Release Characteristic = 0.18 m^3/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.656 kg/m^3 @ 40^{o}C, +1 mbarg internal pressure, 25mm circular opening (vent), coefficient of discharge 0.9]

Assume minimal ventilation rate of **3 m/s** from OCU extraction. Diameter of tank = 8 m. CSA = 50.2 m^2, there**fore minimal ventilation rate = 151 Nm^3/hr**

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **HIGH**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 2 (NEGLIGIBLE EXTENT) HEADSPACE
EXTENT OF ZONE – N/A

6.9.2 Recommendations

The following recommendations are made to further mitigate risk:

- Internal hazardous area classification of zone 2 Negligible Extent of liquid reception tank(s). Note exposure of instruments/equipment of submerged components should be considered.
- Weekly drain down/turnover to minimal levels
- A maximum of 5 days retention in the storage tank is recommended
- Ensure sufficient ventilation/ air changes in the headspace of the liquid reception tank(s), at minimal operation liquid level of 3 m/s at surface.
- Consider pressure conditions of headspace PRV/vent arrangements (e.g., tank drawing in), note though these perform a safety function, a hazardous zone requirement will be required based on the above assessment
- The use of Digestate in the feed would likely result in reassessment though the internal hazardous area zoning would be unlikely to change if the ventilation rate is high
- The use of OCU with independent backup power supply, to prevent non-provision of extraction, on the assessed basis would result in declassification to non-hazardous zone of negligible extent classification.

6.10 PASTEURISER TANKS (ID=10)

6.10.1 Basis of Assessment

Pasteurisation is required for processing of animal derived wastes suitable for anaerobic digestion to comply with ABPR (Animal By-Product Regulations) by reducing/minimisation of biological pathogens.

2, 100m^3 are located externally to the reception hall. When ready for processing substrate is pumped into the tanks with steam injected to raise the temperature above 75^{o}C for 1 hour. The substrate is then suitable for anaerobic digestion.

The high temperatures are also suitable for eliminating the viable anaerobic bacteria that could produce methane. Therefore, this assessment is based on the degassing of methane in an enclosed headspace but a potential of methane generation lower than that of earlier processing steps.

Mixing is provided by pumped recirculation during the heating phase. The tanks are odour controlled via connection to the OCU under negative pressure with a vacuum relief valve located on the roof.

It is assumed in a similar manner to other organic substrates that the contents of this tank are more likely to generate H_2S and malodours. However, in extreme circumstances, levels of the magnitude of 1000's of ppm of H_2S represents a H&S/odour risk and not an explosion/deflagration risk.

Therefore, on the above variability and unknown composition of the substrate it has been assumed in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.10.1.1 DSEAR ASSESSMENT – PASTEURISER TANKS

In operation an explosive atmosphere could form in the headspace of the tank

Release Rate = 5 g/s
Release Characteristic = 0.2 m^3/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.656 kg/m^3 @ 75^{o}C, +1 mbarg internal pressure, 25mm circular opening (vent), coefficient of discharge 0.9]

Assume minimal ventilation rate of **3 m/s** from OCU extraction. Diameter of tank = 3.35 m each. CSA = 8.8 m^2, there**fore minimal ventilation rate = 31 Nm^3/hr**

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **HIGH**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 2 (NEGLIGIBLE EXTENT) HEADSPACE
EXTENT OF ZONE – N/A

6.10.2 Recommendations

The following recommendations are made to further mitigate risk:

- Internal hazardous area classification of zone 2 Negligible extent of pasteuriser tanks. Note exposure of instruments/equipment of submerged components should be considered.

- Minimal liquid substrate retention in the pasteuriser tanks when not in use

- Ensure sufficient ventilation/ air changes in the headspace of the liquid reception tank(s), at minimal operation liquid level of 3 m/s at surface.

- Consider pressure conditions of headspace PRV/vent arrangements (e.g., tank drawing in, over pressurisation with steam), note though these perform a safety function, a hazardous zone requirement will be required based on the above assessment. This would require dynamic DSEAR assessment to determine if a hazardous zone would be created, however with steam dilution the likelihood of a hazardous zone is reduced.

6.11 FEED BUFFER TANK (ID=11)

6.11.1 Basis of Assessment

The feed buffer tank is located outside the reception hall and acts as the feed tank for the anerobic digestion phase.

Though the tank is mixed via a recirculating pump, stratification of this waste is likely due to the high viscosity/rheology, elevated temperature and with significant retention time, local or bulk anaerobic conditions can occur resulting in the production of methane. This risk is mitigated somewhat by the precursor pasterurisation step.

The tank is extracted to the odour control unit. With an atmospheric vent shown.

The contents of this tank are much more likely to generate H_2S and malodours. However, in extreme circumstances, levels of the magnitude of 1000's of ppm of H_2S represents a H&S/odour risk and not an explosion/deflagration risk.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.11.1.1 DSEAR ASSESSMENT – FEED BUFFER TANK

In operation an explosive atmosphere could form in the headspace of the tank

As per section C.3.5 BS EN 60079-10-1:2015

Release Rate = 5 g/s
Release Characteristic = 0.19 m^3/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.605kg/m^3 @ 50^{o}C, +1 mbarg internal pressure, 50mm circular opening (vent), coefficient of discharge 0.9]

Assume minimal ventilation rate of **3.5 m/s** from OCU extraction. Diameter of tank = 11.5 m. CSA = 103.8 m^2, there**fore minimal ventilation rate = 363 Nm^3/hr**

Grade of Release – deemed to be **PRIMARY** when in operation
Degree of Dilution – deemed to be **HIGH**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 2 HEADSPACE
EXTENT OF ZONE – 4m SPHERICAL ZONE 2 @ 2" assumed VENT

6.11.2 Recommendations

The following recommendations are made to further mitigate risk:

- Internal hazardous area classification of zone 2 of Feed Buffer Tank. Note exposure of instruments/equipment of submerged components should be considered.

- Weekly drain/turn over down to minimal levels

- A maximum of 5 days retention in the storage tank

- Consideration for microaeration of the fluid, though this will increase odour carryover into the OCU, the oxygen will inhibit anaerobic conditions from forming and minimise H_2S formation. This would likely result in declassication to Zone 2 NE on the above assessment.

- Ensure sufficient ventilation/ air changes in the headspace of the depackaging reception tank, at minimal operation liquid level, of 10 m/s at surface.

- Consider pressure conditions of headspace PRV/vent arrangements (e.g., tank drawing in), note though these perform a safety function, a hazardous zone requirement will be required based on the above assessment.

- The use of OCU with independent backup power supply, to prevent non-provision of extraction, on the assessed basis would result in declassification to non-hazardous zone of negligible extent classification.

6.12 ODOUR CONTROL UNIT (ID=12)

6.12.1 Basis of Assessment

The odour control unit ventilates from the storage tanks and process areas that have the potential to generate methane.

The ventilation rates suggested should reduce any methane concentration below that of flammable concentrations.

Therefore, on this basis it has been determined in normal operating conditions there is **no potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.12.2 Recommendations

The following recommendations are made to further mitigate risk:

- Any instruments located on the OCU pipework adjacent to tanks with a hazardous zone should be identified. It is advised that no instruments be located within 2m of the hazardous area boundary

- The use of OCU with independent backup power supply, to prevent non-provision of extraction, would result in declassification of many identified hazardous area zones throughout the site.

6.13 DIGESTER/POST DIGESTER HEADSPACE (ID=13)

6.13.1 Basis of Assessment

Two Anaerobic Digesters and one Post Anaerobic Digestion have the capacity to produce methane and are all connected to a common gas header. Each unit has a double membrane gas holder with integrated air injection to control H_2S levels in the headspace.

Relatively small/trace levels of H_2S and Hydrogen are expected to be generated however this does not represent an explosion/deflagration risk.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.13.1.1 DSEAR ASSESSMENT – DIGESTER/POST DIGESTER HEADSPACE

In operation an explosive atmosphere could form in the headspace of the tank

Grade of Release – deemed to be **CONTINOUS** when in operation
Degree of Dilution – deemed to be **LOW**
Availability of Ventilation – deemed to be **POOR**

ZONE CLASSIFICATION – ZONE 0 HEADSPACE
EXTENT OF ZONE – HEADSPACE ONLY

6.13.2 Recommendations

The following recommendations are made to further mitigate risk:

- Internal hazardous area classification of zone 0 of Headspace of the Digesters. Note exposure of instruments/equipment of submerged components should be considered. The units have the potential to be exposed.

- An individual PRV does not have the demonstrated capacity (in supplied) documentation to process the entire design gas generation. Therefore, multiple failures required to prevent adequate over pressurisation of gas system

- Multiple injection points for air should be considered to minimise local concentrations of oxygen

- Though the microaeration oxygen levels are monitored via a gas analyser (emergency shutoff). Physically limiting the maximum air injection via a restriction orifice should be considered. Backflow of methane down the microaeration pipework should be managed with non-return valves.

6.14 DIGESTER/POST DIGESTER "SERVICE BOX" PRESSURE RELIEF VALVE (ID=14)

6.14.1 Basis of Assessment

Two Anaerobic Digesters and one Post Anaerobic Digestion have the capacity to produce methane and are all connected to a common gas header.

Each Digester/Post Digester has two "Service Box" PRV's installed to provide over pressure protection of 5barg and under pressure protection of -0.5mbarg.

Relatively small/trace levels of H_2S and Hydrogen are expected to be generated however this does not represent an explosion/deflagration risk.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.14.1.1 DSEAR ASSESSMENT – DIGESTER/POST DIGESTER TANK PRV's

In operation an explosive atmosphere could form in the headspace of the tank leading to emission

As per section C.3.5 BS EN 60079-10-1:2015

Release Rate = 650 m^3/hr (assumed)
Release Characteristic = 4.1 m^3/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.624kg/m^3 @ 40^{o}C, +5 mbarg internal pressure, coefficient of discharge 0.9]

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **MEDIUM**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 2 HEADSPACE
EXTENT OF ZONE – 9m SPHERICAL ZONE 2 @ each PRV

6.14.2 Recommendations

The following recommendations are made to further mitigate risk:

- Internal hazardous area classification of zone 2, 9m from "Service Box" PRV. Note exposure of instruments/equipment of submerged components should be considered.
- Consideration for cleaning and taking a PRV out of service should be considered. The addition of microaeration can induce the build-up of sulphur/bio slime deposits.
- Recommend locating the PRV's at opposite end of the tanks away from the flow of gas down the biogas pipework.

6.15 DIGESTER/POST DIGESTER GAS PIPEWORK FLANGES/SCREW CONNECTIONS (ID=15)

6.15.1 Basis of Assessment

Two Anaerobic Digesters and one Post Anaerobic Digestion have the capacity to produce methane and are all connected to a common gas header.

The pipework will have penetrations for instruments, flange, or screwed connections.

Relatively small/trace levels of H_2S and Hydrogen are expected to be generated however this does not represent an explosion/deflagration risk.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.15.1.1 DSEAR ASSESSMENT – DIGESTER/POST DIGESTER GAS PIPEWORK FLANGE/SCREW CONNECTIONS

In operation an explosive atmosphere could form in the headspace of the tank leading to emission

As per section C.3.5 BS EN 60079-10-1:2015

For 5 mbarg Pressure
Release Rate = 0.1g/s
Release Characteristic = 3 l/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.624kg/m^3 @ 40°C, +5 mbarg internal pressure, diameter of opening = 2mm, coefficient of discharge 0.9], assumed 1 m/s ventilation rate

For 150 mbarg Pressure
Release Rate = 0.4g/s
Release Characteristic = 15 l/s
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.624kg/m^3 @ 40°C, +150 mbarg internal pressure, diameter of opening = 2mm, coefficient of discharge 0.9], assumed 1 m/s ventilation rate

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **MEDIUM**
Availability of Ventilation – deemed to be **POOR**

ZONE CLASSIFICATION – ZONE 2
EXTENT OF ZONE – 0.3m/0.6m around connections (5/150 mbar internal pressure respectively)

6.15.2 Recommendations

The following recommendations are made to further mitigate risk:

- Consider earthing and build-up of static electricity within gas pipework
- Do not install lagging or heat tracing tape over flanges to mitigate risk of biogas pockets forming should flanges leak
- Periodic bold torque assessments for flanges
- Minimise joints within gas pipework

6.16 DIGESTER/POST DIGESTER GAS HOLDER BLOWERS (ID=16)

6.16.1 Basis of Assessment

Two Anaerobic Digesters and one Post Anaerobic Digestion have the capacity to produce methane and are all connected to a common gas header with integrated double membrane biogas holders. The air space between the membranes is inflated using duty/standby air blowers (*Creative CBLOWER VTEX122S*), with blown air vented through a weighted vent. The degree of flow and backpressure generated by the weighted vent, controls the biogas pressure via applied forces.

At a response pressure of 5 mbar (i.e., +5 mbar system pressure in the gas train) a single blower can generate an air flow of 70 m^3/h

The biogas holder membrane is slightly permeable and therefore the air space has the potential to have a concentration of methane present. The worst-case scenario has been projected which failure of the membrane and explosive concentration of methane formed and blown out of the air vent.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.16.1.1 DSEAR ASSESSMENT – DIGESTER/POST DIGESTER GAS HOLDER BLOWERS

Permeation of methane through the inner membrane occurs in normal operation. However, basis of calculation is that entire inner airspace is at the same concentration of methane as the digestion system. Therefore, assumed hazardous.

As per section C.3.5 BS EN 60079-10-1:2015

Release Rate = 91 m^3/hr (Expected flow 70 m^3/hr)
Release Characteristic = 442 l/hr
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.624kg/m^3 @ 40°C, +5 mbarg internal pressure, average diameter of opening = 25mm, coefficient of discharge 0.9], assumed >0.03 m/s ventilation rate

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **MEDIUM**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 0 (within membrane annulus space)
ZONE CLASSIFICATION – ZONE 2
EXTENT OF ZONE – 3.0m around weighted vent opening

6.16.2 Recommendations

The following recommendations are made to further mitigate risk:

- The area around the weighted vent should be clear and unobstructed to ensure adequate ventilation
- A mesh screen should be fitted to the vent to protect the vent from debris/pests
- The control system should prevent both blowers running in parallel
- Zone has been sized for the design flow + 30%
- Any change to flows or weighted vent could alter the size of external hazardous zone)
- Frequent measurement of methane concentration blown from vents, should be taken which is indicative of internal membrane failure.

6.17 PUMP ROOM (ID=17)

6.17.1 Basis of Assessment

The pump room contains transfer pumps for feeding and recycling of digestate as well as the micro aeration blowers.

Relatively small/trace levels of H_2S and Methane are expected to be generated from any digestate spilled from the process, in normal operation this would not be considered a significant risk, therefore this does not represent an explosion/deflagration risk.

The client has communicated that the room will be ventilated by a 2,600 Nm^3/hr fan. It is assumed that minimal digestate will be allowed to accumulate within the pump room.

On this basis it has been determined in normal operating conditions there is **no potential** to generate a hazardous atmosphere through the accumulation of methane gas.

6.17.2 Recommendations

The following recommendations are made to further mitigate risk:

- Ensure a minimum of 5 air changes per hour ventilation occur within this pump room, as the digestate is a source of odour, connecting to the OCU would be advisable.
- Back flow of biogas/methane through the micro aeration must be prevented i.e., non-return valves
- Digestate spills will be removed expediently
- Recommend the installation of Ex alarms with internal and external beacons/sounders

6.18 DIGESTATE REMOVAL FROM POST DIGESTER VIA TANKER (ID=18)

6.18.1 Basis of Assessment

A gravity drain tanker offloading point is fitted to the Post Digester. This allows liquid digestate/liquor to be removed from the process.

As this digestate contains active biomass, it is assumed that a methane rich headspace can form in the tanker either through active generation or degassing. Note this potentially could result in over pressurisation of the tanker.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.18.1.1 DSEAR ASSESSMENT – DIGESTATE TANKER

Grade of Release – deemed to be **CONTINOUS** within headspace
Degree of Dilution – deemed to be **MEDIUM**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 0 (within tanker headspace)
ZONE CLASSIFICATION – ZONE 2 (around vents and PRV's)
EXTENT OF ZONE – 1m around vents and PRV's

NOTE TEMPORARY ZONES WHILE OPERATION IS CARRIED OUT

6.18.2 Recommendations

The following recommendations are made to further mitigate risk:

- Installation of two valve interlock key system to ensure safe draining of the Post Digester
- A gravity drain system could potentially lead to high flows, as well as rapid generation of malodours. Tanker filling via controlled pumps should be considered
- Tanker Vehicle should be stationary, engine turned off with no hot surfaces within the zone
- To prevent zoning of tankers air/stripping micro aeration could be used to deactivate the digestate, degas methane and odours via connection to the OCU. Consider two small tanks (duty/standby each large enough for suitable volume hold-up) with tanker offloading capabilities. Note this could also mitigate against methane generation and hazardous area considerations if digestate was to be reused.

6.19 BIOGAS STREAM – CHILLER (ID=19)

6.19.1 Basis of Assessment

Chillers are used to remove water in the form of condensate from the Biogas. They usually consist of a chiller unit enclosed within an enclosure for weatherproofing and acoustic attenuation.

No design details have been provided by the client however the PI&D's supplied suggest this operates at an un-boosted pressure. Zone information supplied by Vendors will supersede the assumptions made within this assessment.

A typical approach when determining hazardous zones for such systems is to make the internals of an enclosure a hazardous zone and around any external joints.

External joints/flanges should be treated in the same manner as section 6.15.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.19.1.1 DSEAR ASSESSMENT – CHILLER PACKAGE ENCLOSURE

In operation an explosive atmosphere could form in the enclosure. It is assumed that louvers allow ventilation

As per section C.3.5 BS EN 60079-10-1:2015

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **LOW**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 1 WITHIN ENCLOSURE
EXTENT OF ZONE – WITHIN ENCLOSURE

6.19.2 Recommendations

The following recommendations are made to further mitigate risk:

- Finalised design details are required to determine zoning arrangements

6.20 BIOGAS STREAM – GAS BOOSTERS (ID=20)

6.20.1 Basis of Assessment

Gas boosters are used to raise the dehumidified gas to a pressure suitable for combustion in CHP engines or other consumers. They usually consist of duty/standby blowers enclosed within an enclosure for weatherproofing and acoustic attenuation.

No design details have been provided by the client. Zone information supplied by Vendors will supersede the assumptions made within this assessment.

A typical approach when determining hazardous zones for such systems is to make the internals of an enclosure a hazardous zone and around any external joints.

External joints/flanges should be treated in the same manner as section 6.15. The effect of increasing the feed pressures have negligible effect on the extent of zone.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.20.1.1 DSEAR ASSESSMENT – GAS BOOSTER

In operation an explosive atmosphere could form in the enclosure. It is assumed that louvers allow ventilation

As per section C.3.5 BS EN 60079-10-1:2015

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **LOW**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 1 WITHIN ENCLOSURE
EXTENT OF ZONE – WITHIN ENCLOSURE

6.20.2 Recommendations

The following recommendations are made to further mitigate risk:

- Finalised design details are required to determine zoning arrangements

6.21 BIOGAS STREAM – BIOGAS CONDENSATE PIT (ID=21)

6.21.1 Basis of Assessment

Condensate produced through condensation in the typically unlagged pipework or biogas chiller/dehumidifier flows under gravity to a level-controlled condensate pit. Collected condensate can then be recovered to the digestion process.

No design details have been provided by the client. Zone information supplied by Vendors will supersede the assumptions made within this assessment.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.21.1.1 DSEAR ASSESSMENT – CONDENSATE PIT

In operation an explosive atmosphere could form through the degassing of methane or inbreathing/outbreathing from the condensate pit.

As per section C.3.5 BS EN 60079-10-1:2015

Grade of Release – deemed to be **CONTINOUS** when in operation
Degree of Dilution – deemed to be **LOW**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 0 WITHIN PIT
EXTENT OF ZONE – WITHIN ENCLOSURE

For any vent installed, based on max 8 m^3/hr pit inflow

ZONE CLASSIFICATION – ZONE 2 AROUND VENT
EXTENT OF ZONE – 1m AROUND Vent

6.21.2 Recommendations

The following recommendations are made to further mitigate risk:

- Vents are recommended on the condensate pit none are shown on drawing to allow tank pressure equalisation (e.g., in breathing, outbreathing)
- Condensate lines should have sufficient lutes/u-bends to provide gas seals – the top of with water should also be considered

6.22 BIOGAS STREAM – BIOGAS FLARE 1&2 – 1000/2000 Nm^3/hr (ID=22)

6.22.1 Basis of Assessment

A biogas flare is used as a means of consuming biogas, to prevent excessive system pressure in the event of an excess of biogas production or a failure of consumer units. Two units are to be installed onsite. Note it is likely that these units will be installed in close proximity, therefore a total volumetric flow of 3000 Nm^3/hr is assumed. Note

Therefore, on this basis it has been determined that should there be a common system failure (e.g., power loss/PLC failure), the biogas flares could not operate as supply valves would fail close then system failure is unlikely but possible. Moreover, it is unlikely that the full design flow would be required.

In conclusion there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.22.1.1 DSEAR ASSESSMENT – BIOGAS FLARE 1&2 – 1000/2000 Nm^3/hr

For inherently safe operation, it is assumed the flares can act as a release point.

As per section C.3.5 BS EN 60079-10-1:2015

Grade of Release – deemed to be **SECONDARY**
Degree of Dilution – deemed to be **HIGH**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 2NE (Negligible extent)
EXTENT OF ZONE – 16m around the outer perimeter of both biogas flares

6.22.2 Recommendations

The following recommendations are made to further mitigate risk:

- Though the biogas flares have hazardous zones of negligible extend, we recommend no flammable zones or unprotected ignition sources (except for biogas ignition systems) are installed within 16m of the outer flare periphery.

- We recommend additional fencing is placed around the flare enclosures

6.23 BIOGAS STREAM – BIOGAS CARBON FILTERS (ID=23)

6.23.1 Basis of Assessment

Carbon filters can be used to remove residual contaminants from the biogas so that the treated biogas is suitable for gas upgrading.

No design details have been provided by the client. Zone information supplied by Vendors will supersede the assumptions made within this assessment.

A typical approach when determining hazardous zones for such systems is to make the internals of an enclosure a hazardous zone and around any external joints.

External joints/flanges should be treated in the same manner as section 6.15. The effect of increasing the feed pressures have negligible effect on the extent of zone.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.23.1.1 DSEAR ASSESSMENT – BIOGAS CARBON FILTERS

In operation an explosive atmosphere could form in the enclosure

As per section C.3.5 BS EN 60079-10-1:2015

Grade of Release – deemed to be **CONTINOUS** when in operation
Degree of Dilution – deemed to be **LOW**
Availability of Ventilation – deemed to be **POOR**

ZONE CLASSIFICATION – ZONE 0 WITHIN FILTER
EXTENT OF ZONE – WITHIN FILTER

6.23.2 Recommendations

The following recommendations are made to further mitigate risk:

- Finalised design details are required to determine zoning arrangements

6.24 BIOGAS GAS UPGRADING UNIT (ID=24)

6.24.1 Basis of Assessment

A biogas upgrading unit increases the % methane in the biogas stream by purifying and reducing the concentration of carbon dioxide. The biomethane is then suitable for grid injection or alternate uses.

No design details have been provided by the client. Zone information supplied by Vendors will supersede the assumptions made within this assessment.

The Vendor is liable for producing the assessment of their proprietary, ring-fenced equipment and therefore the unit operation will not be assessed within the scope of this DSEAR assessment.

6.25 BIOGAS STREAM – CHP ENGINES (ID=25)

6.25.1 Basis of Assessment

Plans are for two CHP Engines to be installed to convert biogas to electricity and heat.

No design details have been provided by the client. Zone information supplied by Vendors will supersede the assumptions made within this assessment.

A typical approach when determining hazardous zones for such systems is to introduce a 0.5m zone around all internal gas joints within the enclosed system.

External joints/flanges should be treated in the same manner as section 6.15. The effect of increasing the feed pressures have negligible effect on the extent of zone.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.25.1.1 DSEAR ASSESSMENT – CHP ENGINES

In operation an explosive atmosphere could form in the enclosure

As per section C.3.5 BS EN 60079-10-1:2015

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **MEDIUM**
Availability of Ventilation – deemed to be **POOR**

ZONE CLASSIFICATION – ZONE 2 AROUND BIOGAS PIPEWORK JOINTS
EXTENT OF ZONE – 0.5m

6.26 BIOGAS ANALYSER (ID=26)

6.26.1 Basis of Assessment

The Biogas analyser is in an air-conditioned room with an exhaust to atmosphere. The unit has feeds from both digesters, post digester and biogas treatment. No design details are provided but it is assumed the vent is unobstructed and is above the roof line. The analyser has alarms.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas**.

6.26.1.1 DSEAR ASSESSMENT – BIOGAS ANALYSER

Biogas could accumulate within the cabinet

Grade of Release – deemed to be **SECONDARY** when in operation
Degree of Dilution – deemed to be **LOW**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 1 (within the enclosure)
EXTENT OF ZONE – within enclosure

As per section C.3.5 BS EN 60079-10-1:2015

Release Rate = 0.1 m^3/hr (Standard Peak Flow 0.1 m^3/hr)
Release Characteristic = 1 l/hr
[based on Methane, Mol Weight= 16.043 g/mol, Safety Factor = 1, Lower Flammability Limit = 4.4vol%, Density = 0.655kg/m^3 @ 30°C, +150 mbarg internal pressure, diameter of opening = 25mm, coefficient of discharge 0.9], assumed >0.02 m/s ventilation rate

Grade of Release – deemed to be **CONTINOUS** when in operation
Degree of Dilution – deemed to be **HIGH**
Availability of Ventilation – deemed to be **FAIR**

ZONE CLASSIFICATION – ZONE 2
EXTENT OF ZONE – 0.2m around vent

6.26.2 Recommendations

The following recommendations are made to further mitigate risk:

- Recommend a secondary vent from the biogas analyser enclosure with forced ventilation fitted to avoid internal zones within the analyser – likely produce a zone of negligible extent within the housing
- Blower vent should be above roof line of air-conditioned building and unobstructed
- Bird/pest/debris protection should be installed on the vent to prevent blockage of the vent
- It is assumed that all piping to the analyser is hard piped with minimum flexi or push fir connections used
- Valves should be installed on the feed lines to isolate
- Recommend Ex alarms located within the room with external beacons to warn of gas release

6.27 LIQUID AND GAS SAMPLING (ID=27)

6.27.1 Basis of Assessment

Though no specific details of sample points are provided the plant is likely to have multiple valve or extraction points where both liquid and gas samples can be retrieved.

It is assumed that for liquid and gas samples that the volumes are so low (<1 litre) there is no DSEAR risk to the facility assuming robust risk assessed procedures and methods are in place during sampling operation.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas** for gas samples.

6.27.2 Recommendations

The following recommendations are made to further mitigate risk:

- Recommend risk assessed procedures in place for sampling and to prevent accumulation of biogas in the headspace of sample bottles
- Intrinsically safe equipment and personal gas monitors used when sampling
- Gas sample points have caps installed
- Recommend double isolation installed on sample points

6.28 AIR COMPRESSOR (ID=28)

6.28.1 Basis of Assessment

No design details have provided. The air compressor will be located in the pump room

It is assumed that for liquid and gas samples that the volumes are so low (<1 litre) there is no DSEAR risk to the facility assuming robust risk assessed procedures and methods are in place during sampling operation.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of methane gas** for gas samples.

6.28.2 Recommendations

The following recommendations are made to further mitigate risk:

- Recommend installation in a clean area with consideration of other areas of potentially hazardous equipment

6.29 STANDBY DIESEL BOILER FUEL TANK (ID=29)

6.29.1 Basis of Assessment

Diesel is used to fuel the standby steam boiler used for site thermal heating and pasteurisation.

No design details have been provided for the standby diesel boiler; however, the fuel tank has the potential to have a hazardous atmosphere due to the flash point of diesel.

Therefore, on this basis it has been determined in normal operating conditions there is **potential to generate a hazardous atmosphere through the accumulation of flammable gas**.

Note Vendor DSEAR documentation can supersede this assessment.

6.29.1.1 DSEAR ASSESSMENT – DIESEL BOILER FUEL TANK

Vapours could accumulate within the fuel tank

Grade of Release – deemed to be **CONTINOUS** when in operation
Degree of Dilution – deemed to be **LOW**
Availability of Ventilation – deemed to be **POOR**

ZONE CLASSIFICATION – ZONE 0 (within the headspace)
EXTENT OF ZONE – within headspace

Appendix 1: DSEAR Assessment

			Qty	Classification Required?	DSEAR Assessment Parameters				Zone According to BS EN 60079-10-1:2015		
ID	**Description**	**Location**	**P1 =Phase 1 etc**	**Y=YES, N=NO, N/A = not required**	**Grade of Release** *(C=Continuous, P = Primary, S = Secondary)*	**Type of Ventilation** *(A = Artificial, N= Natural)*	**Availability of Ventilation** *(G = Good, F= Fair, P= Poor)*	**Degree of Ventilation** *(H = High, M = Medium, L = Low)*	**Zone Classification**	**Extent of Zone (m)**	**Comments**
1	*"Tiger"* Hopper Slurry Tank	Reception Hall, Above Surface	P1=1, P2=2	N	-	-	-	-	N/A	N/A	**Background** No methane generation expected or appreciable generation of H_2S under normal operating conditions, particularly if daily emptying, weekly flush conducted and no cross contamination with post digestion residues. Should Digestate be used in feed, reclassification would be required. Recommend local extraction. Recommend future proofing with a level of Ex protection on instrumentation. **Basis of Calculation** Minimal potential for methane generation, therefore negligible potential for explosive atmosphere forming
2	"*Reception Hall"* Pits	Reception Hall, Below Floor	1+	N	-	-	-	-	N/A	N/A	**Background** No methane generation expected or appreciable generation of H_2S under normal operating conditions, particularly if daily emptying, weekly flush conducted and no cross contamination with post digestion residues. Should Digestate be used in feed, reclassification would be required. Recommend local extraction. Recommend future proofing with a level of Ex protection on instrumentation. **Basis of Calculation** Minimal potential for methane generation, therefore negligible potential for explosive atmosphere forming
3	Reception Hall, Drains, Pipework, Pump's, and Gully's	Reception Hall, various	1+	N	-	-	-	-	N/A	N/A	**Background** No methane generation expected or appreciable generation of H_2S under normal operating conditions, particularly if daily emptying, weekly flush conducted and no cross contamination with post digestion residues. Should Digestate be used in feed, reclassification would be required. Recommend local extraction. Recommend future proofing with a level of Ex protection on instrumentation. **Basis of Calculation** Minimal potential for methane generation, therefore negligible potential for explosive atmosphere forming

			Qty	Classification Required?	DSEAR Assessment Parameters				Zone According to BS EN 60079-10-1:2015		
ID	**Description**	**Location**	**P1 =Phase 1 etc**	**Y=YES, N=NO, N/A = not required**	**Grade of Release** *(C=Continuous, P = Primary, S = Secondary)*	**Type of Ventilation** *(A = Artificial, N= Natural)*	**Availability of Ventilation** *(G = Good, F= Fair, P= Poor)*	**Degree of Ventilation** *(H = High, M = Medium, L = Low)*	**Zone Classification**	**Extent of Zone (m)**	**Comments**
4	Dewatering Filter Press	Reception Hall, Above Surface	2+	**Y**	Internal – C External – C	Internal – N/A External – A	Internal – P External – F	Internal – L External – H	Internal – 0 External – 2	External = 1m radius spherical	**Background** Methane generation/degassing in internals of press, assumed to be hazardous. Zone classification can be removed if digestate is methane stripped prior to processing. **Basis of Calculation** Minimal ventilation rate of 0.3 m/s will result in 1m spherical Zone 2
5	Filtrate Collection Tank	Reception Hall, Below Floor	2+	**Y**	Internal – C External – C	Internal – A External – A	Internal – F External – F	Internal – L External – M	Internal – 0 External – 0	External = 2m radius spherical	**Background** Processed Digestate. Risk of methane degassing from stored liquid. Assumed to be hazardous. Zone classification can be removed if digestate is methane stripped prior to processing. **Basis of Calculation** Ventilation rate of 0.01-3 m/s will result in 2m spherical Zone 0 from vent
6	Dewatered Solid Storage Bunker	Reception Hall	2+	N	-	-	-	-	N/A	N/A	**Basis of Calculation** No hazardous area classification, degassed methane assumed in press and minimal residue in filter cake solid
7	Rainwater Harvesting Tanks	Reception Hall	1+	N	-	-	-	-	N/A	N/A	**Basis of Calculation** No hazardous area classification if used for water
8	Depackaging Reception Tank	External	1+	**Y**	P	A	F	H	Internal – 2NE	Internal Only	**Background** Periodic methane generation expected and/or appreciable generation of H_2S under normal operating conditions. Potential to accumulate in headspace. Should Digestate be used in feed, reclassification would be required. **Basis of Calculation** Ventilation rate of 3 m/s will result in internal zone 2NE of headspace

			Qty	Classification Required?	DSEAR Assessment Parameters				Zone According to BS EN 60079-10-1:2015		
ID	**Description**	**Location**	**P1 =Phase 1 etc**	**Y=YES, N=NO, N/A = not required**	**Grade of Release** *(C=Continuous, P = Primary, S = Secondary)*	**Type of Ventilation** *(A = Artificial, N= Natural)*	**Availability of Ventilation** *(G = Good, F= Fair, P= Poor)*	**Degree of Ventilation** *(H = High, M = Medium, L = Low)*	**Zone Classification**	**Extent of Zone (m)**	**Comments**
9	Liquid Reception Tank(s)	External	P1=1, P2=3	**Y**	P	A	F	H	Internal – 2NE	Internal Only	**Background** Periodic methane generation expected and/or appreciable generation of H_2S under normal operating conditions. Potential to accumulate in headspace. Should Digestate be used in feed, reclassification would be required. **Basis of Calculation** Ventilation rate of 3 m/s will result in internal zone 2NE of headspace
10	Pasteuriser(s)	External	2	**Y**	S	A	F	M	Internal – 2NE	Internal Only	**Background** Periodic methane generation degassing and/or appreciable generation of H_2S under normal operating conditions. Potential to accumulate in headspace. **Basis of Calculation** In comparison to item 8 release secondary due to pasteurising effect in denaturing anaerobic bacteria. Ventilation rate of 3 m/s will result in internal zone 2NE of headspace.
11	Feed Buffer Tank	External	1	**Y**	P	A	F	H	Internal – 2	External = 4m radius spherical	**Background** Periodic methane generation degassing and/or appreciable generation of H_2S under normal operating conditions. Potential to accumulate in headspace. **Basis of Calculation** Ventilation rate of 3.5 m/s will result in internal zone 2 of headspace
12	Odour Control Unit	External	1 (3 Fans)	N	-	-	-	-	N/A	N/A	**Background**

											No methane generation potential. Dilution of methane below LEL
			Qty	Classification Required?	DSEAR Assessment Parameters				Zone According to BS EN 60079-10-1:2015		
ID	**Description**	**Location**	**P1 =Phase 1 etc**	**Y=YES, N=NO, N/A = not required**	**Grade of Release** *(C=Continuous, P = Primary, S = Secondary)*	**Type of Ventilation** *(A = Artificial, N= Natural)*	**Availability of Ventilation** *(G = Good, F= Fair, P= Poor)*	**Degree of Ventilation** *(H = High, M = Medium, L = Low)*	**Zone Classification**	**Extent of Zone (m)**	**Comments**
13	Digester/Post Digester Gas Head Space	External	2 Primary Digesters/1 Post Digester	**Y**	C	A	P	L	0	Internal Only	**Background** Methane Generation in headspace. Assumption that headspace has explosive potential. Single air/oxygen injection point. NRV to prevent methane backflow. **Basis of Calculation** 5mbar under pressure. Oxygen injection into headspace, Under normal conditions 1.2 vol% O_2 not explosive
14	Digester/Post Digester *Anergia "Service box"* PRV	External	2 per Digester/Post Digester	**Y**	S	N	F	M	2	9m radius spherical from PRV	**Background** Methane Generation in headspace. Maximum PRV release rate at 5 mbarg release point is circa 650 m3/hr. Total Biogas Flow in phase 3 is 3000 Nm^3/hr therefore 67approx. 2 PRV's required. Therefore, basis of failures can only allow for one PRV to fail. On failure of all consumers. Power cut. Therefore, steps are required to ensure PRV's design intent maintained. **Basis of Calculation** 5mbar Overpressure. -0.5mbar under pressure. Oxygen injection into headspace, max release rate 650 Nm^3/hr. Extent of zone based on release rate/characteristics of 650 Nm^3/hr.
15	Digester/Post Digester Gas Flanged and Screwed connections	External	Multiple	**Y**	S	N	P	M	2	0.3m (5mbar), 0.6m (150 mbar) radius spherical	**Background** Small leak path, assume no air flow worst case **Basis of Calculation** 2mm circular leak patch
16	Digester/Post Digester Gas Holder Blowers Vent	External	1 vent per tank	**Y**	S	N	F	M	0 within gas bag annulus 2 @ vent	3.0m radius spherical @ vent	**Background** Assumed explosive concentration of methane in air space between biogas holder membrane **Basis of Calculation** DN50 vent weighted to 5 mbarg, 91 m3/h air flow
17	Pump Room	Internal	1	**N**	-	-	-	-	N/A	N/A	**Basis of Calculation**

											No hazardous area classification providing adequate ventilation
			Qty	**Classification Required?**	**DSEAR Assessment Parameters**				**Zone According to BS EN 60079-10-1:2015**		
ID	**Description**	**Location**	**P1 =Phase 1 etc**	**Y=YES, N=NO, N/A = not required**	**Grade of Release** *(C=Continuous, P = Primary, S = Secondary)*	**Type of Ventilation** *(A = Artificial, N= Natural)*	**Availability of Ventilation** *(G = Good, F= Fair, P= Poor)*	**Degree of Ventilation** *(H = High, M = Medium, L = Low)*	**Zone Classification**	**Extent of Zone (m)**	**Comments**
18	Tanker Offloading	External	1	**Y**	C	N	F	M	0 within tanker 2 @ vent/PRV	3m radius spherical at vent	**Background** Assumed explosive concentration of methane in air space between biogas holder membrane **Basis of Calculation** 70 m3/hr loading rate
19	Biogas Chiller	External	1	**Y**	S	N	F	L	1 in enclosure	Enclosure only	**Background** No design details, based on previously industry examples. Vendor Assessment will take precedence. **Basis of Calculation** assumed
20	Biogas Booster	External	1	**Y**	C	N	F	L	0 in headspace 2 around vent	1m radius spherical around vent	**Background** No design details, based on previously industry examples. Vendor Assessment will take precedence. **Basis of Calculation** assumed
21	Biogas Condensate Pit	External	1	**Y**	C	N	F	L	0 in headspace	Headspace only	**Background** No design details, based on previously industry examples. Vendor Assessment will take precedence. Note no vent this would require amendment to zone and likely would require classification. **Basis of Calculation** assumed
22	Biogas Flare	External	P1=1000 Nm^3/hr, P2= 1000 Nm^3/hr + 2000 Nm^3/hr	**Y**	S	N	F	H	2NE (Negligible Extend)	16m radius spherical (Negligible Extend)	**Background** No design details, based on previously industry examples. Vendor Assessment will take precedence. **Basis of Calculation** Combined flows of 3000 Nm^3/hr, recommend fencing and 19.2 m radius exclusion zone from top of flares

			Qty	Classification Required?	DSEAR Assessment Parameters				Zone According to BS EN 60079-10-1:2015		
ID	**Description**	**Location**	**P1 =Phase 1 etc**	**Y=YES, N=NO, N/A = not required**	**Grade of Release** *(C=Continuous, P = Primary, S = Secondary)*	**Type of Ventilation** *(A = Artificial, N= Natural)*	**Availability of Ventilation** *(G = Good, F= Fair, P= Poor)*	**Degree of Ventilation** *(H = High, M = Medium, L = Low)*	**Zone Classification**	**Extent of Zone (m)**	**Comments**
23	Biogas Carbon Filters	External	1	**Y**	C	N	P	L	0 in headspace	Headspace only	**Background** No design details, based on previously industry examples. Vendor Assessment will take precedence. **Basis of Calculation** assumed
24	Biogas GUU	-	-	-	-	-	-	-	-	-	**NOT IN SCOPE**
25	CHP Engines	External	1	**Y**	S	?	P	M	2 around joints	0.5m radius spherical	**Background** No design details, based on previously industry examples. Vendor Assessment will take precedence. **Basis of Calculation** assumed
26	Gas Analysers	Located in Air-conditioned room	1	**Y**	C	N	P	L	1 in cabinet 2 around vent	0.2m radius spherical around vent	**Background** No design details, based on previously industry examples. Vendor Assessment will take precedence. **Basis of Calculation** Assumed no forced ventilation within cabinet and vent of 1" installed above roof level
27	Sample Points	Unknown	1	N	-	-	-	-	-	-	**Background** No design details, based on previously industry examples. Based on low volumes and robustly risk assessed.
28	Air Compressor	Pumping Room	1	N	-	-	-	-	-	-	**Background** No design details do not locate in hazardous zones, no explosion/deflagration risk.
29	Standby Diesel Boiler	External	1	**Y**	C	Y	P	L	0	Headspace only	**Background** No design details. Vendor Assessment will take precedence. Note Diesel fuel is now considered in scope by HSE. **Basis of Calculation** Headspace above fuel tank, no vent or PRV present

Appendix 2: DSEAR EXTENT OF ZONE CALCULATION

BSEN 60079-10-1 (2015)[1] APPENDIX B & D is used as the basis to calculate the extent of external zones. See Appendix 1 for the determination of Zonal Classification.

B.7.2.3.2 Release rate of gas with non choked gas velocity (subsonic releases)

Non choked gas velocity is a discharge velocity below the speed of sound for the particular gas.

The release rate of gas from a container, if the gas velocity is non-choked, can be estimated by means of the following approximation:

$$W_g = C_d\, S\, p \sqrt{\frac{M}{Z\,R\,T}\,\frac{2\gamma}{\gamma-1}\left[1-\left(\frac{p_a}{p}\right)^{(\gamma-1)/\gamma}\right]}\left(\frac{p_a}{p}\right)^{1/\gamma} \text{ (kg/s)} \qquad \text{(B.3)}$$

B.1 Symbols

- A_p pool surface area (m^2);
- C_d discharge coefficient (dimensionless) which is a characteristic of the release openings and accounts for the effects of turbulence and viscosity, typically 0,50 to 0,75 for sharp orifices and 0,95 to 0,99 for rounded orifices;
- c_p specific heat at constant pressure (J/kg K);
- γ polytropic index of adiabatic expansion or ratio of specific heats (dimensionless);
- M molar mass of gas or vapour (kg/kmol);
- p pressure inside the container (Pa);
- Δp pressure difference across the opening that leaks in (Pa);
- p_a atmospheric pressure (101 325 Pa);
- p_c critical pressure (Pa);
- p_v vapour pressure of the liquid at temperature T (kPa);
- Q_g volumetric flow rate of flammable gas from the source (m^3/s);
- R universal gas constant (8314 J/kmol K);
- ρ liquid density (kg/m^3);
- ρ_g gas or vapour density (kg/m^3);
- S cross section of the opening (hole), through which the fluid is released (m^2);
- T absolute temperature of the fluid, gas or liquid (K);
- T_a absolute ambient temperature (K);
- u_w wind speed over the liquid pool surface (m/s);
- W release rate of liquid (mass per time, kg/s);
- W_e evaporation rate of liquid (kg/s);
- W_g mass release rate of gas (kg/s);
- Z compressibility factor (dimensionless).

For ideal gas the equation $\gamma = \frac{M\,c_p}{M\,c_p - R}$ may be used

Where

$\frac{W_g}{\rho_g\, k\, LFL}$ is a characteristic of release in (m^3/s);

$\rho_g = \frac{p_a\, M}{R\, T_a}$ is the density of the gas/vapour (kg/m^3);

k is the safety factor attributed to LFL, typically between 0,5 and 1,0.

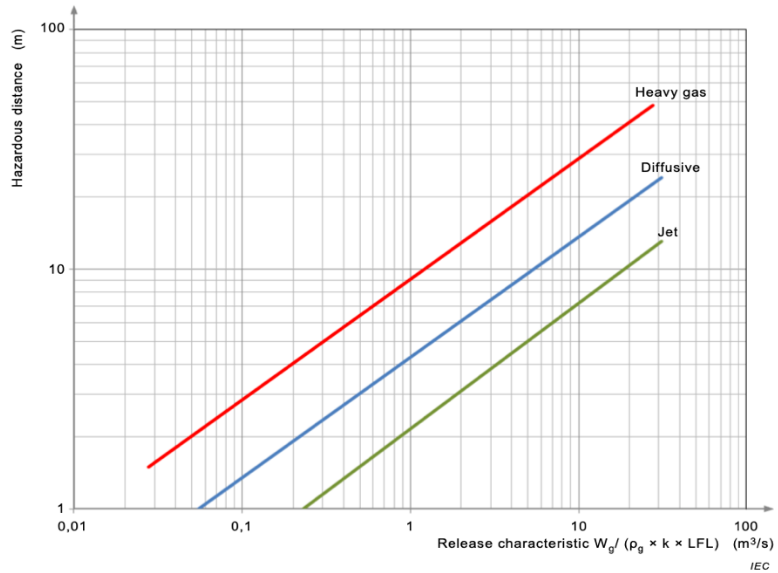

Figure D.1 – Chart for estimating hazardous area distances

Installed in this phase?		**N**	**N**	**N**	**Y**	**Y**
ID		**4**	**5**	**5**	**8**	**9**
DESCRIPTION		DEWATERING FILTER PRESS	FILTRATE COLLECTION TANK	FILTRATE COLLECTION TANK	DEPACKAGING RECEPTON TANK	LIQUID RECEPTION TANK(S)
ZONE LOCATION			HEADSPACE	VENT/EXTERNAL	HEADSPACE	HEADSPACE
Gas	UNITS	**METHANE**	**METHANE**	**METHANE**	**METHANE**	**METHANE**
Molecular Weight	g/mol	16.043	16.043	16.043	16.043	16.043
safety factor		1	1	1	1	1
LFL	%	4.4	4.4	4.4	4.4	4.4
Normal Operating Temperature	^oC	38	38	35	25	40
Pressure	Pa	101325	101325	101325	101325	101325
	bar	1.01325	1.01325	1.01325	1.01325	1.01325
Density	kg/m^3	0.628	0.628	0.634	0.656	0.624
Coefficient of Discharge		0.9	0.9	0.9	0.9	0.9
Diameter of Opening	mm	6		25		
CSA of Openening	m^2	2.83E-05	0.00E+00	4.91E-04	0.00E+00	0.00E+00
	mm^2	28.3	0.0	490.9	0.0	0.0
Internal pressure	mbar	5	1	1	1	1
	bar	0.005	0.001	0.001	0.001	0.001
	Pa	101825	101425	101425	101425	101425
compressability factor		1	1	1	1	1
specific heat	J/kg.K	2232	2232	2232	2232	2232
polytropic index		1.3	1.3	1.3	1.3	1.3
critical pressure		185817	185817	185817	185817	185817
Flow assessment		NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC
MANUAL FLOW ENTRY		**NO**	**NO**	**NO**	**NO**	**NO**
MANUAL ENTRY FLOW	m^3/h					
		IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE
ACTUAL FLOW (CHECK)	m^3/h	**3.66**	**0.00**	**28.25**	**27.45**	**28.83**
	kg/s	**0.0006**	**0.0000**	**0.0050**	**0.0050**	**0.0050**
Release characterisitic	m^3/s	**0.02**	**0.00**	**0.18**	**0.17**	**0.18**
Haz Zone Distance radius	m	**1.0**	CONFINED TO HEADSPACE	**2.0**	CONFINED TO HEADSPACE	CONFINED TO HEADSPACE
Haz Zone Shape		**SPHERE**	**N/A**	**SPHERE**	**N/A**	**N/A**

Installed in this phase?		Y (1+2)	Y	Y	Y	Y
ID		**10**	**11**	**11**	**13**	**14**
DESCRIPTION		PASTEURISER TANKS	FEED BUFFER TANK	FEED BUFFER TANK	DIGESTER/ POST DIGESTER	DIGESTER/ POST DIGESTER SERVICEBOX PRV
ZONE LOCATION		HEADSPACE	HEADSPACE	VENT/EXTERNAL	HEADSPACE	VENT/EXTERNAL
Gas	UNITS	**METHANE**	**METHANE**	**METHANE**	**METHANE**	**METHANE**
Molecular Weight	g/mol	16.043	16.043	16.043	16.043	16.043
safety factor		1	1	1	1	1
LFL	%	4.4	4.4	4.4	4.4	4.4
Normal Operating Temperature	^oC	75	50	50	40	40
Pressure	Pa	101325	101325	101325	101325	101325
	bar	1.01325	1.01325	1.01325	1.01325	1.01325
Density	kg/m^3	0.562	0.605	0.605	0.624	0.624
Coefficient of Discharge		0.9	0.9	0.9	0.9	0.9
Diameter of Opening	mm			50		
CSA of Openening	m^2	0.00E+00	0.00E+00	1.96E-03	0.00E+00	0.00E+00
	mm^2	0.0	0.0	1963.5	0.0	0.0
Internal pressure	mbar	10	1	1	5	5
	bar	0.01	0.001	0.001	0.005	0.005
	Pa	102325	101425	101425	101825	101825
compressability factor		1	1	1	1	1
specific heat	J/kg.K	2232	2232	2232	2232	2232
polytropic index		1.3	1.3	1.3	1.3	1.3
critical pressure		185817	185817	185817	185817	185817
Flow assessment		NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC
MANUAL FLOW ENTRY		**NO**	**NO**	**NO**	**NO**	**YES**
MANUAL ENTRY FLOW	m^3/h					**650**
		IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE	OK
ACTUAL FLOW (CHECK)	m^3/h	**32.05**	**29.75**	**115.70**	**0.00**	**650.00**
	kg/s	**0.0050**	**0.0050**	**0.0194**	**0.0000**	**0.1127**
Release characterisitic	m^3/s	**0.20**	**0.19**	**0.73**	**0.00**	**4.10**
Haz Zone Distance radius	m	CONFINED TO HEADSPACE	CONFINED TO HEADSPACE	**4.0**	CONFINED TO HEADSPACE	**9.0**
Haz Zone Shape		**N/A**	**N/A**	**SPHERE**	**N/A**	**SPHERE**

Installed in this phase?		Y	Y	Y	Y	Y
ID		15a	15b	16	18	18
DESCRIPTION		DIGESTER/ POST DIGESTER GAS CONNECTIONS (SCREWED AND FLANGED)	DIGESTER/ POST DIGESTER GAS CONNECTIONS (SCREWED AND FLANGED)	DIGESTER/ POST DIGESTER GAS HOLDER BLOWER VENTS	DIGESTATE REMOVAL BY TANKER	DIGESTATE REMOVAL BY TANKER
ZONE LOCATION		EXTERNAL	EXTERNAL		HEADSPACE	VENT/EXTERNAL
Gas	UNITS	METHANE	METHANE	METHANE	METHANE	METHANE
Molecular Weight	g/mol	16.043	16.043	16.043	16.043	16.043
safety factor		1	1	1	1	1
LFL	%	4.4	4.4	4.4	4.4	4.4
Normal Operating Temperature	^oC	40	40	40	40	40
Pressure	Pa	101325	101325	101325	101325	101325
	bar	1.01325	1.01325	1.01325	1.01325	1.01325
Density	kg/m^3	0.624	0.624	0.624	0.624	0.624
Coefficient of Discharge		0.9	0.9	0.9	0.9	0.9
Diameter of Opening	mm	2	2	25		10
CSA of Opennening	m^2	3.14E-06	3.14E-06	4.91E-04	0.00E+00	7.85E-05
	mm^2	3.1	3.1	490.9	0.0	78.5
Internal pressure	mbar	5	150	5	5	1
	bar	0.005	0.15	0.005	0.005	0.001
	Pa	101825	116325	101825	101825	101425
compressability factor		1	1	1	1	1
specific heat	J/kg.K	2232	2232	2232	2232	2232
polytropic index		1.3	1.3	1.3	1.3	1.3
critical pressure		185817	185817	185817	185817	185817
Flow assessment		NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC
MANUAL FLOW ENTRY		NO	NO	NO	NO	NO
MANUAL ENTRY FLOW	m^3/h					
		IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE
ACTUAL FLOW (CHECK)	m^3/h	0.41	2.33	63.75	0.00	4.56
	kg/s	0.0001	0.0004	0.0111	0.0000	0.0008
Release characterisitic	m^3/s	0.00	0.01	0.40	0.00	0.03
Haz Zone Distance radius	m	**0.3**	**0.6**	**3.0**	**CONFINED TO HEADSPACE**	**1.0**
Haz Zone Shape		**SPHERE**	**SPHERE**	**SPHERE**	**N/A**	**SPHERE**

Installed in this phase?		Y	Y	Y	Y	Y
ID		19	20	21	21	22
DESCRIPTION		BIOGAS CHILLER	BIOGAS GAS BOOSTER	BIOGAS CONDENSATE PIT	BIOGAS CONDENSATE PIT	BIOGAS FLARES
ZONE LOCATION		HEADSPACE	HEADSPACE	HEADSPACE	VENT/EXTERNAL	VENT/EXTERNAL
Gas	UNITS	METHANE	METHANE	METHANE	METHANE	METHANE
Molecular Weight	g/mol	16.043	16.043	16.043	16.043	16.043
safety factor		1	1	1	1	1
LFL	%	4.4	4.4	4.4	4.4	4.4
Normal Operating Temperature	^{o}C	40	40	40	40	40
Pressure	Pa	101325	101325	101325	101325	101325
	bar	1.01325	1.01325	1.01325	1.01325	1.01325
Density	kg/m^3	0.624	0.624	0.624	0.624	0.624
Coefficient of Discharge		0.9	0.9	0.9	0.9	0.9
Diameter of Opening	mm				10	10
CSA of Openening	m^2	0.00E+00	0.00E+00	0.00E+00	7.85E-05	7.85E-05
	mm^2	0.0	0.0	0.0	78.5	78.5
Internal pressure	mbar	5	5	5	1	150
	bar	0.005	0.005	0.005	0.001	0.15
	Pa	101825	101825	101825	101425	116325
compressability factor		1	1	1	1	1
specific heat	J/kg.K	2232	2232	2232	2232	2232
polytropic index		1.3	1.3	1.3	1.3	1.3
critical pressure		185817	185817	185817	185817	185817
Flow assessment		NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC
MANUAL FLOW ENTRY		NO	NO	NO	YES	YES
MANUAL ENTRY FLOW	m^3/h				8	2000
		IGNORE ABOVE	IGNORE ABOVE	IGNORE ABOVE	OK	OK
ACTUAL FLOW (CHECK)	m^3/h	0.00	0.00	0.00	8.00	2000.00
	kg/s	0.0000	0.0000	0.0000	0.0014	0.3469
Release characterisitic	m^3/s	0.00	0.00	0.00	0.05	12.63
Haz Zone Distance radius	m	CONFINED TO HEADSPACE	CONFINED TO HEADSPACE	CONFINED TO HEADSPACE	1.0	16.0
Haz Zone Shape		N/A	N/A	N/A	SPHERE	SPHERE

Installed in this phase?		Y	Y	Y	Y
ID		21	25	26	29
DESCRIPTION		BIOGAS CARBON FILTERS	CHP ENGINES	BIOGAS ANALYSER	CHP ENGINES
ZONE LOCATION		HEADSPACE	HEADSPACE	VENT/EXTERNAL	HEADSPACE
Gas	UNITS	**METHANE**	**METHANE**	**METHANE**	**DIESEL**
Molecular Weight	g/mol	16.043	16.043	16.043	198
safety factor		1	1	1	1
LFL	%	4.4	4.4	4.4	0.6
Normal Operating Temperature	^{o}C	40	40	30	30
Pressure	Pa	101325	101325	101325	101325
	bar	1.01325	1.01325	1.01325	1.01325
Density	kg/m^3	0.624	0.624	0.645	7.960
Coefficient of Discharge		0.9	0.9	0.9	0.9
Diameter of Opening	mm			25	
CSA of Openening	m^2	0.00E+00	0.00E+00	4.91E-04	0.00E+00
	mm^2	0.0	0.0	490.9	0.0
Internal pressure	mbar	150	150	150	10
	bar	0.15	0.15	0.15	0.01
	Pa	116325	116325	116325	102325
compressability factor		1	1	1	1
specific heat	J/kg.K	2232	2232	2232	2232
polytropic index		1.3	1.3	1.3	1.0
critical pressure		185817	185817	185817	168257
Flow assessment		NON-SONIC	NON-SONIC	NON-SONIC	NON-SONIC
MANUAL FLOW ENTRY		**NO**	**NO**	**YES**	**NO**
MANUAL ENTRY FLOW	m^3/h			**0.1**	
		IGNORE ABOVE	IGNORE ABOVE	OK	IGNORE ABOVE
ACTUAL FLOW (CHECK)	m^3/h	**0.00**	**0.00**	**0.10**	**0.00**
	kg/s	**0.0000**	**0.0000**	**0.0000**	**0.0000**
Release characterisitic	m^3/s	**0.00**	**0.00**	**0.00**	**0.00**
Haz Zone Distance radius	m	CONFINED TO HEADSPACE	CONFINED TO HEADSPACE	**0.2**	CONFINED TO HEADSPACE
Haz Zone Shape		**N/A**	**N/A**	**SPHERE**	**N/A**

APPENDIX 3: SUMMARY OF SUGGESTED ACTIONS

Number	Suggested Actions
1	Finalised design details are required to finalise DSEAR. Reassessment of DSEAR will be required based on finalised OCU extraction rates and locations
2	Robust and prominent signage onsite (on entrance and within) in relation to hazardous zoned areas
3	Use of personal Ex Gas monitors as standard
4	All Ex rated equipment is inspected and maintained by appropriately trained and certified individuals/organisations
5	A Permit to Work (PTW) system is introduced incorporating the finding from this DSEAR assessment
6	Non-Standard operations (commissioning, start-up, shutdown etc) be risk assessed to mitigate explosion risk
7	Provision of Respirate Protective Equipment (RPE) e.g., escape Sets, Breathing Apparatus sets for emergency use etc
8	Appropriate tools/equipment for work in zoned areas e.g., spark proof tools, non-static PPE
9	Training for staff (DSEAR, Breathing Apparatus, Escape Set)
10	Regularly Clean Out Sumps/Drains/Pits, Area where Organic Substrate can ferment to prevent malodour and reduce risk of Explosive Gas Forming e.g., daily emptying of sumps, tanks etc
11	Daily Empty of Slurry Tanks, Tiger Sump, Storage Tanks to prevent methane generation and Malodours
12	Installation of local odour extraction for sumps, tiger dewatering sump, filter press digestion residues to provide a level of ventilation and mitigation of explosive gas formation risk and malodours

Number	**Suggested Actions (cont.)**
13	Future proofing of instruments with high(er) Ex protection ratings to future proof design particular in areas where additional risk may be introduced e.g., through reuse/recycling of digestate
14	Segregation of post digestion residues to prevent cross seeding and secondary ABPR issues e.g., cleanliness of plant equipment before and after change of duty
15	Daily turnover of post digestion residues to prevent flammable gas pockets forming
16	Installation of Fixed Ex monitors in critical places e.g., sumps, near post digestion residues, Filter Press, on top of digesters if platforms to access Digester roof furniture, externally near flares etc
17	An independent backup power supply for the OCU will allow declassification of hazardous zones, particularly within headspaces
18	Installation of vent on the filtrate tank
19	Consider methane stripping digestate to reduce risk of hazardous zones forming while tankering and for recycling of digestate
20	Manage retention times in substrate tanks to a **max** of five days and ensure mixing is always adequate
21	Ensure robust and sufficient ventilation rate air changes/velocities on all feed substrate storage tanks
22	Consider air injection into the Feed Buffer Tank. This is most likely location for significant methane generation. Air will mitigate/inhibit anaerobic bacteria and there will reduce the risk of methane formation
23	Consider excess pressure generation within all feed tanks, pits and storage tanks and install PRV's as appropriate. Please note this may have hazardous zone implications.

Number	**Suggested Actions (cont.)**
24	The physical locations of instruments associated with the OCU should not be located close to hazardous zones on the system boundary
25	Consider the varying levels of liquids of tanks as part of operation, and the potential exposure to submerged instruments to hazardous zones
26	The number of service box PRV's installed on the tanks linked to the biogas common system should be considered considering the max total capacity and stated flow of 650 Nm^3/hr, particularly for situations such as downtime for maintenance etc
27	Multiple injection points for Digester microaeration should be installed to reduce localised concentrations of oxygen within the headspace.
28	Non-return valves should be fitted on all microaeration system to prevent back flow of hazardous gases outside the defined zone.
29	Consider locating the Digester PRV's as far as possible from the biogas outlet point and microaeration injection points equidistant from one another to minimise the risk of the PRV blocking with sulphur and biological foulants
30	Gas Pipework should be appropriately earthed
31	Lagging or trace heating should not be installed over gas joints
32	Flanges on gas pipework should be torque checked on a regular basis to prevent leakage
33	External vents from tanks and equipment should have protected from debris, rodents, birds etc

34	The system should be designed that the air blowers used to inflate the gas bag should not operate in parallel which would generate a larger hazardous zone
Number	**Suggested Actions (cont.)**
35	The settings/position for the gas holder air blower outlet weighted valve should be fixed and not altered to prevent changes to the resulting hazardous zone
36	The pumping room should have robust ventilation of at least 5 air change per hour
37	Digestate spills in the pumping room should be cleaned daily with all sumps/drains cleaned to reduce the risk of methane generation
38	Consider the risk of inadvertently draining the Post Digester under gravity. E.g., consider the use of interlocked valve and/or more controllable drainage/transfer via pump
39	Consider hazardous zones around tankers e.g., tankers should be stationary with engine turned off
40	The flares have a 16m zone of negligible extent however it is advised to not locate any other equipment within this distance to any of the flares
41	Fencing around the flares at the appropriate 16m zone distance is recommended
42	Recommend a secondary vent is fitted to the gas analyser housing routed to an appropriate externally ventilated area to prevent build-up of explosive gases in the housing
43	The gas analyser should be hard piped as far as reasonably practicable with push fit joints minimised and if installed checked regularly for leaks

44	The risk of exposing or exposure to a hazardous zone should be considered when sampling
45	Recommend double isolation procedures when extracting or analysing gas samples