

**Biogen (UK) Ltd., Merthyr Road, Bryn
Pica, Llwydcoed, Aberdare, Rhondda
Cynon Taff, CF44 0BX**



DSEAR RISK ASSESSMENT 2022 REPORT

**Carried out by:
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Report prepared by:



Date: 23rd February 2023

Chart Associates Ltd.

DOCUMENT REVISIONS

V0	Internal Draft for comment	Reviewed: MM / CH	Date: 28/02/2023
V1	First Client Issue for comment	Reviewed:	Date:
V2	Second Client Issue for comment	Reviewed:	Date:
V3	Final Report Issue for client	Authorised:	Date:

1.0 EXECUTIVE SUMMARY

An assessment of the activities has been carried out in compliance with the DSEAR regulations 2002, incorporating Amendment 1: June 2015, and overall risk deemed as requiring further controls. Feedback indicates a number of relevant actions, with the full list of recommendations contained within Section 9. The following points of particular significance were noted:

- 1.1 Plant safety is reliant on adequate procedural, ventilation, and ignition controls to minimise fire and explosion hazard – this needs to be supported by safe systems of work and if necessary, Hazardous Area Classification – albeit this should not have a major impact upon existing site arrangements given the controls proposed.
- 1.2 Hazardous Area Classification is recorded for those areas where a flammable atmosphere may persist either briefly or for longer periods of time as outlined in the regulations – specifically those associated with gas production on site.
- 1.3 Storage of flammable gas cylinders requires Hazardous Area Classification and adequate controls. This is discussed later in the report.
- 1.4 Anaerobic digestion plant requires Hazardous Area Classification and adequate controls. This is discussed later in the report.
- 1.5 Open topped digestate storage tank requires minimal Hazardous Area Classification and adequate controls. This is discussed later in the report.
- 1.6 Flare unit, Boiler unit, and CHP unit require Hazardous Area Classification and adequate controls. This is discussed later in the report.
- 1.7 Diesel fuel bulk storage does not require Hazardous Area Classification. This is discussed later in the report.
- 1.8 Flammable liquids storage and handling requires Hazardous Area Classification and adequate controls. This is discussed later in the report.
- 1.9 Other actions identified may assist with emergency illumination, evacuation, and signage controls and staff training. All recommendations should be considered in the spirit of DSEAR to reduce potential risk to a level **as low as reasonably practicable** (or ALARP¹) as is required for full compliance with the regulations, and the Health and Safety at Work Etc. Act.

Additional information on DSEAR and Hazardous Area Classification is provided in the Appendices attached.

¹ <http://www.hse.gov.uk/risk/theory/alarpglance.htm>

2.0 INTRODUCTION

A visit was made to Biogen's Bryn Pica site, CF44 0BX, on 21st December 2022 to consider compliance with the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR), incorporating Amendment 1: June 2015.

The site takes food waste, and processes it, producing biogas from the organic material, and this is converted via a CHP set, feeding electricity back into the grid. Additionally, PAS110 certified bio fertiliser is produced from the digestate.

Overall site footprint extends to circa 5,000m² (ref. Google maps measurement). The buildings consist of steel framed structures with concrete floors and brick/block and sheet panel walling, which house specialist processing, workshop, and storage areas. There are also quality assurance, office, and staff amenity areas at the premises.

Routine plant operations involve potentially hazardous substances but are not especially complex and / or have purpose-designed process controls. There is storage and handling of flammable and combustible materials, and dispensing of flammable gas and liquids applies on-site. Additionally, accumulation of some combustible / flammable materials may add to the residual DSEAR hazard at the premises.

All sites handling significant quantities of flammable materials capable of forming a potentially explosive atmosphere come under the ATEX 1999/92/EC 'Worker Protection' Directive², (also known as "ATEX 137") which is implemented in the UK by means of the Dangerous Substances and Explosive Atmospheres Regulations³ (DSEAR).

The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) impose a requirement to eliminate or reduce risks to safety from fire, explosion or other events arising from the hazardous properties of any dangerous substance used in connection with work processes. The employer is required to carry out a suitable and sufficient assessment of risk to employees where a dangerous substance is - or may be - present at the premises.

DSEAR should supplement ongoing fire risk assessment undertaken in line with requirements of the Regulatory Reform (Fire Safety) Order 2005, and The Fire Safety (Scotland) Regulations 2006. This report focuses upon identification of hazardous substances and potential release sources - while also evaluating whether existing control measures are sufficient to limit the likelihood of fire and / or explosion incident.

In working with the company, it is incumbent on us to provide advice on remedial actions to minimise the impact from hazardous substances. Recognised standards and guidance are used in determining the appropriate status and extent of DSEAR hazardous zones for site operations. Significant findings from the survey are set out above. Detailed recommendations to mitigate fire and explosion hazards or support best practice on-site are contained within the body of the document, and collated in Section 9 - Recommendations.

² ATEX Directive 1999/92/EC: Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres

³ Dangerous Substances Explosive Atmospheres Regulations:2002 ('DSEAR').

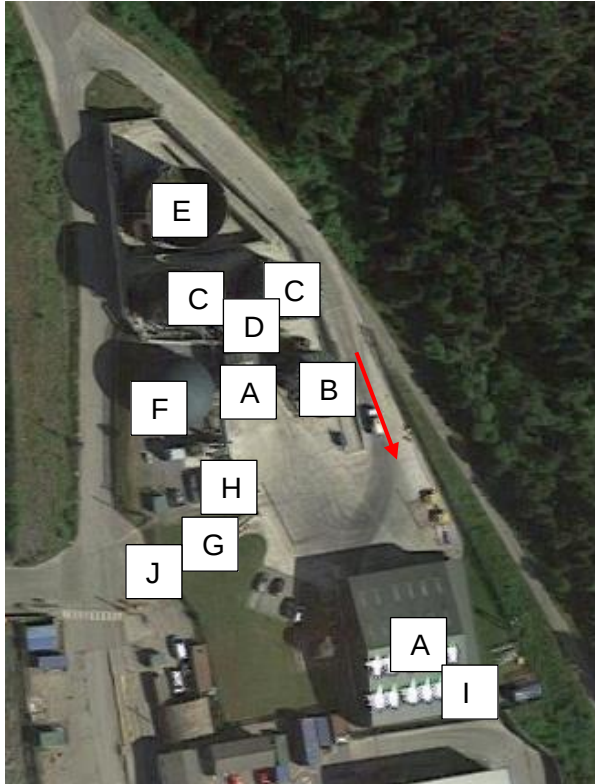
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This report is based on information supplied by Biogen for review, and the use of relevant Codes of Practice and established calculations where appropriate. To the best of our knowledge, the data supplied is correct and no changes to the plans have occurred up to the date of the final report that might affect the assessment. We cannot take responsibility for conclusions based on data that is subsequently shown to be incomplete or incorrect.

Documentary evidence was provided pertaining to proposed material inventory, site procedures and operations - plus an overview of installed site safety systems at the time of survey. Additional background information was provided by Kate Lister, Compliance Director, Graeme Vincent, Operations Director, Leigh Hawkins, Site Manager, and other relevant persons associated with site operations.

3.0 SITE OVERVIEW

3.1 Site Layout:



The facility is located on a brownfield site on former mine workings.

The site is bounded to the north and east by open land, to the south by industrial neighbours, and to the west by a roadway thence car parking.

The nearest access road is approx. 2 metres from the site structures.

Nearby facilities are not thought to threaten the site.

Separation distance from nearest occupied areas is such that thermal radiation / heat from a major fire should not pose a threat within ½ hour.

Smoke from a major fire could be a threat to neighbours.

Access point shown by red arrow

Areas of focus:

- Reception and separation areas (A)
- Raw waste buffer tank (B)
- Digesters (C)
- Pasteuriser (D)
- Digestate storage tank (E)
- Gas storage membrane (F)
- Flare unit (G)
- Boiler and CHP set (H)
- Flammable liquids storage (I)
- Gas cylinders (J)

3.2 Site Arrangements:

Most areas are in use and critical to business continuity. Primary focus of report is aimed at hazards associated with fire, explosion, or release of dangerous substances. It was indicated that operations at the time of survey were representative of typical site arrangements.

4.0 PERSONS AT RISK

4.1 Staff Numbers / Arrangements:

- Around 7 persons are employed at the site including personnel associated with operations (7) and office functions
- Operations are based on single day 08:00-18:30 shift pattern Monday to Sunday, and up to 7 persons may report to site at any one time
- Remote monitoring of SCADA and alarm systems is possible by duty managers
- Some operations on-site involve the direct handling of flammable or hazardous substances (under DSEAR)
- Office and ancillary facilities are located separately from the processing areas, so segregated from industrial fire risk

4.2 Visitor Arrangements:

- Visitor entry to site is monitored / recorded and subject to sign-in procedure
- Visitor / contractor numbers are not normally significant in hazard / process areas
- Contractors are admitted to site strictly by appointment, and subject to safe systems of work / supervision
- Other relevant persons attending the site receive safety induction and are accompanied

4.3 General Occupancy Controls:

- Persons in occupation at the premises are distributed throughout the site locations
- There are no basements nor sleeping accommodation, and limited lone working applies
- Automated fire alarm and emergency lighting systems in place in operational areas
- Relevant emergency evacuation procedures apply to all site areas
- The building has secured entry doors, and overall, the site is effectively fenced and gated
- Security controls include external and internal CCTV and PIR intruder alarms

5.0 HAZARDOUS SUBSTANCES

5.1 Significant DSEAR hazardous substances present

DSEAR Regulation 5 (2) requires: (a) the hazardous properties of the substance; (b) information on safety provided by the supplier, including information contained in any relevant safety data sheet.

Hazardous Substance	Nature of Hazard	Additional Comments
Biogas	Extremely flammable gas – May be found in anaerobic digestion system in high percentage	Assumed 55 to 60% CH ₄ , <40% CO ₂ , <5% N ₂ , <1% H ₂ , <0.5% O ₂ , <0.1% H ₂ S Risk of explosion in contact with: chlorine; fluorine; chlorine dioxide; difluoro dioxide; difluoro oxide; dinitrogen oxide; liquid oxygen; nitrogen dioxide; nitrogen trifluoride The substance can react dangerously with: strong oxidizing agents; acetylene; bromine pentafluoride; chlorine trifluoride; iodine heptafluoride
LPG / Propane	Extremely flammable gas – Cylinders may be used in site maintenance and fabrication activities, and flare ignition	Forms explosive mixtures with air. Practically insoluble in water. Gas is heavier than air. Risk of explosion in contact with: chlorine dioxide The substance can react dangerously with: barium peroxide
Aerosols (Isobutane)	Extremely flammable gas – Used in maintenance operations, such as leak and flaw detection, paints, and lubricants	Aerosol cans may expand rapidly / explode on heating - hazardous contents may lead to / support fire & explosion - safety reliant on effective controls and good aerosol storage practice
Hydrogen Sulphide	Extremely flammable gas – May be found in anaerobic digestion system in low fractional percentage	Forms explosive mixtures with air. Gas is heavier than air. In gas cylinders it is present as a liquefied gas. Acute or chronic health hazards result from the substance. The substance is hazardous to the aquatic environment.

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		Risk of explosion in contact with: benzene diazonium chloride and sulphate; p-bromine aniline diazonium chloride; bromine pentafluoride; calcium oxide + air; chlorine oxide; dichlorine oxide; difluoride oxide; iron(III)-oxide; iodates; copper (oxygen); perchloric fluoride; mercury(II)-oxide / air; rust; silver bromate; silver fulminate; nitrogen dioxide; nitrogen trichloride and triiodide; bismuth chromate The substance can react dangerously with: ammonia; halogens; potassium; potassium hydroxide; sodium; sodium hydroxide; oxidizing agents; nitric acid; oxygen; barium hydroxide; lead hypochlorite; calcium hydroxide; chlorine(III) chloride; chromyl chloride; dimethylamine; ethylamine; ethylene oxide; fulminates; oxidizing gases; halogen oxides; halogen nitrogen compounds; copper (powder); copper chromate; metal oxides; methylamine (rare); peroxides; mercury bromate; sulphur dioxide; conc. sulphuric acid; trimethylamine (rare); tungsten
Ammonia	The gas is poorly flammable – Evolved as component of food waste decomposition	The danger of ignition exists, but only localised and under certain conditions. The flame extinguishes without further addition of heat. Freely soluble in water. Aqueous solution reacts alkaline. Gas is lighter than air. In gas cylinders it is present as a liquified gas. Outflow of the liquid or expansion of large quantities of the gas causes formation of cold mist spreading on the ground. Acute or chronic health hazards result from the substance. The substance is hazardous to the aquatic environment. Risk of explosion in contact with: oxidizing agents; mercury; hydrogen peroxide; chlorites; stibine (heat); calcium; halogens except bromine; chlorine-azide; chloronitrobenzene; chloroform ammonium nitrate; chloronitrobenzene (heat); dichloroethane (liquid ammonia); dichlorine oxide; difluoride trioxide; gold; gold chloride; hydrocarbons/air; air/fire; magnesium perchlorate/gas; sodium hypochlorite (dry); picric acid; mercury hypo iodide; oxygen/catalyst; sulphur; silver; silver chloride; silver nitrate; silver oxide; nitrogen trichloride; sulfinyl chloride; tellurium halogenides Mixtures with oxidizing gases are explosive. The substance can react dangerously with: bromine; acids; nitric oxides; acetaldehyde; acrolein; barium; boron; boron

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		halogenides; bromine pentafluoride; hydrogen bromide; chlorine compounds; chromium trioxide; dimethyl sulphate; dinitrogen oxide; ethene oxide; hydrogen fluoride; carbon oxides; methane/heat; methyl mercaptan; pentaborane; phosgene; phosphorus oxide; phosphine; platinum catalysts; sulphur dioxide; hydrogen sulphide; silane; tetramethyl ammonium amide
Carbon Dioxide	Non-combustible gas – May be found in anaerobic digestion system in lesser percentage.	Compared to oxygen and nitrogen, carbon dioxide is relatively soluble in water and reacts to a small proportion (about 0.2 %, depending on the temperature) to carbon dioxide. Colloquially, often also the gas is inaccurately named carbonic acid. "Free carbonic acid" refers to the sum of the actual acid and the dissolved carbon dioxide. Evaporation of dry ice or expansion of the gas causes formation of cold mist spreading on the ground. Gas is heavier than air. Danger of suffocation at high concentrations. Accidents due to electrostatic charging are reported. Risk of explosion in contact with: metal dust / heat; aluminium hydride (rare); potassium (solid); sodium peroxide (heat) / metal powder The substance can react dangerously with: amines; ammonia; sodium; strong bases; water; acetylides; acrylaldehyde (polymerization); aziridine (polymerization); barium peroxide (heat); caesium oxide; ethylamine; lithium aluminium hydride; lithium (heat); methylamine
Argon	Non-flammable gas – Cylinders stored and used in site maintenance and fabrication activities	Included in scope of DSEAR since June 2015, as cylinders may rupture with explosive force in a fire. Inert gas, does not engage in any normal chemical reaction. Only slightly soluble in water. Gas is heavier than air. In gas cylinders it is present as a compressed gas. Can be liquified by cooling. Evaporation of very cold liquid or expansion of the gas causes formation of cold mist spreading on the ground. Danger of suffocation at high concentrations.
Solvents	Highly flammable and flammable – Used for cleaning of parts and	Storage in separate fire resistant cabinets. Local storage requires improvement.

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	equipment, and found in paints and thinners	
Diesel / Fuel oil	Flammable liquid – Used for workplace transport, and dual fuel boiler	Diesel fuel now falls within scope of DSEAR risk assessment due to CLP2015 classification raising the flash point temperature band to 60°C from 55°C. Energy Institute model code of safe practice – Part 15 – Area classification code for installations handling flammable fluids (IP15) classifies it as a Class III (1) liquid; <i>liquids that have flashpoints above 55°C up to and including 100°C, handled below flashpoint.</i> However, it is not stored or handled within 15°C of its flashpoint, and if dispensed under gravity or at low pressure, loss of containment or splashing presents a low risk of ignition as fine droplet sprays, or mists are not created.
Miscellaneous Combustibles	Minimal flammable/combustible consumables present - includes misc. maintenance, cleaning, or waste materials etc.	Minimal inventory of combustible substances evident for plant maintenance or cleaning tasks etc. Small-scale maintenance / consumable items not normally a significant DSEAR hazard
Ferric Chloride	Corrosive liquid – Stored in IBCs and used for hydrogen sulphide removal from wet biogas	Freely soluble in water. Sensitive to moisture. Aqueous solution reacts strongly acidic. Acute or chronic health hazards result from the substance. Risk of explosion in contact with: alkali metals; ethylene oxide The substance can react dangerously with: Water; allyl chloride; aluminium (heat) The compound reacts as a catalyst and/or as an initiator of polymerizations.
Diethanolamine (TEA) solution	Corrosive liquid – Stored in IBCs and used for water treatment	Combustible substance, poorly flammable. Freely soluble in water. Hygroscopic. Aqueous solution reacts alkaline. Acute or chronic health hazards result from the substance. The substance is hazardous to the aquatic environment. The substance can react dangerously with:

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		strong oxidizing agents; acids
Miscellaneous cleaning and disinfecting solutions	Corrosive liquids – Used for cleaning applications	Risks from self-accelerating thermal decomposition. Risks from corrosion to metals and structures. Risk from mixing with incompatible substances and thermal decomposition. Correct segregated storage a necessity.

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5.2 Hazardous Substance Properties:

Based upon observations at time of survey, site operations routinely involve hazardous substances as defined under DSEAR. A release of gas or vapour that is heavier than air may build up in unventilated spaces – or travel some distance along the ground to a source of ignition. Significant flammable inventory noted includes gases and liquids – critical properties for some key materials in use at the premises are indicated below.

5.2.1 Gases

Substance	Key Hazard	Flammable Range (LEL – UEL % in Air)	Flash Point	Boiling Point	Vapour pressures kPa	Relative density to Air @ 20°C	Auto Ignition Temp.	Gas Group	T Class	Quantity	Comment
Methane	H220: Extremely flammable gas	4.4 – 17%	N/A	-161.5°C	N/A	0.6	595°C	IIA	T1	Main component of biogas, may be present throughout AD process plant	CAS 74-82-8 MIE 0.29mJ UN 1972 ADR 2.1 Packing Group -
Hydrogen Sulphide	H220: Extremely flammable gas H330: Fatal if inhaled	4.3 – 45.5%	N/A	-60.2°C	20°C – 1819 30°C – 2310 50°C – 3650	1.19	270°C	IIB	T3	Appx 1,000 - 5,000ppm of biogas composition ex warm digester	CAS 7783-06-4 MIE 0.068mJ UN 1053 ADR 2.3 / 2.1 Packing Group -
LPG / Propane	H220: Extremely Flammable gas	1.7 – 10.9%	-104°C	-42°C	20°C – 832.7 30°C – 1080 50°C – 1708	1.55	470°C	IIA	T1	47kg cylinders stored externally and used for maintenance activities, and flare ignition	CAS 74-98-6, MIE 0.24mJ UN 1978 ADR 2.1 Packing Group -
Isobutane	H220: Extremely Flammable gas	1.5 – 9.4%	-83°C	-11.7°C	20°C – 301.9 30°C – 410 50°C – 677.8	2.07	460°C	IIA	T1	500g each, several canisters internally	CAS 75-28-5 MIE 0.25mJ UN 1969 ADR 2.1 Packing Group -
Ammonia	H221: Flammable gas H331: Toxic if inhaled	14 – 32.5%	N/A	-33.4°C	20°C – 857 30°C – 1170 50°C – 2030	0.6	630°C	IIA	T1	Evolved in low ppm during waste separation	CAS 7664-41-7 MIE 680mJ UN 1005 ADR 2.3 Packing Group -

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Carbon dioxide	No H phrase	N/A	N/A	N/A	20°C – 5730 30°C – 7210	1.53	N/A	N/A	N/A	Lesser component of biogas, may be present throughout AD process plant	CAS 124-38-9 UN 1013 ADR 2.2 Packing Group -
Argon	H280: Contains gas under pressure; may explode if heated	N/A	N/A	-185.9°C	N/A	1.38	N/A	N/A	N/A	Not stored at site, only brought onto site by authorised contractor under SSoW	CAS 7440-37-1 UN 1006 ADR 2.2 Packing Group -

5.2.2 Liquids

Substance	Key Hazard	Flammable Range (LEL – UEL % in Air)	Flash Point	Boiling Point	Vapour pressures kPa	Relative density to Air @ 20°C	Auto Ignition Temp.	Gas Group	T Class	Quantity	Comment
General solvent borne paints	H226: Flammable liquid and vapour	N/A	>29°C	N/A	N/A	N/A (>1)	>230°C	IIA	T3	Several x 2.5 and 5L containers, internally in stores and workshops	CAS mixture MIE > 0.55mJ UN 1263 ADR 3 Packing Group II
White spirit	H226: Flammable liquid and vapour	1.4 – 7.6%	38°C	150 - 200°C	38°C – 19	N/A (>1)	230°C	IIA	T3	Several 1L containers, internally in stores and workshops	CAS 64742-82-1 MIE > 0.3mJ UN 1300 ADR 3 Packing Group II
Diesel / fuel oil	H226: Flammable liquid and vapour	0.6 – 6.5%	>55°C	>141°C	40°C – 0.4	4.5	225°C	IIA	T3	4,600L storage tank, plus local storage tank for emergency generator	CAS 68334-30-5 MIE > 12mJ UN 1202 ADR 3 Packing Group III
Diethanolamine (TEA) solution	H302: Harmful if swallowed H315: Causes skin irritation	2.1 – 10.6%	176°C	269°C	N/A	N/A	355°C	N/A	T2	1,000L IBCs, several at water treatment areas	CAS 111-42-2 UN - ADR - Packing Group -

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	H318: Causes serious eye damage										
Ferric Chloride	H302: Harmful if swallowed H315: Causes skin irritation H318: Causes serious eye damage	N/A	N/A	N/A	N/A	N/A	Decomposition occurs >200°C	N/A	N/A	1,000L IBCs, several at water treatment areas	CAS 7705-08-0 UN1773 ADR 8 Packing Group III
Lubricant and hydraulic oils	H303: May be harmful if swallowed	N/A	>220°C	>300°C	20°C – <0.1	N/A	>450°C	IIA	T1	Various sized containers noted internally in stores	CAS mixtures UN - ADR - Packing Group -

Note 1 – Data shows flammable / explosible properties for typical hazardous substances / worst case component present on site

Note 2 – Flammable range & LEL data provided for guidance only as this varies with composition and environmental factors etc.

Note 3 – Gas group & T class provided to aid in identification of safe equipment category within hazardous zones on-site

6.0 RELEVANT SITE OPERATIONS

This section is not intended to provide a technical reference to site operations, but is an overview of relevant facilities and hazardous substance arrangements that may impact upon DSEAR risk assessment or control measures, as evident at the time of report compilation.

6.1 Utility and maintenance areas

6.1.1 Gas cylinder storage and use

DESCRIPTION and OBSERVATIONS
Equipment and processes
Gas cylinders are stored at site, at the workshop area [picture P1], and at the flare unit [picture P2]. For the workshop area, it appears this are a part of the normal inventory, and not brought onto site for specific activities only. It does not appear that they are controlled under a safe system of work. Also, once activities are complete, it does not appear that the gas cylinders are removed from site.

6.1.1 Hazards

Hazards
<i>Flammable gas, asphyxiating gas, compressed gas</i>
Ignition of flammable gas due to loss of containment and introduction of ignition source. Gas cylinder pressure up to 23 bar for LPG, up to 300 bar for other gases. Gas cylinders are a convenient way to transport and store gases under pressure. The main hazards are: • Impact from the blast of a gas cylinder explosion or rapid release of compressed gas. • Impact from parts of gas cylinders or valves that fail, or any flying debris. • Contact with the released toxic or corrosive gases or fluids (such as chlorine). • Fire and/or explosion resulting from the escape of flammable gases or fluids (such as liquefied petroleum gas).

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- Oxygen-enrichment and increased fire risks from released oxidants, such as oxygen, nitrous oxide, and fluorine.
- Asphyxiation risks from released inert gases – most gases except air, oxygen, and some diving/medical gas mixtures.
- Some gases are heavier than air so released gases, and their associated hazards, collect in low areas, such as basements, cellars, cable ducts, drains, etc.
- Impact from falling cylinders.
- Manual handling injuries.

6.1.1 Observations / Recommendations

DSEAR 2002 hierarchy:		Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum		
		Type and quantity of gas cylinders to be commensurate with activity requirements. No external gas cylinder storage cages evident.	HSE guidance ⁴ states: “Cylinders should be stored preferably in the open air on a concrete or load-bearing surface. Flammable liquids, combustible, corrosive, oxidising materials, toxic materials, or compressed gas cylinders should be kept separate in general. Containers should be stored with their valves uppermost.”	Review and ensure types and quantities of gas cylinders do not exceed activity requirements (RA1). Ensure temporary gas cylinder stores are at external, secure, and well ventilated locations (RA2). Arrange for prompt disposal of waste flammable gas cylinders from site (RA3).
	B	Avoidance or minimising the release of a dangerous substance		
		There are no gas cylinder storage cages for gases not in use. Gas cylinders not always chained upright.	Empty gas cylinders must always be treated as containing gas residues. According to BCGA CP4 ⁵ 8.2.1, the gas installation should be inspected weekly	Ensure gas cylinder stores locked when not in use (RB1). Ensure cylinders chained upright (RB2).

⁴ <https://www.hse.gov.uk/comah/sragtech/techmeascylinder.htm>

⁵ BCGA CP4 - Industrial Gas Cylinder Manifolds and Gas Distribution Pipework (excluding Acetylene), Revision 4, 2012

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		<i>Gas manifold</i> Gas pipework not identified. Not known if gas manifold equipment and hoses periodically inspected	for condition and function of components, and as per 8.2.2, annually as part of a written scheme of inspection by competent persons.	Ensure pipework correctly coloured and/or identified (RB3). Ensure gas cylinder manifold equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB4).
		Control of release of a dangerous substance at source		
	C	Gas cylinder valves should be closed when cylinder not in use. <i>Gas manifold</i> Valves not identified. Flashback arrestor not evident.	Integrity of means of control of releases to be demonstrated.	Ensure gas cylinder valves are closed during storage (RC1). Ensure Isolation valves identified and readily operable (RC2). Ensure flashback arrestor installed (RC3).
		Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation		
	D	Small leakages of gas are credible during storage. Gas cylinders are stored in an external well ventilated position. Dilution by ambient air flow possible.	For gas storage locations to be considered adequately ventilated at least 25% of the store surface area. This is achieved. <i>Hazardous Areas</i> External flammable gas cylinder stores will require Hazardous Area Classification as per Section 7.	Ensure gas cylinders are stored in adequately ventilated locations (RD1).
	E	Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe		

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F	In event of a release of gas, there are no containment measures. Dilution by ambient air flow possible, and readily achieved when the cylinders are stored externally.	Following BCGA guidance note 44⁶: When used to store flammable gases, the location of LPG storage cages should be more than 3 metres from flammable liquids, boundaries, wooden structures or combustible materials, drains, vent pipes, fixed sources of ignition, vehicle parking areas; and 2 metres from pits and drains, building openings. Following BCGA CP4: When used to distribute flammable LPG, separation distances from gas manifolds should be more than 3 metres from areas stated above, and 6 metres from pits and drains	Observe minimum separation distances for gas cylinder stores (RE1).
	The avoidance of viable ignition sources		
	Use of equipment producing naked flames to be controlled by hot work permit. Hot surfaces should not be present in the store or manifold. Fixed electrical sources of ignition present in vicinity of manifold. External gas storage locations require adequate separation distances from ignition sources.	Possible: Naked flames – personal items or from hot work nearby Hot surfaces – from or hot work nearby Faulty electrical equipment – from equipment nearby Sparks – from equipment or hot work nearby Static – from clothing	Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2). Verify earth resistance of circuit protective conductors for any electrical equipment (RF3). Ensure electrical circuits adequately identified (RF4).

⁶ BCGA CP44 – The storage of gas cylinders, 2016

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		Prohibition of personal sources of ignition will be required.		Ensure adequate identification of main isolation point (RF5). Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). Utilise static dissipative footwear and clothing, mats, and floor coatings (RF7). Rigorously control / separate flammables from personal sources of ignition (RF8). Ensure no sources of ignition within separation distance of flammable gas stores (RF9).
		The avoidance of adverse conditions which could give rise to harmful physical effects		
	G	It is assumed that safe systems of work are adhered to when carrying out activities involving gas cylinders. It is assumed these include use of gas detection equipment, appropriate isolation measures, and ultimately, appropriate PPE and emergency measures.	The immediate health effects of explosions⁷ include: • Smoke inhalation • Trauma and burns due to the force and heat of the blast • Lacerations / penetrations from flying debris • Worsening of pre-existing medical conditions as a result of acute physiological or psychological stress	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE (RG1). Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2).
	H	Segregation of incompatible dangerous substances		

⁷ <https://www.gov.uk/government/publications/health-effects-of-explosions-and-fires/health-effects-of-explosions>, PHE 8th July 2005

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		Incompatible dangerous substances to be kept separate from storage locations.	Separation required under <i>HSG71</i> ⁸ for different classes of materials.	No recommendations.
Mitigative	I	Reduce number of employees exposed		
		Storage areas attended occasionally by operations staff.	Only authorised personnel to be present in area.	Review and minimise personnel attendance at gas storage areas (RI1).
	J	Avoidance of propagation of fires or explosions		
		Flammable and combustible material to be removed from gas cylinder storage areas.		Ensure no flammable or combustible materials present at gas cylinder storage areas (RJ1).
	K	Provision of explosion relief arrangements		
		Not applicable for these locations.		No recommendations.
	L	Provision of explosion suppression equipment		
		Not applicable for these locations.		No recommendations.
	M	Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
		Not applicable for these locations.		No recommendations.
	N	Provision of suitable personal protective equipment		
		Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when handling flammable and hazardous substances.	Ensure authorised contractors adhere to site PPE rules (RN1).

⁸ HSE HSG71 - Chemical Warehousing; The storage of packaged dangerous substances, 4th edition 2009

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		Means of raising alarm / shutting down systems from a safe place		
		Fire alarm detection and manual call points to be identified and operable near to gas cylinder storage locations. Means of emergency shutting down of gas manifold not evident.	Fire protection measures for the storage area and adjacent spaces to be reviewed.	Ensure means of raising alarm readily identifiable and operable from a safe place near to gas cylinder stores (RO1). Ensure means of shutting down systems from a safe place provided and readily identified (RO2). Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor (RO3).
	P	Means of escape		
		Ready means of escape to be present where gas cylinders are stored. Emergency lighting to be present at all gas cylinder storage locations. Fire-fighting equipment to be present at all gas cylinder storage locations.	Fire escape measures for the storage area and adjacent spaces to be reviewed.	Ensure adequate illumination provided for non-daylight hours or emergency evacuation (RP1). Ensure adequate fire-fighting equipment provided in gas cylinder store area (RP2).
Indicative	Q	Signage		
		Warning signage to be present at gas cylinder storage locations.		Appropriate warning signage required where asphyxiating gas cylinders are stored (RQ1).

			  Caution Asphyxiant gas Appropriate warning signage required where flammable gas cylinders are stored (RQ1).  Danger Highly flammable No smoking or naked lights Including EX sign (RQ2). 
R	Training		

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		Site training records for compressed gas hazards not seen.	Training for new employees, and visiting contractors, plus periodic refresher training required. With appropriately targeted detail for managers, engineers, and operators.	Train staff in COSHH & DSEAR risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).
	Provision of information for emergency services			
	S	Information for emergency services to be provided on site plan.		Provide inventories of dangerous substances (RS1). Locations to be identified on site emergency response plan (RS2).

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6.1.2 Air compressors and receivers

DESCRIPTION and OBSERVATIONS
Equipment and processes
Situated within the facility are air compressors and receivers, which are used to store compressed air for powering pneumatically operated equipment [no picture].

6.1.2 Hazards

Hazards
<i>Compressed gas</i>
Violent rupturing of pressure vessel if subjected to extreme heat in event of fire.

6.1.2 Observations / Recommendations

DSEAR 2002 hierarchy:		Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum		
		Substance types and quantities stored commensurate with activities.		No recommendations.
	B	Avoidance or minimising the release of a dangerous substance		
		Pipework not identified.		Ensure pipework correctly coloured and/or identified (RB3).
	C	Control of release of a dangerous substance at source		

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		Valves not identified. Not known if compressors, receiver tanks and distribution system placed on critical items register and recorded service contracts arranged with specialist sub-contractor.		Ensure isolation valves are identified and operable (RC2). Ensure receiver tank and distribution system placed on critical items register and ensure recorded service contracts arranged with specialist sub-contractor (RC4).
	D	Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation		
Not applicable for these installations.		Hazardous Areas	No recommendations.	
		Hazardous Area Classification of air receivers not relevant.		
	E	Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe		
Pressure relief valve installed to receivers.			No recommendations.	
	F	The avoidance of viable ignition sources		
Not applicable for these installations.		Not applicable to compressed air receivers, see FRA for general fire scenarios.	No recommendations.	
	G	The avoidance of adverse conditions which could give rise to harmful physical effects		
Pressure relief valve installed to receivers.			No recommendations.	
	H	Segregation of incompatible dangerous substances		
Not applicable for these installations.			No recommendations.	

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Mitigative		Reduce number of employees exposed		
	I	Areas attended infrequently during working hours by operations staff or specialist contractor staff.	Only authorised personnel to be present in area.	Review and minimise personnel attendance at compressor areas (R11).
	J	Avoidance of propagation of fires or explosions		
		Not applicable for these installations.		No recommendations.
	K	Provision of explosion relief arrangements		
		Pressure relief valve installed to air receivers.	In event of fire the pressure relief valve activates and relieves air pressure in the receiver.	Ensure pressure relief valve on critical items register and checked by specialist sub-contractor at appropriate interval (RK1).
	L	Provision of explosion suppression equipment		
		Not applicable for these installations.		No recommendations.
	M	Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
		Not applicable for these installations.		No recommendations.
	N	Provision of suitable personal protective equipment		
		Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when working in process areas.	No recommendations.
	O	Means of raising alarm / shutting down systems from a safe place		

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		Internally, fire alarm detection and manual call points present at compressor areas. Means of shutting down in an emergency not always evident.		Ensure means of shutting down systems from a safe place provided and readily identified (RO2). Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor (RO3).
	P	Means of escape		
		Ready means of escape available from compressor areas. Emergency lighting present in compressor areas. Fire-fighting equipment present in compressor areas.		No recommendations.
Indicative	Q	Signage		
		Warning signage not adequate at compressor areas.		Appropriate warning signage required at compressor areas (RQ1).

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	R	Training			
		Site training records for hazardous substances hazards not seen.		Train staff in compressed gas risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).	
	S	Provision of information for emergency services			
		Information for emergency services to be provided on site plan.		Locations to be identified on site emergency response plan (RS2).	

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6.1.3 Flammable fuel storage

DESCRIPTION and OBSERVATIONS
Equipment and processes
Situated in the reception hall, is an approx. 2,000 litre diesel fuel tank and dispenser [no pictures].

6.1.3 Hazards

Hazards
<i>Flammable vapours, flammable liquids</i>
Diesel fuel and fuel oil now falls within scope of DSEAR risk assessment due to CLP2015 classification raising the flash point temperature band to 60°C from 55°C. If it is not stored or handled within 10°C of its flashpoint, and if dispensed under gravity or at low pressure, loss of containment or splashing presents a low risk of ignition as fine droplet sprays, or mists are not created. However, splash filling and pumping systems may give rise to loss of containment and fine droplet sprays.

6.1.3 Observations / Recommendations

DSEAR 2002 hierarchy:	Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum	
		Substance types and quantities stored generally commensurate with activities. Some evidence of fuel spillage on floor. Where elimination or substitution cannot be made, reduction is required, unless quantities commensurate with operational requirements.	Review and ensure types and quantities do not exceed activity requirements (RA1). Review and maintain high standard of housekeeping (RA4).

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		Avoidance or minimising the release of a dangerous substance		
		<i>Tank</i> Tank of robust double skin polymer construction, with internal bund. Tank not protected from mechanical impact from vehicles. Tank and equipment features bund alarm. Filling of fuel tank is monitored by the delivery driver, with shutdown of transfer in event of spillage possible. Manual connections for filling and dispensing operations cannot always avoid inadvertent release of flammable substances. <i>Diesel dispenser</i> Dispenser nozzle rested in holster when not in use. Fuel delivery hose stowed within locked tank enclosure when not in use, away from possible mechanical damage. Drive-away fail-safe break couplings are installed to dispenser hose.	Integrity of the tanks and pipework is paramount, as this is the primary containment.	Implement robust impact protection barrier around tank (RB5). Review and ensure satisfactory operation of excess high / low condition switches and alarms (RB6). Ensure alarm switches placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB7). Review maintenance and leak prevention for rotating pumps and process equipment (RB8). Review maintenance and leak prevention for equipment connections and access hatches (RB9). <i>Diesel dispenser</i> Ensure hose stowed away from roadway when not in use (RB10).
	C	Control of release of a dangerous substance at source		
		<i>Tank</i> Isolation valves present at tank.	Integrity of means of control of releases to be demonstrated.	Ensure isolation valves are identified and operable (RC2).

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		Isolation valves not all identified. Isolation valves fitted with operating handles. Tank periodically inspected by fuel supplier. <i>Diesel dispenser</i> For manual filling and dispensing operations, control of releases relies on personal competence. Dispenser use is an attended operation at all times. The dispenser nozzle requires hand pressure to dispense fuel and will shut-off if pressure released.		Review and ensure satisfactory operation of control system inputs and outputs and associated control equipment (RC5). Ensure tank and dispenser placed on critical items register and ensure recorded inspection and service contract arranged with specialist sub-contractor (RC6).
		Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation		
	D	<i>Tank</i> Tank is constructed to OFS T100, so will not produce vapours internally due to dip pipe filling. Tank vent breathes to internal bund at low pressure, and at temperature above flashpoint, thereby preventing formation of a potentially explosive atmosphere.	General fire scenarios to be covered by Fire Risk Assessment. Diesel or fuel oil tanks manufactured to BS799 Part 5 or OFS T200 / T100 and below 150,000 litre capacity do not require Hazardous Area Classification in use⁹. Referring to APEA June 2015 Bulletin, Hazardous Areas are defined around higher flowrate diesel dispenser hoses and nozzles during use.	No recommendations.

⁹ HSE letter to FEA, ref :TRIM2016/435961, November 2016

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		Externally, ventilation is of natural type, and reliant on air currents around the tank enclosure. Dilution by ambient air flow possible. <i>Diesel dispenser</i> Due to low flowrate and low pressure dispensing, a potentially explosive atmosphere of sufficient volume and persistence to cause harm, is unlikely to be produced.	<i>Hazardous Areas</i> Hazardous Area Classification not required to diesel storage tank. Hazardous Area Classification not required to low pressure diesel dispenser hose and nozzle during use.	
	E	Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe		
		<i>Vapour</i> Release of vapours contained within tank internal breather vent to integral bund. <i>Liquid</i> Tank of robust double skin steel construction, with internal bund. Spill kits not evident in area. In event of significant loss of containment, separation from groundwater to prevent contamination is provided by interceptor system.	Integrity of secondary / tertiary containment, or relief lines to be demonstrated. Reduction of layers of containment may be contra to EA ¹⁰ regulations for prevention of contamination of groundwater from fuel oils.	Ensure spill kits available in areas (RE2).
F	The avoidance of viable ignition sources			

¹⁰ Oil Pollution Prevention Guidelines (England & Wales) 2001 PPG2 - Above Ground Oil Storage Tanks

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		Use of equipment producing naked flames to be controlled by hot work permit. Hot surfaces may be present from vehicles in vicinity. Sparks may be present from vehicles in vicinity. Electrical circuits and isolation points not always identified. Electrical sources of ignition in vicinity of fuel tank includes power circuits for instrumentation and controls. Supplementary earth connection to steel tank installed. Tanker earth point not evident. Prohibition of personal sources of ignition will be required.	Possible: Naked flames – personal items, vehicles or from hot work nearby Hot surfaces – from equipment, vehicles, or hot work nearby Faulty electrical equipment – from equipment Sparks – from equipment, vehicles, or hot work nearby Static – from clothing	Implement delivery tanker earthing point (RF17). Ensure vehicle ignition systems switched off during refuelling (RF18). Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2). Verify earth resistance of circuit protective conductors for any electrical equipment (RF3). Ensure electrical circuits adequately identified (RF4). Ensure adequate identification of main isolation point (RF5). Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). Utilise static dissipative footwear and clothing, mats, and floor coatings (RF7). Rigorously control / separate flammables from personal sources of ignition (RF8).
	G	The avoidance of adverse conditions which could give rise to harmful physical effects		

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		It is assumed that safe systems of work are adhered to when carrying out activities involving flammable substances. It is assumed these include use of vapour detection equipment, appropriate isolation measures, and ultimately, appropriate PPE and emergency measures.	The immediate health effects of fires and explosions¹¹ include: • Smoke inhalation • Trauma and burns due to the force and heat of the blast • Lacerations / penetrations from flying debris • Worsening of pre-existing medical conditions as a result of acute physiological or psychological stress Employee exposure levels should be checked against EH40¹², and suitable protection measures implemented if necessary.	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE (RG1). Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2).
	H	Segregation of incompatible dangerous substances		
		No incompatible substances stored.	Separation required under HSG71¹³ for different classes of materials. Where waste is collected and stored for disposal, segregation into different types is required.	Ensure hazardous waste disposed using licenced waste carrier with consignment note received (RH1).
Mitigative	I	Reduce number of employees exposed		

¹¹ <https://www.gov.uk/government/publications/health-effects-of-explosions-and-fires/health-effects-of-explosions>, PHE 8th July 2005

¹² HSE EH40/2005 - Workplace exposure limits, 3rd Edition 2018

¹³ HSE HSG71 - Chemical Warehousing; The storage of packaged dangerous substances, 4th edition 2009

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		Tank and dispenser attended occasionally during working hours by authorised persons and vehicles. Tank attended occasionally by supplier's personnel during refilling.	Only authorised personnel to be present in areas.	Review and minimise personnel attendance at storage areas (RI1).
	Avoidance of propagation of fires or explosions			
	J	Tank separation distance is not adequate. Combustible material not evident at storage tank location.	Fire engineering measures for the tank area and adjacent spaces to be reviewed. Referring to OFTEC guidance¹⁴, non-domestic tanks of less than 3,500 litres capacity should be sited at least 2 metres away from buildings or boundaries. For tanks of more than 3,500 litres capacity should be sited at least 6 metres away from buildings or boundaries. Referring to HSG 176¹⁵, small tanks between 1 and 5m³ capacity require to be sited at least 4 metres from buildings or boundaries. Employees are not in immediate danger in event of a fire, so moving the tank enclosure to a distance of more than 2, 4 or 6 metres would be for asset protection.	Ensure combustible material removed from storage tank area (RJ2). Consider relocating tank to exterior of building (RJ3). If not feasible, then ensure adequate separation distances, or implement adequate fire rated barrier (RJ4).

¹⁴ OFTEC PUB 18 issue 1, 2006

¹⁵ HSG 176 - The storage of flammable liquids in tanks, 2015

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			Where this is not achievable then a 2 hour fire resistance barrier extending 900mm higher and wider than the end of the tank enclosure along the side facing the building, is required.	
	K	Provision of explosion relief arrangements		
		Not applicable for this storage area.		No recommendations.
	L	Provision of explosion suppression equipment		
		Not applicable for this storage area.		No recommendations.
	M	Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
		Not applicable for this storage area.		No recommendations.
	N	Provision of suitable personal protective equipment		
		Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when handling flammable and hazardous substances.	No recommendations.
	O	Means of raising alarm / shutting down systems from a safe place		
		Fire alarm detection and manual call points present near to storage tank location. Isolation switch present and operable, but not readily identified at installation to shut off dispenser electrical supply in event of fire.	Fire protection measures for the storage areas and adjacent spaces to be reviewed.	Ensure means of shutting down systems from a safe place provided and readily identified (RO2). Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor (RO3).

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Indicative	P	Means of escape		
		Means of escape readily available from storage area. Emergency lighting present at storage area. Fire-fighting equipment present at storage area.	Fire escape measures for the storage areas and adjacent spaces to be reviewed.	No recommendations.
	Q	Signage		
		Warning signage not adequate at tank storage area.		Appropriate warning signage required at storage tank area (RQ1). 
	R	Training		
		Site training records for hazardous and flammable substances hazards not seen.	Training for new employees, and visiting contractors, plus periodic refresher training required. With appropriately targeted detail for managers, engineers, and operators.	Train staff in COSHH & DSEAR risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).
	S	Provision of information for emergency services		

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		Information for emergency services to be provided on site plan.		Provide inventories of dangerous substances (RS1). Hazardous substances storage locations to be identified on site emergency response plan (RS2).
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6.1.4 Emergency generator

DESCRIPTION and OBSERVATIONS
Equipment and processes
Situated behind the boiler house is the emergency generator [picture P3]. The unit is fuelled from a small on-board storage tank (<200L).

6.1.4 Hazards

Hazards
<i>Flammable vapours, flammable liquids</i>
Diesel fuel and fuel oil now falls within scope of DSEAR risk assessment due to CLP2015 classification raising the flash point temperature band to 60°C from 55°C. If it is not stored or handled within 10°C of its flashpoint, and if dispensed under gravity or at low pressure, loss of containment or splashing presents a low risk of ignition as fine droplet sprays, or mists are not created. However, splash filling and pumping systems may give rise to loss of containment and fine droplet sprays.
<i>Corrosive substances</i>
Violent chemical reactions of corrosive and other substances if loss of containment and mixing with incompatible substances occurs. Substances that can corrode metals could cause structural damage reducing integrity of structures if not suitably contained.

6.1.4 Observations / Recommendations

DSEAR 2002 hierarchy:	Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum	

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		Substance types and quantities stored commensurate with activities.	Where elimination or substitution cannot be made, reduction is required, unless quantities commensurate with operational requirements.	No recommendations.
		Avoidance or minimising the release of a dangerous substance		
	B	Generator sited on kerbed or separated areas, protected from mechanical impact. Generator equipment is within a secured enclosure. Tank and equipment features high / low deviation alarms.	Integrity of the tank and pipework is paramount, as this is the primary containment.	Review and ensure satisfactory operation of excess high / low condition switches and alarms (RB6). Ensure alarm switches placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB7). Review maintenance and leak prevention for rotating pumps and process equipment (RB8). Review maintenance and leak prevention for equipment connections and access hatches (RB9).
		Control of release of a dangerous substance at source		
	C	Isolation valves present within generator enclosure. Isolation valves identified. Isolation valves fitted with operating handles. Generator equipment features operational controls and positional feedback.	Integrity of means of control of releases to be demonstrated.	Review and ensure satisfactory operation of control system inputs and outputs and associated control equipment (RC5). Ensure generator placed on critical items register and recorded inspection and service contract arranged with specialist sub-contractor (RC7).

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		Enclosure periodically inspected by generator supplier.		
	D	Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation		
		Prevention of formation of a potentially explosive atmosphere reliably prevented due to capillary non-pressurised fuel feed from storage tank. Diesel high pressure injection systems constructed and maintained to relevant BS EN standards. Evolution of hydrogen during battery charging when the engine is running is minimal. Externally, ventilation is of natural type when the units are not in use, and reliant on air currents around the enclosure. Internally, ventilation is of artificial type when the unit is in use, and use louvres and forced air fans to provide air currents around the generator. Dilution by ambient air flow possible.	General fire scenarios to be covered by Fire Risk Assessment.	No recommendations.
			Hazardous Areas	
			Hazardous Area Classification not required to diesel emergency generator enclosure. Hazardous Area Classification not required to batteries during charging.	
	Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe			
	E	Vapour Artificial ventilation exhausting to exterior when generator in use. Liquid	Integrity of secondary / tertiary containment, or relief lines to be demonstrated.	Ensure spill kits available in areas (RE2).

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		Generator enclosure is of robust double skin steel construction, with integral bund. Spill kit not evident nearby.		
		The avoidance of viable ignition sources		
	F	Use of equipment producing naked flames to be controlled by hot work permit. Hot surfaces may be present from equipment operating. Sparks should not be present from equipment operating. Electrical circuits and isolation points not always identified. Electrical sources of ignition in vicinity of diesel fuel include the engine and controls. Supplementary earth bonding present to generator enclosure. Prohibition of personal sources of ignition will be required.	Possible high energy: Naked flames – personal items or from hot work nearby Hot surfaces – from equipment, vehicles, or hot work nearby Faulty electrical equipment – from powered equipment Chemical reactions and thermal decomposition leading to self-ignition	Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2). Verify earth resistance of circuit protective conductors for any electrical equipment (RF3). Ensure electrical circuits adequately identified (RF4). Ensure adequate identification of main isolation point (RF5). Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). Utilise static dissipative footwear and clothing, mats, and floor coatings (RF7). Rigorously control / separate flammables from personal sources of ignition (RF8).
	G	The avoidance of adverse conditions which could give rise to harmful physical effects		

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		It is assumed that safe systems of work are adhered to when carrying out activities involving flammable substances. It is assumed these include use of vapour detection equipment, appropriate isolation measures, and ultimately, appropriate PPE and emergency measures.	The immediate health effects of fires and explosions¹⁶ include: • Smoke inhalation • Trauma and burns due to the force and heat of the blast • Lacerations / penetrations from flying debris • Worsening of pre-existing medical conditions as a result of acute physiological or psychological stress Employee exposure levels should be checked against EH40¹⁷, and suitable protection measures implemented if necessary.	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE (RG1). Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2).
	H	Segregation of incompatible dangerous substances		
		Loss of containment of corrosive battery liquids may adversely affect structural integrity of enclosure structure.	Separation required under HSG71 ¹⁸ for different classes of materials.	Ensure structural steelwork protected from spill of corrosive substances (RH2).
Mitigative	I	Reduce number of employees exposed		
		Area attended infrequently by operations staff.	Only authorised personnel to be present in areas.	Review and minimise personnel attendance at generator enclosure (RI1).

¹⁶ <https://www.gov.uk/government/publications/health-effects-of-explosions-and-fires/health-effects-of-explosions>, PHE 8th July 2005

¹⁷ HSE EH40/2005 - Workplace exposure limits, 3rd Edition 2018

¹⁸ HSE HSG71 - Chemical Warehousing; The storage of packaged dangerous substances, 4th edition 2009

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		1 to 2 specialist contractor personnel may be in attendance during equipment inspections.		
		Avoidance of propagation of fires or explosions		
	J	Generator adequately separated so as to avoid propagation of fires or explosions.	Fire engineering measures for the generator area and adjacent spaces to be reviewed.	No recommendations.
		Provision of explosion relief arrangements		
	K	Not applicable for this installation.		No recommendations.
		Provision of explosion suppression equipment		
	L	Not applicable for this installation.		No recommendations.
		Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
	M	Not applicable for this installation.		No recommendations.
		Provision of suitable personal protective equipment		
	N	Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when handling flammable and hazardous substances.	No recommendations.
		Means of raising alarm / shutting down systems from a safe place		
	O	Fire alarm detection and manual call point not evident at generator location. Emergency stop pushbutton present at generator installation.	Fire protection measures for the generator area and adjacent spaces to be reviewed.	Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged

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Indicative				with competent specialist sub-contractor (RO3).
	P	Means of escape		
	P	Ready means of escape available from generator area. Emergency lighting for evacuation or emergency working not evident in area. Fire-fighting provision not evident in area.	Fire escape measures for the generator area and adjacent spaces to be reviewed.	Ensure adequate illumination provided for non-daylight hours or emergency evacuation (RP1). Ensure adequate fire-fighting equipment provided in area (RP2).
	Q	Signage		
	Q	Warning signage not adequate at generator area.		Appropriate warning signage required at generator area (RQ1). 
	R	Training		
	R	Site training records for hazardous and flammable substances hazards not seen.	Training for new employees, and visiting contractors, plus periodic refresher training required. With appropriately targeted detail for managers, engineers, and operators.	Train staff in COSHH & DSEAR risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).

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	S	Provision of information for emergency services		
		Information for emergency services to be provided on site plan.		Provide inventories of dangerous substances (RS1). Generator location to be identified on site emergency response plan (RS2).

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6.1.5 Hazardous / flammable substances storage

DESCRIPTION and OBSERVATIONS
Equipment and processes
Situated around the site are storage areas for hazardous / flammable substances. • Reception hall area, Ferric Chloride and T.E.A solution IBCs and drums [pictures P4, P5]; • Maintenance and area, flammable and hazardous substances [pictures P6, P7]; • CHP area, lubricant oil tanks (clean / used), and other fluids [picture P8]; • Contractor's container, flammable and hazardous substances [no pictures].

6.1.5 Hazards

Hazards
<i>Flammable vapours, flammable liquids</i>
The main hazards from the use of flammable liquids are fire and explosion, involving either the liquid or the vapour given off from it. Fires or explosions are likely to occur when vapours or liquids are released from a controlled environment to areas where there may be an ignition source, or, alternatively, when an ignition source is introduced into a controlled environment. Common causes of such incidents include: • lack of awareness of the properties of flammable liquids; • operator error, due to lack of training; • hot work on or close to flammable liquid containers; • inadequate design of equipment; • inadequate installation or maintenance; • failure or malfunction of equipment; • exposure to heat from a nearby fire;

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- misuse of flammable liquids, for example, to burn waste materials or brighten fires;
- inadequate control of ignition sources;
- electrostatic discharges;
- heating materials above their auto-ignition temperature;
- dismantling or disposing of equipment containing flammable liquids.

Incidents involving flammable liquids commonly arise during transfer operations, including:

- movement from storage;
- decanting or dispensing;
- movement within premises;
- use in processes;
- disposal;
- emptying vehicle fuel tanks;
- dealing with spillages.

Corrosive substances

Violent chemical reactions of corrosive and other substances if loss of containment and mixing with incompatible substances occurs. Substances that can corrode metals could cause structural damage reducing integrity of structures if not suitably contained.

6.1.5 Observations / Recommendations

DSEAR 2002 hierarchy:		Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum		
		Substance types and quantities stored may not always be commensurate with activities. Legacy used, part-used, and damaged containers in evidence.	Where elimination or substitution cannot be made, reduction is required, unless quantities commensurate with operational requirements.	Review and ensure types and quantities do not exceed activity requirements (RA1). Review and maintain high standard of housekeeping (RA4).

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		Disposal of waste not well controlled.	BS EN 14470 rated flammables cabinets are preferred as manufactured to a specified fire resistance time.	Review inventory of legacy hazardous substances and remove redundant stocks (RA5). Ensure a maximum of 250 litres of flammable liquids only is stored in one location, of which 50 litres may be highly flammable (RA6). Remove not in use containers of flammable liquids to secure, spill containing, fire resistant cabinets / chests (RA7). Review and ensure bins emptied regularly (RA8).
	Avoidance or minimising the release of a dangerous substance			
	B	Tanks of robust double skinned steel construction. Storage of hazardous substances not always on spill pallets / trays. Storage chests and cabinets appear to be suitably spill containing. Instances of hazardous chemicals stored inappropriately on floors, surfaces, and shelving, often stacked more than one row high.	Integrity of the containers is paramount, as this is the primary containment.	Ensure hazardous liquids stood on secondary spill containing pallets / trays (RB11). Ensure substances stored appropriately in single layers within storage enclosures (RB12).
	Control of release of a dangerous substance at source			
	C	Storage chests and cabinets not always locked when not in use.	Integrity of means of control of releases to be demonstrated.	Ensure storage enclosures locked when not in use (RC8).

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			Where flammable liquids are decanted, additional precautions required as per HSE HSG140¹⁹, summary: Flammable solvent inventory within the area should be minimised / controlled at all times (RC9). Utilise secondary containment / bunded trays or similar for holding flammable containers (RC10). Ensure adequate ventilation (RC11) and earthing (RC12) for dispensing / decanting of flammable solvents. Use only metallic containers (RC13) and limit the flow rate (RC14), avoiding splashing where possible (RC15). Avoid open containers / faulty containers and subsequent vapour potential at all times (RC16). Ensure use of top mounted dispensing pumps for medium and large containers (RC17).
	D	Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation	

¹⁹ HSE HSG140 - Safe Use and Handling of Flammable Liquids, 2nd Edition 2015

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		In event of loss of containment, prevention of formation of a potentially explosive atmosphere not assured in storage locations. Ventilation louvres present at storage enclosures. Externally, ventilation is of natural type, and reliant on air currents. Internally, ventilation is of natural type, and reliant on air movements within the storage containers or rooms of buildings.	Referring to HSE guidance HSG51²⁰, the storage areas require adequate spill retention, plus ventilation and control of ignition sources. Where containers are stored externally, adequate fresh air ventilation is deemed as available. For a flammables store-room / enclosure, ventilation is recommended in the form of louvres, to 1-3% [2.5%] of the combined wall and ceiling area. [Ref HSG51, clause 61], to give 5 air changes per hour minimum. This level of ventilation availability should keep the LFL below 25%.	Ensure ventilation to enclosed and open stores is adequate and achieves 0.1m/s and 5ACH (RD2). Ensure hazardous waste stored in external well ventilated location (RD3).
			<i>Hazardous Areas</i>	
			Flammable storage containers, chests, and cabinets will require Hazardous Area Classification as per Section 7. Decanting / mixing of flammables will require Hazardous Area Classification as per Section 7. Solvent waste bins / skips will require Hazardous Area Classification as per Section 7.	

²⁰ HSE HSG51 - The storage of flammable liquids in containers, 3rd Edition 2015

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	E	Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe		
		<i>Vapours</i> Release of vapours may not be adequately controlled. <i>Liquids</i> Integral spill bunds to tanks. Some use of spill pallets/trays for drums. Use of flammables cabinets and chests to contain spillages. Several instances of drums and containers stood on wooden pallets or loose on shelving, surfaces, and floors. Spill kits not always evident or readily accessible in areas. In event of significant loss of containment, separation from groundwater to prevent contamination is provided by interceptor system.	Integrity of secondary / tertiary containment, or relief lines to be demonstrated.	Ensure in use hazardous and flammable substances stood on spill pallets / trays (RB11). Ensure spill kits available in areas (RE2).
		The avoidance of viable ignition sources		
	F	Use of equipment producing naked flames to be controlled by hot work permit. Hot surfaces may be present from vehicles.	Possible: Naked flames – personal items, vehicles or from hot work nearby Hot surfaces – from equipment, vehicles, or hot work nearby Faulty electrical equipment – from equipment	Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2).

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		Electrical sources of ignition not present in vicinity of flammables storage locations. Supplementary earth bonding not evident where hazardous substances are stored in or on metal structures. Prohibition of personal sources of ignition will be required.	Sparks – from equipment, vehicles, or hot work nearby Static – from clothing Chemical reactions and thermal decomposition leading to self-ignition	Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). Utilise static dissipative footwear and clothing, mats, and floor coatings (RF7). Rigorously control / separate flammables from personal sources of ignition (RF8).
		The avoidance of adverse conditions which could give rise to harmful physical effects		
	G	Inhalation of toxic vapours may cause respiratory health issues. Externally stored flammable substances containers may not be shielded from direct sunlight. It is assumed that safe systems of work are adhered to when carrying out activities involving flammable and hazardous substances. It is assumed these include use of vapour detection equipment, appropriate isolation measures, and ultimately, appropriate PPE and emergency measures.	The immediate health effects of explosions²¹ include: • Smoke inhalation • Trauma and burns due to the force and heat of the blast • Lacerations / penetrations from flying debris • Worsening of pre-existing medical conditions as a result of acute physiological or psychological stress Employee exposure levels should be checked against EH40²², and suitable protection measures implemented if necessary.	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE (RG1). Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2). Ensure flammable liquids containers shielded from sunlight if stored externally (RG3).
	H	Segregation of incompatible dangerous substances		

²¹ <https://www.gov.uk/government/publications/health-effects-of-explosions-and-fires/health-effects-of-explosions>, PHE 8th July 2005

²² HSE EH40/2005 - Workplace exposure limits, 3rd Edition 2018

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		Incompatible substances may be stored together at storage locations. Loss of containment of corrosive liquids may adversely affect structural integrity of steel racking supports, and columns of buildings.	Separation required under <i>HSG71</i>²³ for different classes of materials: 3 metres minimum distance between each of: • Class 3 flammable liquids • Class 4 flammable solids • Class 5 oxidising substances • Class 6 toxic substances • Class 8 corrosive substances If space is an issue, then these distances may be achieved by use of solid fire resisting partitions, or relocating into secure fire resisting chests/cabinets. Where waste is collected and stored for disposal, segregation into different types is required.	Ensure minimum separation distances between different classes of hazardous substances are observed (RH3). Ensure structural steelwork protected from spill of corrosive substances (RH2). Ensure different waste types are effectively managed to separate waste streams (RH4). Ensure hazardous waste disposed using licenced waste carrier with consignment note received (RH1).
Mitigative	I	Reduce number of employees exposed		
		External areas attended occasionally by site staff, passing persons and vehicles. Internal storage areas attended occasionally by operations staff.	Only authorised personnel to be present in area.	Review and minimise personnel attendance at storage areas (RI1).
	J	Avoidance of propagation of fires or explosions		
		Combustible materials evident in vicinity of storage areas, and within storage enclosures.	Fire engineering measures for the storage locations and adjacent spaces to be reviewed.	Ensure combustible material removed from storage areas (RJ5).

²³ HSE HSG71 - Chemical Warehousing; The storage of packaged dangerous substances, 4th edition 2009

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				Ensure stores are located such that propagation of fires or explosion is contained as required for the facility (RJ6). Ensure bins / skips are suitably fire resistant (RJ7).
	K	Provision of explosion relief arrangements		
		Not applicable for these storage areas.		No recommendations.
	L	Provision of explosion suppression equipment		
		Not applicable for these storage areas.		No recommendations.
	M	Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
		Not applicable for these storage areas.		No recommendations.
	N	Provision of suitable personal protective equipment		
		Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when handling flammable and hazardous substances.	No recommendations.
	O	Means of raising alarm / shutting down systems from a safe place		
		Fire alarm detection and manual call points not always present at storage areas.	Fire protection measures for the storage areas and adjacent spaces to be reviewed.	Ensure means of raising alarm readily identifiable and operable from a safe place implemented (RO1). Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged

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				with competent specialist sub-contractor (RO3).
	P	Means of escape		
	P	Means of escape readily available from storage areas. Emergency lighting not always present at storage areas. Fire-fighting equipment not always present at storage areas.	Fire escape measures for the storage areas and adjacent spaces to be reviewed.	Ensure adequate illumination provided for non-daylight hours or emergency evacuation (RP1). Ensure adequate fire-fighting equipment provided in area (RP2).
Indicative		Signage		
	Q	Warning signage not adequate at all storage areas.		Appropriate warning signage required at hazardous chemical storage areas (RQ1).  Know your GHS symbols Flammable Corrosive Oxidising Explosive Compressed Gas Harmful Irritant Dangerous for the Environment Health Hazard Toxic Appropriate warning signage required at flammable storage areas (RQ1).

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				 Including EX sign at flammable storage areas (RQ2). 
	R	Training		
		Site training records for hazardous and flammable substances hazards not seen.	Training for new employees, and visiting contractors, plus periodic refresher training required. With appropriately targeted detail for managers, engineers, and operators.	Train staff in COSHH & DSEAR risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).
	S	Provision of information for emergency services		
		Information for emergency services to be provided on site plan.		Provide inventories of dangerous substances (RS1). Hazardous substances storage locations to be identified on site emergency response plan (RS2).

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6.2 Mechanical Treatment areas

6.2.1 Receiving hall and separation room

DESCRIPTION and OBSERVATIONS
Equipment and processes
In the process building, food waste is received and shredded as per the Biogen process description document, and Engineering Line Diagram – BP-ELD-001-SLUDGE [pictures P9, P10, P11, P12, P13]. There are gas detection and alarm systems installed to the separation room [picture P14]. Ventilation odour extraction and associated filter equipment installed [picture P15].

6.2.1 Hazards

Hazards
<i>Asphyxiating, toxic, and flammable gases</i>
Asphyxiation and toxic gas poisoning possible. Methane, carbon dioxide, ammonia, and hydrogen sulphide may be evolved from decomposing food waste.

6.2.1 Observations / Recommendations

DSEAR 2002 hierarchy:	Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum	
		Substance types and quantities used commensurate with activities. Generally, for the activities carried out, housekeeping adequately controlled,	Where elimination or substitution cannot be made, reduction is required, unless quantities are commensurate with operational requirements. Review, improve, and maintain high standard of housekeeping (RA4).

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		some accumulations present on and around equipment and surfaces.		
	B	Avoidance or minimising the release of a dangerous substance		
		The shredding and processing equipment is enclosed, with equipment featuring high / low deviation sensors, pressure switches or limit switches on relief hatches, and alarms. The shredding and processing equipment is enclosed, with extraction ventilation available to the machinery. Not known if shredding and processing equipment placed on a recorded maintenance and service contract to periodically check process deviation functions.	Integrity of the equipment housings and connected conveying systems is paramount, as this is the primary containment.	Review and ensure satisfactory operation of excess high / low condition switches and alarms (RB6). Ensure alarm switches placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB7). Review maintenance and leak prevention for rotating equipment (RB8). Review maintenance and leak prevention for equipment connections and access hatches (RB9). Ensure process equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB13).
		Control of release of a dangerous substance at source		
	C	The shredding and processing equipment is enclosed, features operational controls and positional feedback. Not known if shredding and processing equipment placed on a recorded maintenance and service contract to periodically check controls and actuators.	Integrity of means of control of releases to be demonstrated.	Review and ensure satisfactory operation of control system inputs and outputs and associated control equipment (RC5). Ensure process control equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RC18).

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	D	Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation		
		Due to frequent turnover and processing of food waste, evolution of flammable gas in explosive concentration is not thought credible at the shredding and processing equipment open points. Dust is not produced in sufficient quantity, nor dryness, to form an explosive dust atmosphere. Natural and artificial ventilation installed to process areas. The shredding and processing equipment is enclosed, with extraction ventilation available to the machinery. Gas detection and alarm systems installed to process areas.	Ventilation provided by mechanical extract ventilation (MEV) to external odour control system. This causes slight negative pressure in the process areas. Due consideration should be given to reviewing performance of mechanical extract ventilation (MEV) systems as regards controlling airborne particulates. The guidance contained in HSE HSG258 applies. MEV system to be periodically examined by ventilation specialist contractor.	Ensure MEV systems are interlocked to functioning of required machinery (RD4). Review and ensure satisfactory performance of MEV systems (RD5). Ensure gas detection and alarm systems placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RD6).
			<i>Hazardous Areas</i>	
			Hazardous Area Classification not required within receiving hall and separation room. Hazardous Area Classification not required to MEV and odour control system.	
	E	Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe		
		Natural and artificial ventilation installed to process areas to remove odours. The shredding and processing equipment is enclosed, with extraction ventilation available to the machinery.	Ventilation provided by mechanical extract ventilation (MEV) to external odour control system. This causes slight negative pressure in the process areas.	Review and ensure satisfactory performance of odour control and containment measures (RE3). Use vacuum cleaner as required to ensure surfaces and ledges are

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		Cleaning down of sorting and shredding line carried out periodically. Floor sumps collect wastewater, which is recirculated through process systems.		regularly cleaned to remove dust accumulations (RE4). For releases of a dangerous substance, ensure measures to contain or collect or remove to a safe place are documented, and reviewed periodically (RE5).
		The avoidance of viable ignition sources		
	F	Use of equipment producing naked flames controlled by hot work permit. Hot surfaces may be present as part of unit operations. Hot particles may be present as part of unit operations. Supplementary bonding to all equipment and metal surfaces not always present. Bonding to or across flexible connections / hoses not evident. Electrical circuits not always identified. Not known if shredding and processing equipment placed on a recorded maintenance and service contract to periodically check electrical equipment and mechanical moving parts.	Possible: Naked flames – personal items or from hot work nearby Hot surfaces – from equipment or hot work nearby Mechanical friction – from equipment nearby Faulty electrical equipment – from equipment nearby Sparks – from equipment or hot work nearby Static – from clothing or material transfer	Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2). Verify earth resistance of circuit protective conductors for any electrical equipment (RF3). Ensure electrical circuits adequately identified (RF4). Ensure adequate identification of main isolation point (RF5). Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). Rigorously control / separate flammables from personal sources of ignition (RF8).
	G	The avoidance of adverse conditions which could give rise to harmful physical effects		

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		Asphyxiant and toxic gases present within processing areas. Gas detection and alarm systems installed to process areas. It is assumed that safe systems of work are adhered to when carrying out activities within the mechanical treatment plant. It is assumed these include use of gas detection equipment, appropriate isolation measures, and ultimately, appropriate PPE and emergency measures.	Employee exposure levels should be checked against EH40 , and suitable protection measures implemented if necessary.	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE (RG1). Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2). Ensure gas detection and alarm systems placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RD6).
	Segregation of incompatible dangerous substances			
	H	Corrosive substances stored and used in AD plant, ferric chloride and T.E.A. solution. Loss of containment of corrosive liquids may adversely affect structural integrity of steel racking supports, and columns of buildings.	Separation required under HSG71²⁴ for different classes of materials: 3 metres minimum distance between each of: • Class 3 flammable liquids • Class 4 flammable solids • Class 5 oxidising substances • Class 6 toxic substances • Class 8 corrosive substances If space is an issue, then these distances may be achieved by use of solid fire	Ensure minimum separation distances between different classes of hazardous substances are observed (RH3). Ensure structural steelwork protected from spill of corrosive substances (RH2). Ensure different waste types are effectively managed to separate waste streams (RH4). Ensure hazardous waste disposed using licenced waste carrier with consignment note received (RH1).

²⁴ HSE HSG71 - Chemical Warehousing; The storage of packaged dangerous substances, 4th edition 2009

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			resisting partitions, or relocating into secure fire resisting chests/cabinets. Where waste is collected and stored for disposal, segregation into different types is required.	
Mitigative	I	Reduce number of employees exposed		
		Process area attended frequently by operations staff.	Only authorised personnel to be present in area.	Review and minimise personnel attendance at process plant areas (RI1).
	J	Avoidance of propagation of fires or explosions		
		Due to use of water in the shredding and process areas, material is kept damp. Shredding and process equipment located in partitioned areas. Separator located in separate enclosure in open yard area.	Fire engineering measures for the process areas and adjacent spaces to be reviewed.	No recommendations.
	K	Provision of explosion relief arrangements		
		Not present for these installations.		No recommendations.
	L	Provision of explosion suppression equipment		
		Not present for these installations.		No recommendations.
	M	Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
		Not present for these installations.		No recommendations.

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	N	Provision of suitable personal protective equipment		
		Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when working in process areas.	No recommendations.
	O	Means of raising alarm / shutting down systems from a safe place		
		The shredding and process equipment features emergency shutdown controls. Emergency shutdown controls are operable from remote location in event of fire or explosion. Fire detection, call point and alarm coverage present in areas.	Fire protection measures for the process areas and adjacent spaces to be reviewed.	Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor (RO3).
		Means of escape		
	P	Means of escape readily available from process areas. Emergency lighting installed in areas. Fire-fighting equipment present in areas.	Fire escape measures for the process areas and adjacent spaces to be reviewed.	No recommendations.
Indicative	Q	Signage		
		Appropriate warning signage present at processing areas.	Statutory warning signage of approved type required under COSHH.	No recommendations.
	R	Training		
		Site training records for hazardous substances hazards not seen.	Training for new employees, and visiting contractors, plus periodic refresher training required.	Train staff in combustible dust risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).

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			With appropriately targeted detail for managers, engineers, and operators.	
	S	Provision of information for emergency services		
		Information for emergency services to be provided on site plan.		Process locations to be identified on site emergency response plan (RS2).

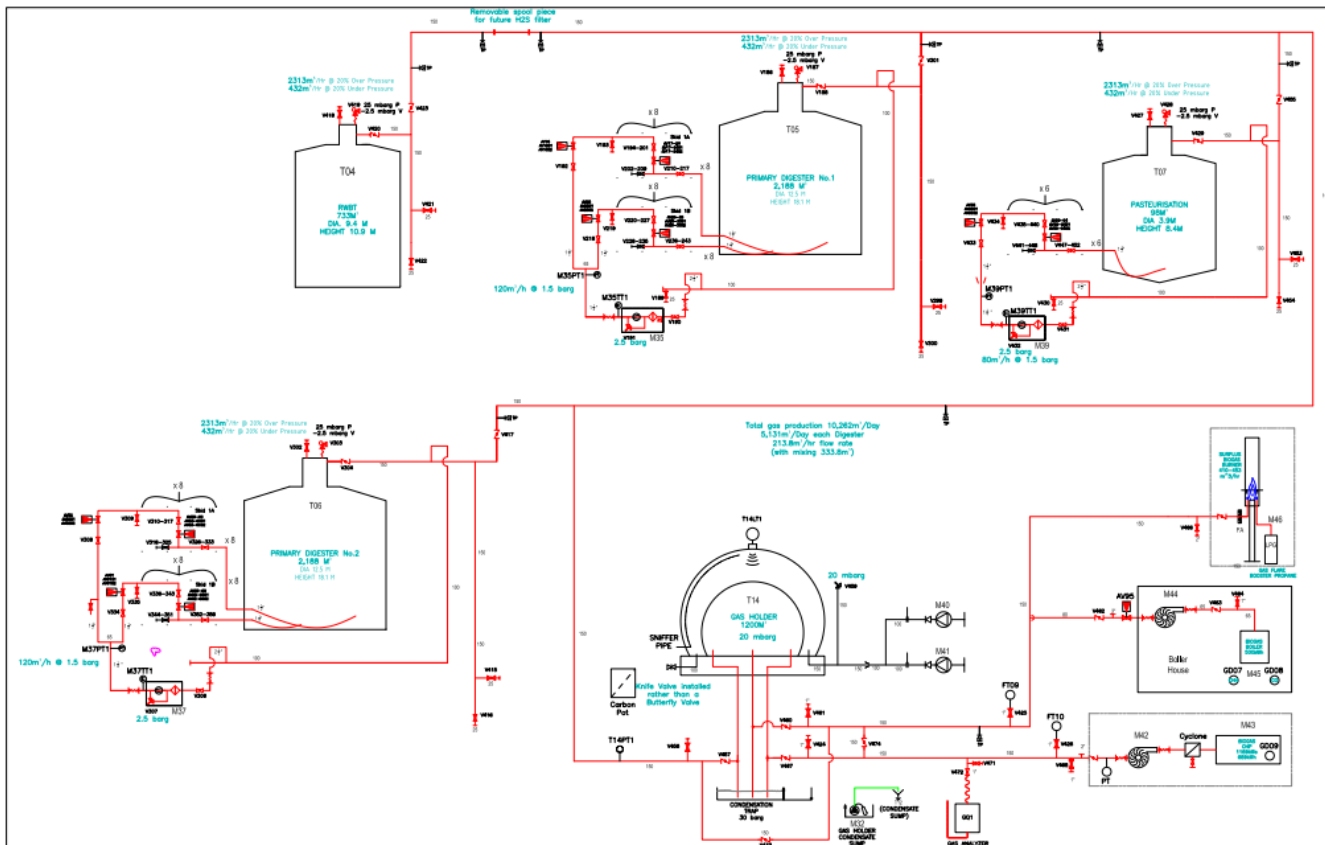
6.3 Anaerobic Digestion plant areas

6.3.1 AD plant

DESCRIPTION and OBSERVATIONS

Equipment and processes

Situated at the north side of the facility is the anaerobic digestion plant, shown below, and pictures [P16, P17, P18, P19, P20, P21, P22, P23, P24, P25, P26, P27, P28, P29, P30, P31, P32, P33, P34, P35, P36, P37, P38, P39, P40, P41, P42, P43, P44]:



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This comprises a raw waste buffer tank (RWBT – T04), primary digesters (D1, D2 – T05, T06), gas mixer system (disconnected), pasteurisation tank (PT – T07), a heat exchanger plant (HX1, HX2, HX4), digestate storage tank (DST – T08), odour control system, and associated equipment, as per the Biogen process description document, and Engineering Line Diagram – BP-ELD-001-SLUDGE.

The gas system ex the RWBT, D1, D2 and PT comprises a common piping network to the gas storage membrane (T14), thence branches to the gas flare (M46), gas boiler (M44), and gas filters and compressors (M42) to the CHP engine container (M43), and associated equipment, as per the Biogen process description document, and Engineering Line Diagram – BP-ELD-003-GAS (not satisfactory).

GSiUR²⁵ requires that:

A gas distribution schematic is produced and available for gas pipework systems of 50mm diameter and above.

Accurate gas distribution schematic to be produced (RS3).

6.3.1 Hazards

Hazards

Flammable, asphyxiating, and toxic gases

Ignition of flammable gas due to loss of containment and introduction of ignition source.

Flammable bio-methane is produced and may accumulate in fixed process and storage tanks, and be released around valves, equipment seals and hatches, or condensate traps and sumps.

Operating pressure stated as between 15 to 25 mbar.

Asphyxiation and toxic gas poisoning possible.

Corrosive substances

Violent chemical reactions of corrosive and other substances if loss of containment and mixing with incompatible substances occurs.

Substances that can corrode metals could cause structural damage reducing integrity of structures if not suitably contained.

²⁵ Gas Safety (Installation and Use) Regulations 1998

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6.3.1 Observations / Recommendations

DSEAR 2002 hierarchy:		Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum		
		Production of bio-methane is the objective for the process, therefore substance types and quantities stored are commensurate with activities. Housekeeping adequately controlled, with minor accumulations on equipment and surfaces.	Where elimination or substitution cannot be made, reduction is required, unless quantities are commensurate with operational requirements.	No recommendations.
	B	Avoidance or minimising the release of a dangerous substance		
		The process units are constructed to process and store digestate. Not all pipework correctly identified, with direction of flow also. Pipework mostly maintained in good condition. The units are enclosed, with equipment featuring high / low deviation sensors, pressure switches or limit switches on relief hatches, and alarms. There are no weir overflow arrangements, or limpet boxes installed. The discharge arrangements are enclosed, but there may be air entrainment and/or gas presence during normal operation.	Integrity of the vessels and pipework systems is paramount, as this is the primary containment. Hazardous Areas are present during normal operation, and in foreseeable abnormal operation reliance is made on safety instrumented systems to shut-down operations in event of loss of containment.	Ensure pipework correctly coloured and/or identified (RB3). Ensure pipework is maintained in good condition (RB14). Review and ensure satisfactory operation of excess high / low condition switches and alarms (RB6). Ensure alarm switches placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB7). Review maintenance and leak prevention for rotating equipment (RB8). Review maintenance and leak prevention for equipment connections and access hatches (RB9).

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		At time of survey, there were no arrangements in place for a specialist contractor to inspect and calibrate the pressure vacuum relief valves (PVRVs) installed to the process tanks. Not known if other process units placed on a recorded maintenance and service contract to periodically check process deviation functions.		Ensure process equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB13).
		Control of release of a dangerous substance at source		
	C	Not all valves identified. The process units are enclosed, with equipment featuring operational controls and positional feedback. Not known if process equipment placed on a recorded maintenance and service contract to periodically check controls and actuators.	Integrity of means of control of releases to be demonstrated.	Ensure isolation valves are identified and operable (RC2). Review and ensure satisfactory operation of control system inputs and outputs and associated control equipment (RC5). Ensure process control equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RC18).
		Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation		
	D	Formation of a potentially explosive atmosphere within the anaerobic digester plant occurs as part of normal operation.	Evolution of methane and other biogas components. Therefore, Hazardous Area Classification is required to the AD process plant.	Seriously consider implementing nitrogen purging to process tanks during start-up and shut-down (RD7). Ensure gas detection and alarm systems placed on critical items register and
			<i>Hazardous Areas</i>	

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		Nitrogen inerting not utilised to tank systems during start-up and shut-down modes. This includes the digestate storage tanks, even though residence time is short, and the digestate has been pasteurised, there is no measurement of gas concentration within the tanks, and therefore it is possible that gases will be evolved and released. This is evidenced by the fact that an odour scrubber and ventilation is required to the tank. Accumulations and releases of flammable gas are credible. External to the process tanks, dilution by natural air flow possible. Personal multi-gas monitors worn by personnel within AD plant process area	Hazardous Area Classification of raw waste buffer tank required, as per Section 7. Hazardous Area Classification of digester tanks required, as per Section 7. Hazardous Area Classification of pasteuriser tank required, as per Section 7. Hazardous Area Classification required to the gas storage membrane, as per Section 7. Hazardous Area Classification of condensate pits required, as per Section 7. Congested plant area requires additional Hazardous Area Classification, as per Section 7. Minimal Hazardous Area Classification of storage tank required, as per Section 7.	recorded service contracts arranged with specialist sub-contractor (RD6).
	Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe			
	E	The process units are constructed to process and store digestate. Pressure relief systems installed to process tank roofs. Odour control system installed to mitigate gas odours from storage tanks.	Integrity of secondary / tertiary containment, or relief lines to be demonstrated.	Review and ensure satisfactory performance of relief systems (RE6). Ensure scrubber arrangements to gas storage membrane are fit for purpose (RE7). For releases of a dangerous substance, ensure measures to contain or collect or

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		Temporary scrubber arrangements appear to be installed to AD gas storage membrane. Flare system installed to burn excess gas. Cleaning down of process systems is carried out periodically. Floor sumps collect wastewater, which is recirculated through process systems.		remove to a safe place are documented, and reviewed periodically (RE5).
		The avoidance of viable ignition sources		
F		Use of equipment producing naked flames to be controlled by hot work permit. Electrical circuits and isolation points nearly always identified. Loose cabling and un-terminated cut cable ends not evident in process areas. Corrosion and damage noted to electrical enclosures in process area. EX rated instrumentation, controls, motors, and actuators within and around the AD plant noted. Only a few non-EX rated instrumentation, controls, motors, and actuators within and around the AD plant noted. Gas holder fans and motors not suitably EX rated. Not all EX equipment installed correctly as per ATEX certificate X conditions.	Possible: Naked flames – personal items or from hot work nearby Hot surfaces – from equipment or hot work nearby Faulty electrical equipment – from equipment nearby Sparks – from equipment or hot work nearby Static – from clothing Lightning – from lightning strike to tall structures Adiabatic compression, shock waves, gas flows – due to flame propagation At least 6 metre separation distance required between gas storage membrane and uncontrolled sources of ignition.	Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2). Verify earth resistance of circuit protective conductors for any electrical equipment (RF3). Ensure electrical circuits adequately identified (RF4). Ensure adequate identification of main isolation points (RF5). Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). Utilise static dissipative footwear and clothing, mats, and floor coatings (RF7).

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	Supplementary earth bonding to all equipment and metal surfaces not present. Static may be present from personnel clothing and footwear. Personal sources of ignition to be prohibited in areas. Lightning protection system to top of all main process tanks partly installed, requires completion. However, no lightning protection system installed around gas holder.		Rigorously control / separate flammables from personal sources of ignition (RF8). Ensure no uncontrolled sources of ignition within separation distance of gas storage membrane (RF19). Where equipment must remain in a Hazardous Area: - Ensure earthing system for EX electrical installation is TN-S, IT or TT, not TN-C, TN-C-S (RF10). - Ensure electrical switches, contactors and relays remove power from both phase and neutral conductors (RF11). - Ensure electrical and mechanical equipment within Hazardous Areas is suitably EX rated (RF12). - Ensure EX equipment is installed as per the X conditions on accompanying ATEX certificates (RF13). - Ensure robust barriers installed to cable and pipework routes between Hazardous Areas and non-Hazardous Areas (RF14). - Ensure electrical installation within area is approved by EX certified electrical supervisor (RF15).
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				Place EX equipment on critical items register and ensure recorded service contracts arranged with specialist sub-contractor (RF16). Ensure lightning protection systems installations completed to process tanks, and new lightning protection system installed around gas holder (RF20). Ensure lightning protection system placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RF21).
		The avoidance of adverse conditions which could give rise to harmful physical effects		
	G	Flammable, asphyxiant, and toxic gases present within AD plant process area. Personal multi-gas monitors worn by personnel within AD plant process area. It is assumed that safe systems of work are adhered to when carrying out activities within the anaerobic digester plant. It is assumed these include use of gas detection equipment, appropriate isolation measures, and ultimately, appropriate PPE and emergency measures.	The immediate health effects of explosions²⁶ include: • Smoke inhalation • Trauma and burns due to the force and heat of the blast • Lacerations / penetrations from flying debris • Worsening of pre-existing medical conditions as a result of acute physiological or psychological stress	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE (RG1). Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2). Ensure gas detection and alarm systems placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RD6).

²⁶ <https://www.gov.uk/government/publications/health-effects-of-explosions-and-fires/health-effects-of-explosions>, PHE 8th July 2005

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	H	Segregation of incompatible dangerous substances		
		Corrosive substances stored and used in AD plant, ferric chloride and T.E.A. solution. Loss of containment of corrosive liquids may adversely affect structural integrity of steel racking supports, and columns of buildings.	Separation required under <i>HSG71</i> ²⁷ for different classes of materials: 3 metres minimum distance between each of: • Class 3 flammable liquids • Class 4 flammable solids • Class 5 oxidising substances • Class 6 toxic substances • Class 8 corrosive substances If space is an issue, then these distances may be achieved by use of solid fire resisting partitions, or relocating into secure fire resisting chests/cabinets. Where waste is collected and stored for disposal, segregation into different types is required.	Ensure minimum separation distances between different classes of hazardous substances are observed (RH3). Ensure structural steelwork protected from spill of corrosive substances (RH2). Ensure different waste types are effectively managed to separate waste streams (RH4). Ensure hazardous waste disposed using licenced waste carrier with consignment note received (RH1).
Mitigative	I	Reduce number of employees exposed		
		AD plant areas attended occasionally during working hours by operations staff or specialist contractor staff.	Only authorised personnel to be present in area.	Review and minimise personnel attendance at effluent treatment plant areas (RI1).
	J	Avoidance of propagation of fires or explosions		

²⁷ HSE HSG71 - Chemical Warehousing; The storage of packaged dangerous substances, 4th edition 2009

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		No combustible material present in area. The AD plant is separated from the rest of the facility, so should be able to contain and avoid propagation of fires or explosions. Fire isolation flame arrestors not installed between gas process or storage tanks storage, flare unit, and gas engines.	Fire engineering measures for the AD plant area and adjacent spaces to be reviewed.	Seriously consider implementing flame arrestors to gas distribution network (RJ8). Ensure measures to avoid propagation of fires and explosions are documented, and reviewed periodically (RJ9).
	K	Provision of explosion relief arrangements		
		Pressure relief valves installed to AD process tanks, set at 25 mbar. Pressure relief hatches installed to AD process tanks, set at 50 mbar (no evidence).		Ensure pressure relief valves on critical items register and checked by specialist sub-contractor at appropriate interval (RK1). Ensure relief hatches on critical items register and checked by specialist sub-contractor at appropriate interval (RK2).
	L	Provision of explosion suppression equipment		
		Not present for these installations.		No recommendations.
	M	Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
		Not present for these installations.		No recommendations.
	N	Provision of suitable personal protective equipment		
		Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when working in process areas.	No recommendations.
	O	Means of raising alarm / shutting down systems from a safe place		

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		Fire detection, call point and alarm coverage present in areas. Emergency shutdown controls present at AD plant equipment. No shutdown schedules available for review, not known if adequately identified. Emergency shutdown controls to be operable from remote location in event of fire or explosion.	Fire protection measures for the AD plant area and adjacent spaces to be reviewed.	Ensure means of shutting down systems from a safe place provided and readily identified (RO2). Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor (RO3).
	P	Means of escape Ready means of escape available from AD plant area. Emergency lighting present in AD plant area. Fire-fighting provision present in AD plant area.	Fire escape measures for the AD plant area and adjacent spaces to be reviewed.	No recommendations.
Indicative		Signage		
	Q	Warning signage not present at all entrances to AD plant. EX signage present at most AD plant areas	Statutory warning signage of approved type required under COSHH and DSEAR.	Ensure appropriate warning signage displayed (RQ1). 

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				Including EX sign (RQ2).
				
	R	Training		
		Site training records for hazardous substances hazards not seen.	Training for new employees, and visiting contractors, plus periodic refresher training required. With appropriately targeted detail for managers, engineers, and operators.	Train staff in flammable gas risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).
S	Provision of information for emergency services			
		Information for emergency services to be provided on site plan.		Hazardous locations to be identified on site emergency response plan (RS2).

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6.3.2 AD flare unit

DESCRIPTION and OBSERVATIONS
Equipment and processes
Associated with the AD plant is a biogas flare. This safely burns off excess biogas in event of a failure within the biogas processing plant, or gas engines [pictures P45, P46, P47]. The flare unit operation is described in the Biogen process description document, and Engineering Line Diagram – BP-ELD-003-GAS (not satisfactory). At time of survey, the flare unit was operational, with no signs of thermal degradation.

6.3.2 Hazards

Hazards
<i>Flammable gas</i>
Ignition of flammable gas due to loss of containment and introduction of ignition source. Low pressure gas production from digestate, the flare unit is rated to 50 mbar and 1,000m³/h. The flare utilises propane gas cylinders for maintaining pilot light to igniter.

6.3.2 Observations / Recommendations

DSEAR 2002 hierarchy:	Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum	
		The flare requires biogas to operate, not applicable.	Where elimination or substitution cannot be made, reduction is required, unless quantities are commensurate with operational requirements.
			No recommendations.

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		Avoidance or minimising the release of a dangerous substance		
		Gas pipework not identified. Flare stack recently replaced after structural failure. New refractory lining installed as part of repair. The unit is open at top and bottom (with air flow dampers), with equipment featuring high / low deviation sensors and alarms. The discharge arrangements are open, but due to combustion, do not result in gas presence during normal operation. It is stated that process unit placed on a recorded maintenance and service contract to periodically check process deviation functions.	Integrity of the vessels and pipework systems is paramount, as this is the primary containment. Hazardous Areas may be present in foreseeable abnormal operation, and reliance is made on safety instrumented systems to shut-down operations in event of loss of containment.	Ensure pipework adequately identified (RB2). Ensure flare unit is maintained in good condition (RB15). Ensure stack refractory lining is maintained in good condition (RB16). Review and ensure satisfactory operation of excess high / low condition switches and alarms (RB6). Ensure alarm switches placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB7). Review maintenance and leak prevention for equipment connections and access hatches (RB9). Ensure process equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB13).
	B	Control of release of a dangerous substance at source		
		Not all valves identified and operable. The flare unit is enclosed, with equipment featuring operational controls and positional feedback. It is stated that process equipment placed on a recorded maintenance and	Integrity of means of control of releases to be demonstrated.	Ensure isolation valves are identified and operable (RC2). Review and ensure satisfactory operation of control system inputs and outputs and associated control equipment (RC5).

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		service contract to periodically check controls and actuators.		Ensure process control equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RC18).
D	Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation			
	Flare unit requires gas concentration above lower explosion limit in order to operate. Formation of a potentially explosive atmosphere within the flare unit occurs as part of normal operation, this is therefore a special area. Accumulations and leakages of flammable gas are credible. The base enclosure of the flare unit features ventilation openings and louvres. Dilution by natural air flow possible.	Potentially explosive atmospheres are foreseeable during normal operation as biogas will be released during start-up and shut-down up the flare pipe, and also in abnormal operations, such as maintenance. Additionally, propane gas cylinder connection may release flammable gas during normal operation.	Ensure measures to prevent formation of an explosive atmosphere are documented, and reviewed periodically (RD8).	
		Hazardous Areas		
		Hazardous Area Classification of flare unit required, as per Section 7.		
	E	Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe		
	Flare system installed to burn excess gas. Plant produced biogas used as pilot gas. Flue arrangement in place.	Integrity of secondary / tertiary containment, or relief lines to be demonstrated.	Review and ensure satisfactory performance of flue systems (RE8). For releases of a dangerous substance, ensure measures to contain or collect or remove to a safe place are documented, and reviewed periodically (RE5).	
F	The avoidance of viable ignition sources			

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	Use of equipment producing naked flames to be controlled by hot work permit. Most of the apparatus associated with the biogas flare is suitably EX rated. The control cabinet is more than 3 metres from the flare equipment and is not EX rated. Local junction boxes show evidence of thermal degradation. Evidence of earthing of steel structures and electrical equipment not present. Identification of electrical circuits not always present. Not all EX equipment installed correctly as per ATEX certificate X conditions. Static may be present from personnel clothing and footwear. Personal sources of ignition to be prohibited in areas.	Possible: Naked flames – personal items or from hot work nearby Hot surfaces – from equipment or hot work nearby Faulty electrical equipment – from equipment nearby Sparks – from equipment or hot work nearby Static – from clothing Adiabatic compression, shock waves, gas flows – due to flame propagation At least 6 metre separation distance required between flare unit and gas storage or process areas. This is achieved.	Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2). Verify earth resistance of circuit protective conductors for any electrical equipment (RF3). Ensure electrical circuits adequately identified (RF4). Ensure adequate identification of main isolation point (RF5). Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). Replace damaged junction boxes with suitably heat resistant items (RF22). Utilise static dissipative footwear and clothing, mats, and floor coatings (RF7). Rigorously control / separate flammables from personal sources of ignition (RF8). Where equipment must remain in a Hazardous Area: Ensure earthing system for EX electrical installation is TN-S, IT or TT, not TN-C, TN-C-S (RF10). Ensure electrical switches, contactors and relays remove power from both phase and neutral conductors (RF11).
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				Ensure electrical and mechanical equipment within Hazardous Areas is suitably EX rated (RF12). Ensure EX equipment is installed as per the X conditions on accompanying ATEX certificates (RF13). Ensure robust barriers installed to cable and pipework routes between Hazardous Areas and non-Hazardous Areas (RF14). Ensure electrical installation within area is approved by EX certified electrical supervisor (RF15). Place EX equipment on critical items register and ensure recorded service contracts arranged with specialist sub-contractor (RF16).
		The avoidance of adverse conditions which could give rise to harmful physical effects		
	G	It is assumed that safe systems of work are adhered to when carrying out activities within the anaerobic digester plant. It is assumed these include use of gas detection equipment, appropriate	The immediate health effects of explosions²⁸ include: • Smoke inhalation • Trauma and burns due to the force and heat of the blast	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE (RG1).

²⁸ <https://www.gov.uk/government/publications/health-effects-of-explosions-and-fires/health-effects-of-explosions>, PHE 8th July 2005

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		isolation measures, and ultimately, appropriate PPE and emergency measures. Personal gas alarms worn by operations staff when working in AD plant.	- Lacerations / penetrations from flying debris - Worsening of pre-existing medical conditions as a result of acute physiological or psychological stress	Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2).
	H	Segregation of incompatible dangerous substances		
		No incompatible substances stored or processed.	Separation required under HSG71 ²⁹ for different classes of materials.	No recommendations.
Mitigative		Reduce number of employees exposed		
	I	AD plant areas attended infrequently during working hours by operations staff or specialist contractor staff. Temporary barrier placed at internal AD plant entrance to flare unit area.	Only authorised personnel to be present in area.	Review and minimise personnel attendance at effluent treatment plant areas (RI1). Implement fixed barrier at internal AD plant entrance to flare unit area (RI2).
		Avoidance of propagation of fires or explosions		
	J	No combustible material present in area. The flare unit is separated from the rest of the facility, and as such avoids propagation of fires or explosions. Fire isolation flame arrestor installed at gas pipework entry to flare unit.	Fire engineering measures for the AD plant area and adjacent spaces to be reviewed.	Ensure measures to avoid propagation of fires and explosions are documented, and reviewed periodically (RJ9).
	K	Provision of explosion relief arrangements		

²⁹ HSE HSG71 - Chemical Warehousing; The storage of packaged dangerous substances, 4th edition 2009

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		Not present for this installation.		No recommendations.
	L	Provision of explosion suppression equipment		
		Not present for this installation.		No recommendations.
	M	Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
		Not present for this installation.		No recommendations.
	N	Provision of suitable personal protective equipment		
		Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when working in process areas.	No recommendations.
	O	Means of raising alarm / shutting down systems from a safe place		
		Fire detection, call point and alarm coverage not present in area. Emergency shutdown controls present at flare equipment. Emergency shutdown controls to be operable from remote location in event of fire or explosion.	Fire protection measures for the AD plant area and adjacent spaces to be reviewed.	Ensure means of raising alarm readily identifiable and operable from a safe place implemented (RO1). Ensure means of shutting down systems from a safe place provided and readily identified (RO2). Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor (RO3).
	P	Means of escape		

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		Ready means of escape available from AD plant area. Emergency lighting not present in AD plant area. Fire-fighting provision present in AD plant area.	Fire escape measures for the AD plant area and adjacent spaces to be reviewed.	Ensure adequate illumination provided for non-daylight hours or emergency working (RP1).
Indicative		Signage		
	Q	Warning signage not adequate at entrances to AD flare unit area.	Statutory warning signage of approved type required under COSHH and DSEAR.	Ensure appropriate warning signage displayed (RQ1). Including EX sign (RQ2).
	R	Training		

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		Site training records for hazardous substances hazards not seen.	Training for new employees, and visiting contractors, plus periodic refresher training required. With appropriately targeted detail for managers, engineers, and operators.	Train staff in flammable gas risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).
	S	Provision of information for emergency services		
		Information for emergency services to be provided on site plan. Gas distribution schematic available, but requires review and update to reflect current AD plant configuration.	GSIUR ³⁰ requires that: A gas distribution schematic is produced and available for gas pipework systems of 50mm diameter and above.	Location to be identified on site emergency response plan (RS2). Updated gas distribution schematic to be produced (RS3).

³⁰ Gas Safety (Installation and Use) Regulations 1998

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6.3.3 AD gas boiler

DESCRIPTION and OBSERVATIONS
Equipment and processes
Associated with the AD plant is a biogas boiler, situated within an enclosure. This consumes biogas and provides hot water to the process plant and facilities area. [pictures P48, P49, P50]. The boiler unit operation is described in the Biogen process description document, and Engineering Line Diagram – BP-ELD-003-GAS. Boiler equipment includes local isolation valves and a pressure booster fan that increases boiler supply gas pressure to 35 mbar, plus burner and associated gas safety train block. The boiler is a Type B flued appliance, drawing combustion air from within the boiler enclosure, with an exhaust flue to exterior. Two ventilation apertures, each of 600mm high x 800mm wide provide fresh air at high and low level. Effective vent cross sectional areas are 0.24m² (0.6 x 0.8 x 50%) each.

6.3.3 Hazards

Hazards
<i>Flammable gas</i>
Ignition of flammable gas due to loss of containment and introduction of ignition source. Gas is distributed to the boiler enclosure at approx. 20 mbar, and pressure is boosted to 35 mbar within the enclosure to the fired appliance.

6.3.3 Observations / Recommendations

DSEAR 2002 hierarchy:	Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum	

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		Gas pipework contains gas at a pressure not exceeding 50 mbar within the enclosure. Gas installation capacity commensurate with facility requirements.	Where elimination or substitution cannot be made, reduction is required, unless quantities commensurate with operational requirements.	No recommendations.
		Avoidance or minimising the release of a dangerous substance		
	B	Gas pipework routes not subject to mechanical impact. Gas pipework is adequately gapped where it enters the enclosure. Gas pipework route not correctly coloured or identified. Pipework system varies between 80 to 50mm diameter, and utilises flanged joints. The pipework is in good order and shows no signs of corrosion. The process unit is enclosed, with equipment featuring high / low deviation sensors and alarms. A gas pressure booster fan is installed within the enclosure; seal type not known. Specialist contractor attends the boiler plant room at 6 monthly intervals to carry out performance checks.	Integrity of the pipework system is paramount, as this is the primary containment. GSIUR ³¹ requires that: Gas pipework is protected from mechanical damage. Gas pipework is correctly identified. Gas pipework is installed appropriately. Gas pipework is free from corrosion. The gas tightness of the installation should be tested in accordance with the appropriate standard.	Ensure pipework adequately identified (RB3). Review and ensure satisfactory operation of excess high / low condition switches and alarms (RB6). Ensure alarm switches placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB7). Review maintenance and leak prevention for rotating equipment (RB8). Review maintenance and leak prevention for equipment connections and access hatches (RB9).

³¹ Gas Safety (Installation and Use) Regulations 1998

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		Statutory written scheme of inspection carried out at 12 monthly intervals.		
		Control of release of a dangerous substance at source		
	C	AIV present where gas supply enters enclosure. However, not of approved fire safe design. Excess heat detector / fusible link not evident above boiler. It is not known if full system (fire/gas detection to AIV operation) tests have been performed. Isolation valves present at pipework to boiler. Valves not identified. The fired appliance burner systems are enclosed, with equipment featuring operational controls and positional feedback. Pipework and appliances periodically inspected by specialist contractor.	Integrity of means of control of releases to be demonstrated. GSIUR requires that: Means of emergency shut-off of the gas supply is identified and readily operable. Where a manual isolation valve is not readily accessible, then due consideration should be made as regards implementing a suitable alternative, such as a fire alarm activated automatic isolation valve (AIV).	Ensure isolation valves are identified and operable (RC2). Implement approved AIV to gas incomer (RC19). Ensure overheat / fusible link implemented above boiler (RC20). Review and ensure satisfactory operation of control system inputs and outputs and associated control equipment (RC5). Ensure emergency gas isolation equipment placed on critical items register and recorded service contract arranged with specialist contractor (RC21).
		Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation		
	D	Methane gas monitor and alarm installed to boiler plant room at high-level. Alarm indication only to remote SCADA, no local alarm indication outside of enclosure.	However, position of the gas detector head requires review so as to ensure it is effective in detecting release of lighter than air gas from likely leakage points around gas pressure booster fan and gas train to burner.	Implement local alarm indication outside of boiler enclosure (RD9). Consider replacing gas pressure booster fan with enclosed / separated seal type (RD10).

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	Within the boiler enclosure the gas supply pipework is flanged. Small leakages of gas are credible. The gas pressure booster fan does not feature a sealed fan shaft. Small leakages of gas are credible. Ventilation louvres installed to walls. Boiler rating approx. 300kW. Free vent area to the boiler is 0.48m². Gas pressure booster fan is not a sealed unit, therefore small leakages of gas are credible around fan shaft seals.	For the boiler, Type B appliances installed in plant rooms / enclosures require adequate ventilation louvres for total installed boiler capacity³²: 1) Low level Duty of the unit is greater than 75% in summer, therefore, per kW, 4cm² plus 2cm², so 6cm² at low level required. This equates to [6 x 300] 0.18m². 2) High level Duty of the unit is greater than 75% in summer, therefore, per kW, 2cm² plus 2cm², so 4cm² at high level required. This equates to [4 x 300] 0.12m². Total ventilation requirement for the boiler is therefore 0.3m². This is achieved for the boiler. Low level ventilation should be within 1 metre of floor level. High level ventilation should be within 15% of ceiling height. This is achieved for the boiler. This provision of ventilation will also assist gas dilution in event of small leakages.	Ensure measures to prevent formation of an explosive atmosphere are documented, and reviewed periodically (RD8).
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³² Essential Gas Safety, CORGI, 3rd Edition, 2017

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		Gas pipework not within 1 metre of three surfaces, location sufficient to provide natural dilution ventilation to flanged connections.		
		Hazardous Areas		
		Hazardous Area Classification of Zone 2NE required around pipework flanges, as per Section 7. Hazardous Area Classification required around gas pressure booster fan, as per Section 7. Hazardous Area Classification not required to low pressure fired appliances covered by other regulations.		
		Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe		
	E	In event of a release of gas, there are no containment measures. Gas may be released via flue to exterior. No signs of corrosion evident to flue. Internally, release of gas via joints to internal adequately ventilated area. Internally, ventilation is of natural type, and reliant on air movements within the rooms / area. Dilution by ambient air flow possible.	Integrity of secondary / tertiary containment, or relief lines to be demonstrated. Flues are installed at fired appliances and operated correctly, and periodically checked for satisfactory performance.	Review and ensure satisfactory performance of flue systems (RE8).
	F	The avoidance of viable ignition sources		

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	Use of equipment producing naked flames to be controlled by hot work permit. Electrical circuits and isolation points not always identified. Gas pressure booster fan not EX rated. Gas detector unit is suitably EX rated. Boiler equipment and general electrical circuits within the room not EX rated. Gas incoming pipework not earth bonded at entry to enclosure. Supplementary earth bonding to all equipment and metal surfaces not present. Static may be present from personnel clothing and footwear. Personal sources of ignition to be prohibited in areas.	Possible: Naked flames – personal items or from hot work nearby Hot surfaces – from equipment or hot work nearby Faulty electrical equipment – from equipment nearby Sparks – from equipment or hot work nearby Static – from clothing According to <i>BS 6891:2015 8.16.2</i> separation of gas installation pipework from other services, 150mm required. This is achieved.	Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2). Verify earth resistance of circuit protective conductors for any electrical equipment (RF3). Ensure electrical circuits adequately identified (RF4). Ensure adequate identification of main isolation points (RF5). Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). Utilise static dissipative footwear and clothing, mats, and floor coatings (RF7). Rigorously control / separate flammables from personal sources of ignition (RF8). Remove or relocate non-EX equipment from Hazardous Areas (RF24). Where equipment must remain in a Hazardous Area: Ensure earthing system for EX electrical installation is TN-S, IT or TT, not TN-C, TN-C-S (RF10). Ensure electrical switches, contactors and relays remove
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				power from both phase and neutral conductors (RF11). Ensure electrical and mechanical equipment within Hazardous Areas is suitably EX rated (RF12). Ensure EX equipment is installed as per the X conditions on accompanying ATEX certificates (RF13). Ensure robust barriers installed to cable and pipework routes between Hazardous Areas and non-Hazardous Areas (RF14). Ensure electrical installation within area is approved by EX certified electrical supervisor (RF15). Place EX equipment on critical items register and ensure recorded service contracts arranged with specialist sub-contractor (RF16).
	The avoidance of adverse conditions which could give rise to harmful physical effects			
	G	Carbon monoxide gas detection not present within boiler enclosure, but this is not a frequently attended plant area.	The immediate health effects of explosions³³ include: Smoke inhalation	Ensure adverse conditions are avoided by use of appropriate detection,

³³ <https://www.gov.uk/government/publications/health-effects-of-explosions-and-fires/health-effects-of-explosions>, PHE 8th July 2005

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		It is assumed that safe systems of work are adhered to when carrying out activities around the gas pipework and gas appliances. It is assumed these include use of gas detection equipment, appropriate isolation measures, and ultimately, appropriate PPE and emergency measures.	- Trauma and burns due to the force and heat of the blast - Lacerations / penetrations from flying debris - Worsening of pre-existing medical conditions as a result of acute physiological or psychological stress	isolation, ventilation and if necessary, PPE (RG1). Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2).
	H	Segregation of incompatible dangerous substances		
		No incompatible dangerous substances present within boiler enclosure.		No recommendations.
Mitigative		Reduce number of employees exposed		
	I	Boiler plant room locked with access to authorised personnel only. Boiler plant room attended occasionally by operations staff.	Only authorised personnel to be present in area.	Review and minimise personnel attendance at gas pipework and gas appliance areas (RI1).
		Avoidance of propagation of fires or explosions		
	J	Combustible materials not present within boiler enclosure. Fire isolation flame arrestors not evident between gas storage, flare unit, gas boiler, and gas engine.	Adequate separation from, or removal of, combustible materials required. Fire engineering measures for the gas installation and adjacent spaces to be reviewed.	Seriously consider implementing flame arrestors to gas distribution network (RJ8). Ensure measures to avoid propagation of fires and explosions are documented, and reviewed periodically (RJ9). Ensure combustible material removed from gas installation areas (RJ10).

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	K	Provision of explosion relief arrangements		
		Not applicable for this installation.		No recommendations.
	L	Provision of explosion suppression equipment		
		Not applicable for this installation.		No recommendations.
	M	Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
		Not applicable for this installation.		No recommendations.
	N	Provision of suitable personal protective equipment		
		Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when working in process areas.	No recommendations.
	O	Means of raising alarm / shutting down systems from a safe place		
		Fire alarm detection and manual call point present in area, but not readily identified. Boiler emergency stop pushbutton not evident at boiler or at entry to boiler enclosure. It is stated that manual call point activates fire alarm and shuts down interlocked AIV. This function is not labelled however.	Fire protection measures for the gas installation and adjacent spaces to be reviewed.	Ensure means of raising alarm readily identifiable and operable from a safe place implemented (RO1). Ensure means of shutting down systems from a safe place provided and readily identified (RO2). Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor (RO3).
	P	Means of escape		

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		Means of escape readily available from gas installation area. Emergency lighting not evident in boiler enclosure. Fire-fighting equipment not evident in boiler enclosure.	Fire escape measures for gas installation and adjacent spaces to be reviewed.	Ensure adequate illumination provided for non-daylight hours or emergency working (RP1). Ensure adequate fire-fighting equipment provided in area (RP2).
Indicative	Q	Signage		
		Warning signage not adequate at entrance to boiler enclosure.		Appropriate warning signage required at gas installation locations (RQ1).  Including EX sign (RQ2). 
	R	Training		
		Site training for flammable gas hazards not known.	Training for new employees, and visiting contractors, plus periodic refresher training required.	Train staff in DSEAR risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).

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			With appropriately targeted detail for managers, engineers, and operators.	
	S	Provision of information for emergency services		
		Information for emergency services to be provided on site plan. Gas distribution schematic available, but requires review and update to reflect current AD plant configuration.	GSIUR ³⁴ requires that: A gas distribution schematic is produced and available for gas pipework systems of 50mm diameter and above.	Location to be identified on site emergency response plan (RS2). Updated gas distribution schematic to be produced (RS3).

³⁴ Gas Safety (Installation and Use) Regulations 1998

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6.3.4 AD CHP gas engine

DESCRIPTION and OBSERVATIONS
Equipment and processes
Associated with the AD plant is a gas-fired CHP engine, associated gas compressor [pictures P51, P52, P53, P54, P55, P56, P57, P58, P59, P60]. This burns the biogas for both electricity, and steam production for heating the AD plant process. The CHP gas engine consists of a 1,200kW main unit and generator. The CHP gas engine operation is described in the Biogen process description document, and Engineering Line Diagram – BP-ELD-003-GAS (not satisfactory).

6.3.4 Hazards

Hazards
<i>Flammable gas</i>
Ignition of flammable gas due to loss of containment and introduction of ignition source. The gas compressor raises the gas pressure from 20 mbar up to the gas engine requirements for an operating pressure stated as between 230 and 240 mbar.

6.3.4 Observations / Recommendations

DSEAR 2002 hierarchy:	Controls / Observations	Discussion	Recommendations
Preventative	A	Reduction of dangerous substances to a minimum	
		Gas pipework contains gas at a pressure not exceeding 250 mbar within the enclosure.	Where elimination or substitution cannot be made, reduction is required, unless quantities are commensurate with operational requirements.
			No recommendations.

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		Gas installation capacity commensurate with facility requirements.		
		Avoidance or minimising the release of a dangerous substance		
	B	Gas pipework route not subject to mechanical impact. Gas pipework sleeved where it enters the CHP enclosure. Gas pipework route not correctly coloured or identified along entirety of route to CHP engines. The pipework is in good order and shows no signs of corrosion. The process units are enclosed, with equipment featuring high / low deviation sensors and alarms. Specialist contractor attends the CHP unit at 6 monthly intervals to carry out performance checks. Statutory written scheme of inspection carried out at 12 monthly intervals.	Integrity of the pipework system is paramount, as this is the primary containment. GSIUR³⁵ requires that: Gas pipework is protected from mechanical damage. Gas pipework is correctly identified. Gas pipework is installed appropriately. Gas pipework is free from corrosion. The gas tightness of the installation should be tested in accordance with the appropriate standard.	Ensure pipework adequately identified (RB3). Review and ensure satisfactory operation of excess high / low condition switches and alarms (RB6). Ensure alarm switches placed on critical items register and recorded service contracts arranged with specialist sub-contractor (RB7). Review maintenance and leak prevention for rotating equipment (RB8). Review maintenance and leak prevention for equipment connections and access hatches (RB9).
		Control of release of a dangerous substance at source		
	C	AIV present where gas supply enters enclosure. It is not known if full system (fire/gas detection to AIV operation) tests have been performed.	Integrity of means of control of releases to be demonstrated.	Review and ensure satisfactory operation of control system inputs and outputs and associated control equipment (RC5).

³⁵ Gas Safety (Installation and Use) Regulations 1998

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		Isolation valves present at pipework to process units. Valves identified. The unit is enclosed, with equipment featuring operational controls and positional feedback. It is stated that process equipment placed on a recorded maintenance and service contract to periodically check controls and actuators.		Ensure emergency gas isolation equipment placed on critical items register and recorded service contract arranged with specialist contractor (RC21).
		Prevention of formation of an explosive atmosphere, including the application of appropriate ventilation		
	D	The gas compressor does not feature a sealed fan shaft. Small leakages of gas are credible. Methane gas monitor and alarm installed to CHP gas engine enclosure at high level. Gas engine requires gas concentration above lower explosion limit in order to operate. Formation of a potentially explosive atmosphere within the gas engines occurs as part of normal operation, this is therefore a special area. Releases of flammable gas are credible. The enclosure of the gas engine features ventilation openings and louvres, plus	Potentially explosive atmospheres are foreseeable during normal operation as biogas will be released during start-up and shut-down, and also in abnormal operations, such as maintenance. Therefore, reliance is made on safety instrumented systems to shut-down process units in event of loss of containment of flammable gas.	Ensure measures to prevent formation of an explosive atmosphere are documented, and reviewed periodically (RD8).
			<i>Hazardous Areas</i>	
			Hazardous Area Classification of gas compressor required, as per Section 7. Hazardous Area Classification of CHP gas engine required, as per Section 7.	

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		artificial ventilation fans. These are interlocked such that ventilation failure shuts down the gas engine. Dilution by artificial and natural air flow possible.	Hazardous Area Classification of Zone 2NE required around pipework flanges, as per Section 7. Hazardous Area Classification of biogas sample point required, as per Section 7.	
E		Ensure any release of a dangerous substance is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe		
		Gas engine installed to burn gas. Flue arrangements in place.	Integrity of secondary / tertiary containment, or relief lines to be demonstrated.	Review and ensure satisfactory performance of flue systems (RE8). Review and ensure satisfactory performance of ventilation systems (RE9).
		The avoidance of viable ignition sources		
F		Use of equipment producing naked flames to be controlled by hot work permit. Electrical circuits and isolation points nearly always identified. Critical and emergency EX rated instrumentation, controls, motors, and actuators within and around the CHP gas engine enclosure noted. Also, non-critical, non-EX rated instrumentation, controls, motors, and actuators within and around the CHP gas engine enclosure noted. Open control cabinet noted within CHP gas engine enclosure.	Possible: Naked flames – personal items or from hot work nearby Hot surfaces – from equipment or hot work nearby Faulty electrical equipment – from equipment nearby Sparks – from equipment or hot work nearby Static – from clothing Adiabatic compression, shock waves, gas flows – due to flame propagation	Ensure adequate earthing of all metal parts and structures (RF1). Where earth connections exist, these should be on a recorded schedule of earth resistance measurement (RF2). Verify earth resistance of circuit protective conductors for any electrical equipment (RF3). Ensure electrical circuits adequately identified (RF4). Ensure adequate identification of main isolation point (RF5). Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6).

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	Not all EX equipment installed correctly as per ATEX certificate X conditions. Supplementary earth bonding to all equipment and metal surfaces not evident. Static may be present from personnel clothing and footwear. Personal sources of ignition to be prohibited in areas.		Utilise static dissipative footwear and clothing, mats, and floor coatings (RF7). Rigorously control / separate flammables from personal sources of ignition (RF8). Ensure non-EX equipment is safely isolated in event of gas alarm activation (RF24). Where equipment must remain in a Hazardous Area: - Ensure earthing system for EX electrical installation is TN-S, IT or TT, not TN-C, TN-C-S (RF10). - Ensure electrical switches, contactors and relays remove power from both phase and neutral conductors (RF11). - Ensure electrical and mechanical equipment within Hazardous Areas is suitably EX rated (RF12). - Ensure EX equipment is installed as per the X conditions on accompanying ATEX certificates (RF13). - Ensure robust barriers installed to cable and pipework routes between Hazardous Areas and non-Hazardous Areas (RF14). - Ensure electrical installation within area is approved by EX
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				certified electrical supervisor (RF15). Place EX equipment on critical items register and ensure recorded service contracts arranged with specialist sub-contractor (RF16).
		The avoidance of adverse conditions which could give rise to harmful physical effects		
	G	It is assumed that safe systems of work are adhered to when carrying out activities within the AD CHP plant area. It is assumed these include use of gas detection equipment, appropriate isolation measures, and ultimately, appropriate PPE and emergency measures. Personal gas alarms worn by operations staff when working in AD plant.	The immediate health effects of explosions³⁶ include: • Smoke inhalation • Trauma and burns due to the force and heat of the blast • Lacerations / penetrations from flying debris • Worsening of pre-existing medical conditions as a result of acute physiological or psychological stress	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE (RG1). Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE (RG2).
		Segregation of incompatible dangerous substances		
	H	No incompatible substances stored or processed.	Separation required under HSG71 ³⁷ for different classes of materials.	No recommendations.
Mitigative	I	Reduce number of employees exposed		

³⁶ <https://www.gov.uk/government/publications/health-effects-of-explosions-and-fires/health-effects-of-explosions>, PHE 8th July 2005

³⁷ HSE HSG71 - Chemical Warehousing; The storage of packaged dangerous substances, 4th edition 2009

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		AD plant areas attended infrequently during working hours by operations staff or specialist contractor staff.	Only authorised personnel to be present in area.	Review and minimise personnel attendance at AD CHP plant areas (R11).
		Avoidance of propagation of fires or explosions		
	J	No combustible material present in area. The gas engine is separated from the rest of the facility, so should be able to contain and avoid propagation of fires or explosions. Fire isolation flame arrestors not evident between gas storage, flare unit, gas boiler, and gas engine.	Fire engineering measures for the AD CHP plant area and adjacent spaces to be reviewed.	Seriously consider implementing flame arrestors to gas distribution network (RJ8). Ensure measures to avoid propagation of fires and explosions are documented, and reviewed periodically (RJ9). Ensure combustible material removed from gas installation areas (RJ10).
		Provision of explosion relief arrangements		
	K	Not present for these installations.		No recommendations.
		Provision of explosion suppression equipment		
	L	Not present for these installations.		No recommendations.
		Provision of plant which is so constructed to withstand the pressure likely to be produced by an explosion		
	M	Not present for these installations.		No recommendations.
		Provision of suitable personal protective equipment		
	N	Site PPE rules and provision of protective equipment to staff is adequate.	Site to ensure suitable PPE worn when working in process areas.	No recommendations.
	O	Means of raising alarm / shutting down systems from a safe place		

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		Fire detection, call point and alarm coverage present in area. Emergency shutdown controls present at AD CHP plant equipment. Emergency shutdown controls to be operable from remote location in event of fire or explosion.	Fire protection measures for the AD CHP plant area and adjacent spaces to be reviewed.	Ensure means of shutting down systems from a safe place provided and readily identified (RO2). Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor (RO3).
	P	Means of escape Ready means of escape available from AD CHP plant area. Emergency lighting present in AD CHP plant area. Fire-fighting provision present in AD CHP plant area.	Fire escape measures for the AD CHP plant area and adjacent spaces to be reviewed.	No recommendations.
Indicative		Signage		
	Q	Warning signage not adequate at entrances to AD CHP plant area.	Statutory warning signage of approved type required under COSHH and DSEAR.	Ensure appropriate warning signage displayed (RQ1). Including EX sign (RQ2).

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	R	Training		
		Site training records for hazardous substances hazards not seen.	Training for new employees, and visiting contractors, plus periodic refresher training required. With appropriately targeted detail for managers, engineers, and operators.	Train staff in flammable gas risks (RR1). Develop or review procedures for safe operation and maintenance (RR2).
	S	Provision of information for emergency services		
		Information for emergency services to be provided on site plan. Gas distribution schematic available, but requires review and update to reflect current AD plant configuration.	GSIUR ³⁸ requires that: A gas distribution schematic is produced and available for gas pipework systems of 50mm diameter and above.	Location to be identified on site emergency response plan (RS2). Updated gas distribution schematic to be produced (RS3).

³⁸ Gas Safety (Installation and Use) Regulations 1998

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6.4 Other arrangements

LOCATION / FACILITY	HAZARD	OBSERVATIONS
6.4.1 Fixed electrical systems	Ignition source	Fixed wiring should be thoroughly inspected on a 3 yearly basis and any faults rectified in line with recommendations made by a competent person (RF6).
6.4.2 Emergency response	Ineffective response	Emergency procedures should be in place, trained and with the training recorded. See later recommendation (RT2).

7.0 HAZARDOUS AREA CLASSIFICATION

7.1 Hazardous Area Classification Overview

Catastrophic Failure:

It is important to note that Hazardous Area Classification only deals with normal operation and reasonably foreseeable abnormal events and does not consider highly improbable ('catastrophic') events. IEC 60079-10-1: 2015 section 1(c) defines 'catastrophic' failures as "beyond the concept of abnormality dealt with in the standard" and 3.7.4 lists "the rupture of a process vessel, or large scale failures of equipment or piping" as examples.

Thus, a 'catastrophic' failure may cause an explosive atmosphere to be present in an area defined by area classification as 'non-hazardous' and such situations are subject to a risk assessment by the operator under other legislation (such as COMAH).

In Hazardous Area Classification methodology, the concept of catastrophic failure may also be taken to include situations such as fully welded piping or where two independent and unlikely events must occur for a potentially explosive atmosphere to be present. An example of this could be the failure of the LEV at the same time as failure of a flange, but includes foreseeable loss of containment (such as a flange leak), or plant emissions (such as from extraction vents). A defined process is used to identify concentrations of flammable gas, vapour, mist, or dust that are likely to occur as a hazardous substance release in foreseeable circumstances.

The process includes consideration of control measures associated with relevant storage and workplace areas, as part of a formal risk assessment, to help in determining the category of equipment and any additional control measures for safe operation in these Hazardous Areas. In terms of liquid fuels, a flammable concentration of vapour only occurs if the fuel reaches the flashpoint temperature, but accepted practice for Hazardous Area Classification is typically applied as a safety margin, if it is foreseeable that the fuel may achieve temperatures close to the flashpoint, or may be released under pressure as a mist.

The inventory of the flammable / combustible substance is also considered and Hazardous Area Classification would typically be relevant where volumes exceed: Gas release – 5 litres indoors; Liquid – 200 litres outdoors or 20 litres indoors; Dust – explosible concentration 1m³– albeit this is dependent on the substance, location, and particular operation. Ventilation is also critical, but in most cases the 'basis of safety' for Hazardous Areas is the prevention and elimination of ignition sources within a defined Zone. If ignition sources are foreseeable within the Zone boundary, it is not appropriate to use Hazardous Area Classification as a basis of safety and an alternative means of ensuring the safety of personnel is required.

See Appendix C for additional information on Hazardous Area Classification.

7.2 Hazardous Area Classification

Relevant codes of practice and publications are referred to, and recorded as necessary in notes after the Zoning tables.

Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
1	Ref 6.1.1 Flammable gas cylinder stores	LPG - Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 within volume of enclosed gas store	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 1 Drawing number 1 applies
2	Ref 6.1.1 Flammable gas cylinder stores	LPG - Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 1 metre radius around gas store to 1.5 metres height above floor	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 1 Drawing number 1 applies

³⁹ LEAC = list of equipment for area classification.

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
3	Ref 6.1.1 Flammable gas cylinder manifold	LPG - Flammable gas	Primary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 1 for 1.5 metre radius around manifold mixing venturi and connection points, due to connection and disconnection, and gas purge cycle.	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 2 Drawing number 2 applies
4	Ref 6.1.1 Flammable gas cylinder manifold	LPG - Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 1 metre radius around gas cylinder manifold to 1.5 metres height above floor	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 2 Drawing number 2 applies
5	Ref 6.1.5 Flammables cabinets	Flammable vapours Flammable liquids	Continuous	Natural ventilation of Low Dilution (VL)	Zone 0 internal to container headspaces	IIB / T3 worst case	Ventilation rate not assured, therefore Hazardous Area continuously, or for long periods (>1,000 hours per annum). See Note 3

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							Drawing number 3 applies
6	Ref 6.1.5 Flammables cabinets	Flammable vapours Flammable liquids	Secondary	Natural ventilation of Low dilution (VL)	Zone 2 internal to storage cabinet	IIB / T3 worst case EPL Gc	Ventilation rate not assured. Opened and part used non leak containing flammables containers. Vapours in explosible concentration for less than 10 hours per annum. Hazardous Area is not likely to occur in normal operation, but if this does occur, will be for a short period only. See Note 3 Drawing number 3 applies
7	Ref 6.1.5 Flammables decanting	Flammable vapours Flammable liquids	Primary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 1 for 0.5 metre radius above and around funnel lip and down to floor	IIB / T3 worst case EPL Gb	Decanting takes place frequently. Vapours at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 4

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							Drawing number 4 applies
8	Ref 6.1.5 Flammable waste bin	Flammable vapours Flammable liquids	Secondary	Natural ventilation of Low dilution (VL)	Zone 2 internal to waste bin	IIB / T3 worst case EPL Gc	Vapours in explosible concentration for less than 10 hours per annum. Hazardous Area is not likely to occur in normal operation, but if this does occur, will be for a short period only. See Note 3 Drawing number 5 applies
9	Ref 6.1.5 Flammable waste skip	Flammable vapours Flammable liquids	Secondary	Natural ventilation of Low dilution (VL)	Zone 2 within skip volume	IIB / T3 worst case EPL Gc	Opened, non-assured seal containers kept within. Vapours at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 3 Drawing number 5 applies
10	Ref 6.3.1	Flammable gas	Secondary	Natural ventilation of Low dilution (VL)	Zone 1 to internal parts and potential sources of ignition within slurry feed system*	IIA / T1 EPL Gb	*If biogas not prevented from flowing to the reception pit or spent

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
	Slurry feed pumping system* Spent digestate pumping system*						digestate pit areas, the sources of ignition must be either: Isolated upon gas detection / process deviation alarm, or Suitably EX rated for the scenario. See Note 5 Drawing number 6 applies
11	Ref 6.3.1 Slurry feed pumping system* Spent digestate pumping system*	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Good availability	Zone 2 rating for external equipment and potential sources of ignition for 1 metre around slurry feed system*	IIA / T1 EPL Gc	*If biogas not prevented from flowing to the reception pit or spent digestate pit areas, the sources of ignition must be either: Isolated upon gas detection / process deviation alarm, or Suitably EX rated for the scenario. See Note 5 Drawing number 6 applies

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
12	Ref 6.3.1 Process tanks area, Storage tanks area, Process sumps Condensate drain and sump	Flammable gas	Primary	Natural ventilation of Low dilution (VL)	Zone 1 within sumps	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 5 Drawing number 7 applies
13	Ref 6.3.1 Process tanks area, Storage tanks area, Process sumps Condensate drain and sump	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Good availability	Zone 2 for 1 metre radius above and around sumps	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 5 Drawing number 7 applies
14	Ref 6.3.1 Raw waste buffer tank, Digester tanks, Pasteuriser tank,	Flammable gas	Primary	Natural ventilation of Low dilution (VL)	Zone 1 within tanks internal volume down to sludge level (Zone 0 during start-up and shut-down without nitrogen purge).	IIA / T1 EPL Gb	During normal operation, the process vessels operate as 'gas flooded', i.e., concentration of gas above UFL. However, due to nature of pressure and vacuum breathing into the tanks, air

Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
	Internal						may be admitted into headspaces, and a potentially explosive gas atmosphere formed. Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 6 Drawing number 8 applies
15	Ref 6.3.1 Raw waste buffer tank, Digester tanks, Pasteuriser tank, PVRV	Flammable gas	Primary	Natural ventilation of Medium dilution (VM), Good availability	Zone 1 for 1 metre radius sphere around pressure relief vacuum valve outlet	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 9 Drawing number 8 applies
16	Ref 6.3.1 Raw waste buffer tank,	Flammable gas	Secondary	Natural ventilation of Medium dilution	Zone 2 for 5.7 metre radius sphere around pressure relief vacuum valve outlet	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation,

Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
	Digester tanks, Pasteuriser tank, PVRV			(VM), Good availability			but if this occurs will persist for short periods only (<10 hours per annum). See Note 9 Drawing number 8 applies
17	Ref 6.3.1 Raw waste buffer tank, Digester tanks, Pasteuriser tank, Tanks top platforms	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Good availability	Zone 2 for 3 metres radius above and around tank top platform and down sides of tank	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 6 Drawing number 8 applies
18	Ref 6.3.1 Common gas pipework	Flammable gas	Primary	Natural ventilation of Low dilution (VL)	Zone 1 within common gas pipework (Zone 0 during start-up and shut-down without nitrogen purge).	IIA / T1 EPL Gb	During normal operation, the gas pipework operates as 'gas flooded', i.e., concentration of gas above UFL. However, due to nature of pressure and vacuum breathing into the tanks, and possibility of air admittance into tanks and entrainment into pipework, a potentially explosive gas atmosphere may be formed.

Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 6 Drawing number 8 applies
19	Ref 6.3.1 AD plant, congested plant area	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Poor availability	Zone 2 for within congested area from floor level up to 1.5 metres above floor level	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 10 Drawing number 8 applies
20	Ref 6.3.1 Flexible gas storage membrane	Flammable gas	Continuous	Natural ventilation of Low dilution (VL)	Zone 1 within flexible gas storage membrane	IIA / T1 EPL Gb	Once process starts accumulating, concentration of gas exceeds UFL during normal operation. However, process interrupts are possible Gas at explosible concentration occasionally

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 17 Drawing number 9 applies
21	Ref 6.3.1 Flexible gas storage membrane	Flammable gas	Primary	Natural ventilation of Medium dilution (VM), Good availability	Zone 1 for 1 metre radius around flexible gas storage membrane	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation See Note 17 Drawing number 9 applies
22	Ref 6.3.1 Flexible gas storage membrane	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Good availability	Zone 2 for 3 metre radius around flexible gas storage membrane	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 17

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							Drawing number 9 applies
23	Ref 6.3.1 Flexible gas storage membrane, Pressure relief valve	Flammable gas	Primary	Natural ventilation of Medium dilution (VM), Good availability	Zone 1 for 1 metre radius around pressure relief valve	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation See Note 17 Drawing number 9 applies
24	Ref 6.3.1 Flexible gas storage membrane, Pressure relief valve	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Good availability	Zone 2 for 3 metre radius around pressure relief valve	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 17 Drawing number 9 applies
25	Ref 6.3.1 Flexible gas storage membrane, Condensate trap	Flammable gas	Primary	Natural ventilation of Low dilution (VL)	Zone 1 within condensate trap	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum).

Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							Therefore, Hazardous Area occasionally in normal operation. See Note 20, 21 Drawing number 10 applies
26	Ref 6.3.1 Flexible gas storage membrane, Condensate trap	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Good availability	Zone 2 for 1 metre radius above and around condensate trap during normal operation	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 20, 21 Drawing number 10 applies
27	Ref 6.3.1 Flexible gas storage membrane, Condensate trap	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Good availability	Zone 2 for 9 metre radius above and around condensate trap in event of loss of water seal	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 20, 21 Drawing number 10 applies

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
28	Ref 6.3.1 Digestate storage tank, Open topped	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 0.5 metre above clay balls in open topped digestate storage tanks	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 18 Drawing number 11 applies
29	Ref 6.3.2 AD plant flare unit	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 0.5 metre radius around base enclosure vents	IIA / T1 EPL Gc	Gas in explosible concentration for less than 10 hours per annum. Hazardous Area is not likely to occur in normal operation, but if this does occur, will be for a short period only. See Note 28 Drawing number 12 applies
30	Ref 6.3.2 AD plant flare unit	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 0.5 metre radius around venturi nozzle	IIA / T1 EPL Gc	Gas in explosible concentration for less than 10 hours per annum. Hazardous Area is not likely to occur in normal operation, but if this does

Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							occur, will be for a short period only. See Note 28 Drawing number 12 applies
31	Ref 6.3.3 Boiler enclosure, pressure booster fan	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 0.5 metres radius above and around pressure booster fan shaft seal	IIA / T1 EPL Gc	Gas in explosible concentration for less than 10 hours per annum. Hazardous Area is not likely to occur in normal operation, but if this does occur, will be for a short period only. See Note 29 Drawing number 13 applies
32	Ref 6.3.3 Boiler enclosure, gas pipework	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 of Negligible Extent (NE) around gas pipework flanges within area	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 30 Drawing number 14 applies

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
33	Ref 6.3.4 CHP gas compressor	Flammable gas	Primary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 1 for 1 metre radius above and around gas compressor equipment	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 23 Drawing number 15 applies
34	Ref 6.3.4 CHP gas compressor	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 2 metre radius above and around gas compressor equipment	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 23 Drawing number 15 applies
35	Ref 6.3.4 CHP gas compressor, PRV vent	Flammable gas	Primary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 1 for 0.5 metre radius around PRV vent outlet	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation.

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							See Note 31 Drawing number 15 applies
36	Ref 6.3.4 CHP gas compressor, PRV vent	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 2 metre radius around PRV vent outlet	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 31 Drawing number 15 applies
37	Ref 6.3.4 CHP enclosure, gas pipework	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 of Negligible Extent (NE) around gas pipework flanges within area	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum). See Note 30 Drawing number 16 applies
38	Ref 6.3.4 CHP enclosure, gas supply	Flammable gas	Secondary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 2 for 0.5 metre radius around gas AIV	IIA / T1 EPL Gc	Gas at explosible concentration not likely to occur in normal operation, but if this occurs will persist for short periods only (<10 hours per annum).

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
							See Note 32 Drawing number 16 applies
39	Ref 6.3.4 CHP enclosure, gas sampling valve	Flammable gas	Primary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 1 for 0.5 metre radius around PRV vent outlet	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 33 Drawing number 16 applies
40	Ref 6.3.4 CHP enclosure, PRV vent	Flammable gas	Primary	Natural ventilation of Medium dilution (VM), Fair availability	Zone 1 for 0.5 metre radius around PRV vent outlet	IIA / T1 EPL Gb	Gas at explosible concentration occasionally in normal operation (10 > 1,000 hours per annum). Therefore, Hazardous Area occasionally in normal operation. See Note 34 Drawing number 16 applies
41	Ref 6.3.4	Flammable gas	Secondary	Natural ventilation of Medium dilution	Zone 2 for 2 metre radius around PRV vent outlet	IIA / T1	Gas at explosible concentration not likely to occur in normal operation,

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Hazardous Zoning Tables (LEAC ³⁹ Sheets)							
Ref.	Facility / Location	Hazardous Substance	Grade of Release	Ventilation Effect / Housekeeping Effect	Assigned Area Classification and Zone Extent	Temp. Class / Gas Group / EPL	Relevant Comments & Drawing Reference
	CHP enclosure, PRV vent			(VM), Fair availability		EPL Gc	but if this occurs will persist for short periods only (<10 hours per annum). See Note 34 Drawing number 16 applies

Assumptions:

- Hazardous substance inventory controlled & no significant vapour clouds evident on-site – limited hazardous release expected in normal operation to initiate incident
- Purpose-designed equipment minimises risk of incident – and potential for harm – assumes effective maintenance in line with supplier recommendations and safe practice
- Safety management and observation of hazardous zones is also assumed – e.g., avoid unprotected electrics, good housekeeping, and hot-work controls by safe system of work (permit to work) etc.
- Any change to current site arrangements may significantly affect HAC assigned at the premises - and may add to overall risk of fire and explosion

7.3 Notes to Support Hazardous Area Classification Tables

Note 1:

BCGA GN13: 2008, Appendix 3, LPG, applies

Calor Code of Guidance for the Storage of Full and Empty LPG Cylinders and Cartridges, Rev 3: 2010 applies

HSE publication CS4 applies

Note 2:

UKLPG Code of Practice 12:2005 Recommendations for Safe Practice in the Design and Operation of LPG Cylinder Filling Plants

A3.2 Area Classification

Note 3:

HSE HSG51 – The storage of flammable liquids in containers

Appendix 3 – Hazardous Area Classification

Energy Institute – Model Code of Safe Practice IP15 4th Edition – Area classification for installations handling flammable fluids

Section D4.3 – Container storage in buildings

Note 4:

HSE HSG140 – The safe use and handling of flammable liquids

Appendix 3 – Hazardous Area Classification

Energy Institute – Model Code of Safe Practice IP15 4th Edition – Area classification for installations handling flammable fluids

Section D4.1 – Container filling

Note 5:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.7.3.2 – Front pits, pump shafts

Front pits, pumping shafts

In enclosed spaces or shafts (e.g., receiving pits, pump shafts) through which liquid manure or substrate flows or in which such substances are stored, the occurrence of a dangerous, potentially explosive atmosphere is to be expected.

These spaces must be designed in such a way that adequate ventilation is guaranteed.

With natural ventilation, the interior is considered Zone 1. The 1 m area around the outer edges of the openings is considered Zone 2.

With technical ventilation (at least 0.5 times the hourly air change), the interior is classified as Zone 2.

In the case of open shafts (e.g., pump shafts for digested sludge), the interior is classified as Zone 2.

In principle, electrical equipment must be used in the receiving pit that corresponds to the defined zone, even if this equipment is normally used below the liquid level (e.g. submersible pumps). If electrical equipment is used that does not correspond to the required zone, anti-surge protection must be provided.

If zone 2 is defined in the receiving pit, a single system is to be provided for zone 1, a redundant diversity system to avoid surfacing. Before surfacing, all poles of the electrical equipment must be isolated from the power supply. In this regard, reference is also made to the relationship between Ex zones, device categories and interlocks in accordance with ÖNORM EN 1127-1.

This applies to technical ventilation (at least 0.5 air changes per hour) inside as Zone 2.”

Note 6:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.7.3.3 – Fermenter

“In normal operation, the gas space of fermenters is classified as Zone 1 because the upper explosion limit is exceeded in normal operation due to the low oxygen content in the biogas. In the event of a fault, air can be sucked in via the vacuum protection. When starting up and after opening or partial emptying, a dangerous explosive atmosphere is to be expected.

In the case of desulfurization by means of air injection, the occurrence of a gas-explosive atmosphere is often to be expected in the immediate vicinity of the injection point, since in normal operation up to a maximum of 6% air is blown in in relation to the gas production and the upper explosion limit is locally undershot as a result. For this reason, 3 m zone 0 must be provided on all sides around the injection point.

NOTE: According to metrological investigations and numerical simulations (Metrological determination of the biogas/air mixing zone in a fermenter, Dipl.-Ing. Dr. Dietmar Schindler on behalf of ARGE Compost and Biogas Austria, 03/25/2011), this potentially explosive area becomes dangerous when blowing in horizontally specified with a maximum of 30 cm. In order to also take into account special operating conditions (e.g. sharp decline in biogas production, other injection directions) a 10-fold safety factor is used.

Agitator drives should always be located outside of the fermenter. However, if submersible mixers are used, they must be suitable for use in Zone 1. They must not be able to be guided through Zone 0. The electrical supply lines must also not run through Zone 0.

Potentially explosive areas must be provided around openings in the gas space to the outside, e.g.

The area of 1 m around the outer edges of the openings is considered zone 1 and the further area up to a distance of 3 m is considered zone 2.

Openings into other rooms should always be avoided. If this is not possible, appropriately dimensioned Ex zones must be defined in each individual case and adequate room ventilation must be ensured.”

Note 7:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.7.3.4 – Solids introduction

“The fill level of the fermenter must be monitored.

If the fill level falls below the minimum level of 1 m above the feed opening, an alarm is triggered and all non-explosion-proof equipment is to be automatically taken out of service within a 3 m radius of the feed hopper.”

Note 8:

Characteristics of biogas

Biogas is a mixture of gases, and for the purposes of this report, the following component concentrations will be used:

CH₄ Methane, typically present as between 50% and 70% of biogas, 60% concentration used for Hazardous Area calculations
 CO₂ Carbon Dioxide, typically present between 50% and 30% of biogas, 40% concentration used for Hazardous Area calculations
 N₂ Nitrogen, typically less than 5%, ignored for Hazardous Area calculations
 H₂ Hydrogen, typically less than 1%, ignored for Hazardous Area calculations
 O₂ Oxygen, typically less than 0.5%, ignored for Hazardous Area calculations
 H₂S Hydrogen Sulphide, typically less than 0.1%, ignored for Hazardous Area calculations

From literature^{40,41}, composite molar mass stated as between 28 and 29 g/mol, 28 g/mol used for Hazardous Area calculations

Table 3. Thermodynamic parameter (molar mass, universal gas constant, mass share, density, heating value, etc.) for different compositions.

In this research work	Results obtained by Vitázek et al. (2010)
Composition: Methane – 53.87 vol%	Composition: Methane – 57% vol
Carbon dioxide – 46.13vol%	Carbon dioxide – 43% vol
Calculated parameters: Molar mass = 28.9362 kg/mol	Calculated parameters: Molar mass = 28.067 kg/mol
Universal gas constant = 287.3208 (J/kg·K)	Universal gas constant = 296.2 (J/kg·K)
Mass share of methane = 0.307719363	Mass share of methane = 0.3257
Mass share of CO ₂ = 0.692280637	Mass share of CO ₂ = 0.67425
Density of biogas = 1.168982 kg/m ³	Density of biogas = 1.187 kg/m ³
Heating value = 21.13 MJ/m ³	Heating value = 19.31 MJ/m ³

⁴⁰ Experimental and numerical study of biogas, methane and carbon dioxide produced by pre-treated wheat straw and pre-digested cow dung, International Journal of Sustainable Engineering, 2019

⁴¹ Thermodynamics of combustion gases from biogas, Journal of Research in Agricultural Engineering, 2016

Density of the biogas mixture, ρ given by: $\rho = p_a \times M / R \times T_a$

Where:

p_a = ambient pressure = 101,325 Pascal	$101,325 \times 28 = 2,837,100$	
M = molar mass = 28 g/mol		$2,837,100 / 2,436,002 = 1.1646 \text{ kg/m}^3 = \rho$
R = universal gas constant = 8,314 J/kmol.K	$8,314 \times 293 = 2,436,002$	
T_a = ambient temperature = 293 °K		

The value of ρ is generally in alignment with the two stated values from literature, so will be used for Hazardous Area calculations

Lower flammability limit (LFL) for the biogas mixture is given by⁴²:

$$LEL_{Biogas} = \left(1 + \frac{x_{CO_2}}{x_{CH_4}} \right) \cdot LEL_{CH_4, CO_2}$$

$$UEL_{Biogas} = \left(1 + \frac{x_{CO_2}}{x_{CH_4}} \right) UEL_{CH_4, CO_2}$$

where:

LEL_{Biogas} , UEL_{Biogas} Lower/Upper explosion (flammability) limit of biogas
 x_{CO_2} , x_{CH_4} fractions of CO_2 and CH_4 respectively
 LEL_{CH_4, CO_2} , UEL_{CH_4, CO_2} methane fraction at the intersection point with the boundary curves

$[1 + (40\% / 60\%)] \times 4.4\%$ (LFL for methane) = 7.33%, used for Hazardous Area calculations

⁴² Explosion protection in biogas and hybrid power plants, Procedia Engineering 84, 2014 International Symposium on Safety Science and Technology

Note 9a:

Calculation of biogas release rates from PVRVs on vessels – referring to BS EN IEC 60079-10-1:2021

i) Firstly, determine if the release is non-choked (subsonic) or choked (sonic):

For y : $(28 \times 296.2) / [(28 \times 296.2) - 8.3145]$

$y = 1.001$

Critical pressure is determined by the following equation:

$$p_c = p_a \left(\frac{\gamma + 1}{2} \right)^{\gamma/(\gamma-1)} \text{ (Pa)} \quad (\text{B.2})$$

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

NOTE For the majority of gases the approximation $p_c \approx 1.89 p_a$ will generally serve the purpose for a quick estimate. Critical pressures are generally low compared with the majority of operating pressures found in common industrial processes. Pressures below the critical pressure are normally found in terminal gas supply lines to fired equipment like e.g. heaters, furnaces, reactors, incinerators, vaporizers, steam generators, boilers and other process equipment. Such pressures can also be found in atmospheric storage tanks with moderate overpressures (usually up to 50 kPag).

Symbol	Descriptor	Quantity	Unit
M	Biogas mixture molar mass	28	g/mol (kg/kmol)
cp	Biogas mixture gas constant	296.2	J/kg.k
R	Universal gas constant	8.3145	J/mol.k
p	Release pressure	103,825 (25 mbar, or 2,500 + 101,325 Pa)	Pa
T	Temperature	293 (273 + 20)	K
y	Ratio of specific heats	1.001	cp/cv
pa	Ambient pressure	101,325	Pa
pc	Critical pressure	167,120	Pa

So, $p_c = 167,120 = 101,325 \times [(1.001+1)/2]^{1.001/(1.001-1)}$

Therefore, as critical pressure (1.67 bar) is above release pressure (1.04 bar), gas release is non-choked (subsonic).

ii) Non-choked release characteristic via 1 x DN250 (318mm) diameter vent (Whessoe) outlet, opening at 25 mbar:

The rate of gas release is given by the following equation in BS EN IEC 60079-10-1:2021

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:

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

Where:

Symbol	Descriptor	Quantity	Unit
y	Ratio of specific heats	1.001	cp/cv
Z	Gas compressibility coefficient	1	factor
R	Universal gas constant	8314.5	J/kmol.k
T	Temperature	293 (273 + 20)	K
M	Molar mass of gas	28	g/mol
p	Release pressure	103,825 (25 mbar, or 2,500 + 101,325 Pa)	Pa
S	Cross section of release opening	0.0794 (π x 318/2 mm ²)	m ²
Cd	Discharge coefficient	0.75 (irregular aperture due to vent mechanism)	factor
Wg	Mass release rate of gas	4.92	kg/s

$$Cd \times S \times p = 6212.554 - \mathbf{A}$$

$$(M / Z \times R \times T) \times (2y / y-1) = 1.1494 \times 10^{-5} \times 1974.6667 = 0.0227$$

$$1 - (pa / p)^{[(y-1) / y]} = 1 - 0.9999^{[0.001]} = 2.9552 \times 10^{-5}$$

$$\text{Equation in square root: } 0.0227 \times 2.9552 \times 10^{-5} = 6.707 \times 10^{-7}$$

$$\sqrt{} = 6.707 \times 10^{-7} = 8.19 \times 10^{-4} - \mathbf{B}$$

$$(pa / p)^{(1/y)} = 0.9713^{(0.999)} = 0.9713 - \mathbf{C}$$

$$Wg = \mathbf{A} \times \mathbf{B} \times \mathbf{C} = 6182.778 \times 8.19 \times 10^{-4} \times 0.9713 = 4.918 \text{ kg/s}$$

Therefore approx. 5kg/s biogas mass release rate

iii) Volumetric flow rate is given by:

$$Q_g = \frac{W_g}{\rho_g} \left(\text{m}^3 / \text{s} \right) \quad (\text{B.5})$$

Where:

where
 $\rho_g = \frac{p_a M}{R T_a}$ is the density of the gas (kg/m³);

Symbol	Descriptor	Quantity	Unit
R	Universal gas constant	8314.5	J/kmol.k
Ta	Temperature	293 (273 + 20)	K
M	Molar mass of gas	28	kg/kmol
pa	atmospheric pressure	101,325	Pa

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ρ _g	Gas density	1.1646	kg/m ³
W _g	Mass release rate of gas	4.918	kg/s
Q _g	Volumetric flow rate	4.223	m ³ /s

$$\rho_g = 1.1646 = [(101325 \times 28) / (8314.5 \times 293)]$$

$$\text{So } Q_g = 4.223 = 4.918 / 1.1646$$

4.223 m³/s biogas mixture volumetric release rate

iv) For Q_c release characteristic:

$$Q_c = \frac{W_g}{\rho_g \times LFL} \quad \text{is the volumetric release characteristic of the source (m}^3\text{/s);}$$

$$Q_c = Q_g / LFL = 4.223 \text{ m}^3\text{/s} / 7.33\% (0.0733) = 57.61 \text{ m}^3\text{/s}$$

Plotting this on Figure D1, gives a Hazardous Area Zone radius as:

IEC 60079-10-1:2020 © IEC 2020

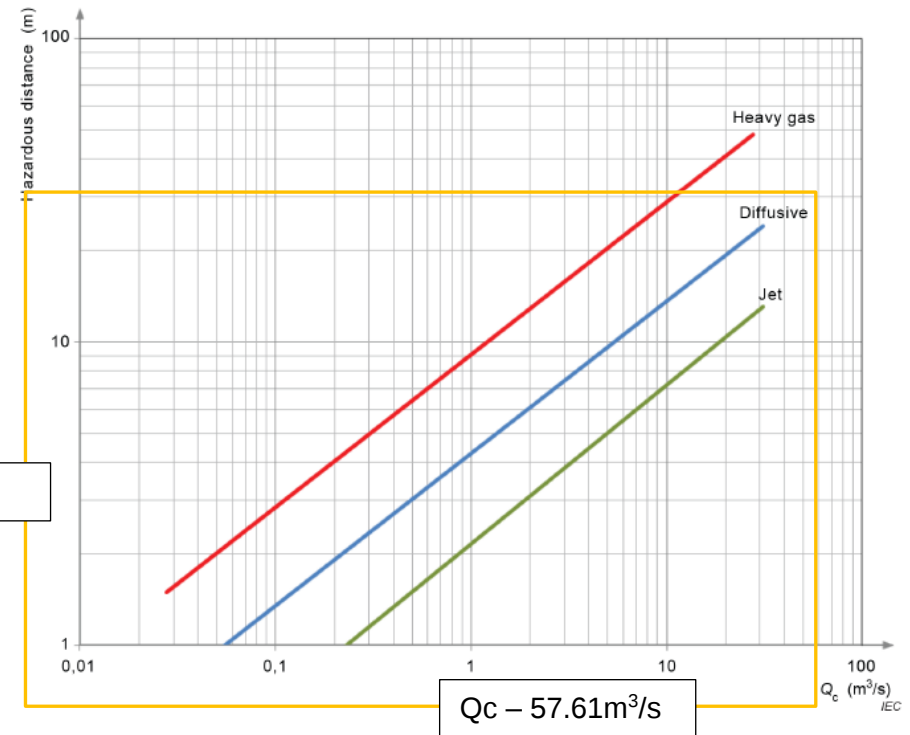
– 71 –

The release type is secondary, with natural ventilation at high level of at least 1 m/s, giving medium dilution, with good availability.

Appropriate line to use is Diffusive - for a diffusive jet release with low velocity (typically a subsonic release), or a jet that loses its momentum due to the geometry of the release or impingement of the jet on nearby surfaces

The buoyancy of the gas is neutral due to components and moisture content, therefore Zone 2 of 32 metre spherical radius around the over-pressure relief vents.

For diffusive gas ~ 32 metre radius



Note 9b:

Calculation of biogas release rates from PVRVs on vessels – using Biogen gas generation information

The Bryn Pica stated maximum gas production rate for the digester with mixing stated as 500 m³/hr, as per the SCADA system scaling.

From BS EN IEC 60079-10-1:2021, Q_g of 500 m³/hr stated, and this will be non-choked, or subsonic, giving 0.139 m³/s

Characteristic of release, Q_c is given by $Q_g / \text{LFL} = 0.139 \text{ m}^3/\text{s} / 7.33\% (0.0733) = 1.896 (1.9) \text{ m}^3/\text{s}$

Plotting the above release rate on Figure D1, gives a Hazardous Area Zone radius as:

The release type is secondary, with natural ventilation at high level of at least 1 m/s, giving medium dilution, with good availability.

Appropriate line to use is Diffusive - for a diffusive jet release with low velocity (typically a subsonic release), or a jet that loses its momentum due to the geometry of the release or impingement of the jet on nearby surfaces

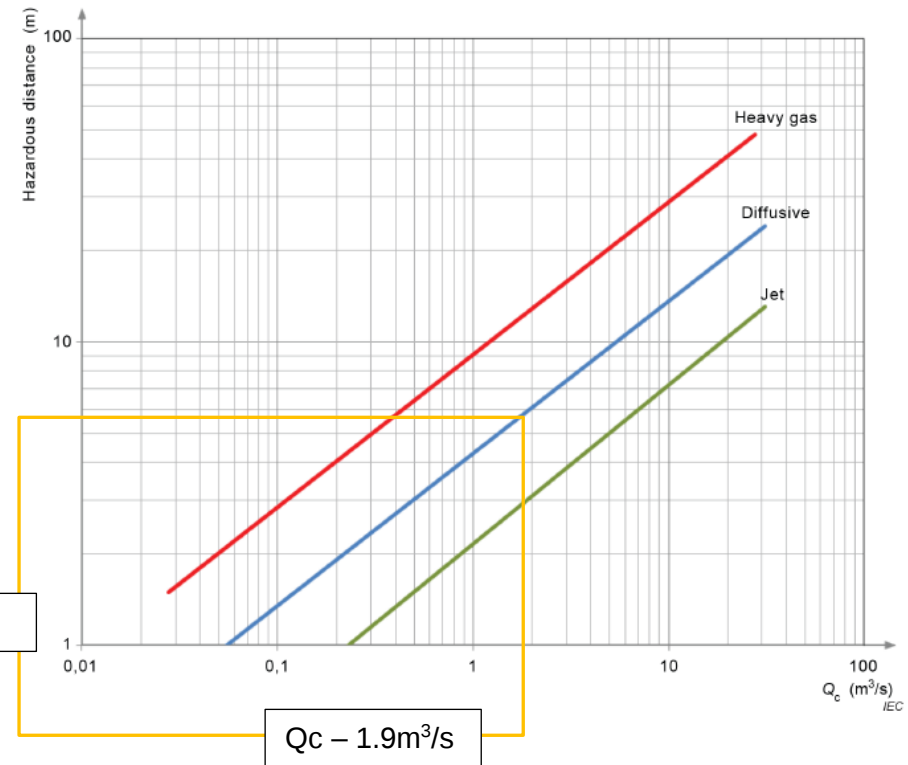
The buoyancy of the gas is neutral due to components and moisture content, therefore Zone 2 of 5.7 metre spherical radius around the over-pressure relief vents.

For diffusive gas ~ 5.7 metre

Q_c – 1.9m³/s

IEC 60079-10-1:2020 © IEC 2020

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Note 9c:

Comparison with other industry codes of practice

1 - IGEM/SR/25⁴³

Primary release - For the immediate volume around the relief valve, the Zone 1 sphere which may be present occasionally during normal operation is stated in Section 5.2.3 as 0.5 metre radius for pressures below 7 bar.

Secondary release - For a non-ideal impeded vent, of 250mm diameter, with mass flow rate of 0.162 kg/s ($500 / 3600 \text{ m}^3/\text{s} \times 1.1646 \text{ kg}/\text{m}^3$), Table 17 states a dispersion (Zone 2) spherical radius of 20 metres.

2 - IE 15⁴⁴

Primary release - For the immediate volume around the relief valve, the Zone 1 sphere which may be present occasionally during normal operation is stated in Section 3.6.2.5 as 1 metre radius.

Secondary release - For a process vent, of 250mm diameter, with volumetric flowrate of approx. $500 \text{ m}^3/\text{h}$, for a Category Gi gas ($19 \text{ g}/\text{mol}$), Table 3.2 estimates spherical Zone 2 radius of 4 metres.

Given the Biogen gas mixture ($28 \text{ g}/\text{mol}$) characteristics do not neatly fit the above, a degree of caution is required in interpreting this estimate.

3 - BMWFW Technische Grundlage für die Beurteilung von Biogasanlagen⁴⁵

Section 7.7.3.7 - Over and under pressure protection

“There is a potentially explosive area around the pressure relief vent outlets to be shown. The area with a radius of 1 m is considered Zone 1 and the other area up to a radius of 3 m as Zone 2.”

⁴³ IGEM/SR/25 - Hazardous area classification of natural gas installations, 2013

⁴⁴ Energy Institute - Model code of safe practice 15 - Area classification for installations handling flammable fluids, 4th Edition 2015

⁴⁵ BMWFW - Technical basis for the assessment of biogas plants, 2017

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Note 9d:

Summary of estimated Hazardous Area extents around tank PVRVs

Biogen HAC drawing	Biogen stated gas production and relief flowrates	BS EN IEC 60079-10-1	EI 15	IGEM SR 25	BMWWF
Zone 1 – 1 metre sphere	Zone 1 -	Zone 1 -	Zone 1 – 1 metre sphere	Zone 1 – 0.5 metre sphere	Zone 1 – 1 metre sphere
Zone 2 – 5 metre hemisphere	Zone 2 – 5.7 metre sphere*	Zone 2 – 32 metre sphere	Zone 2 – Minimum 4 metre sphere	Zone 2 – 20 metre sphere	Zone 2 – 3 metre sphere

Primary releases - It is recommended that Zone 1 is classified around PVRVs as a 1 metre radius sphere.

Secondary releases - Due to stated biogas generation and potential release rate*, it is recommended that Zone 2 is classified around PVRVs as a 5.7 metre radius sphere.

*Subject to process flow verification from Biogen, else Zone 2 to be classified around PVRVs as a 32 metre radius sphere.

Note 9e:

Reverse calculation of release rate from Biogen stated 5 metre Zone 2 radius.

Referring to Figure D1, a 5 metre distance for diffusive gas gives a Qc release characteristic of approx. 1.4 m³/s.

Multiplying by LFL (7.33%) gives a gas volumetric release rate / production rate, Qg of 0.1026 m³/s, or 369.432 m³/h, i.e., below the Biogen stated production rate of up to 500 m³/h.

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Note 10a:

Comparison of stated Hazardous Area radii vs Hazardous release characteristic (Q_{rc}) and gas release rate (Q_g) as per BS EN IEC 60079-10-1:2021 Figure D1:

Hazardous Zone radius	Q _{rc} - Jet characteristic	Q _g after LFL adjustment (x 7.33%)	Q _{rc} - Diffusive characteristic	Q _g after LFL adjustment (x 7.33%)
1 metre	0.21 m ³ /s	0.0154 m ³ /s / 55.44 m ³ /h	0.055 m ³ /s	0.004 m ³ /s / 14.4 m ³ /h
2 metre	0.9 m ³ /s	0.066 m ³ /s / 237.6 m ³ /h	0.22 m ³ /s	0.016 m ³ /s / 57.6 m ³ /h
3 metre	1.9 m ³ /s	0.139 m ³ /s / 500.4 m ³ /h	0.5 m ³ /s	0.037 m ³ /s / 133.2 m ³ /h
4 metre	3.2 m ³ /s	0.235 m ³ /s / 846 m ³ /h	0.9 m ³ /s	0.066 m ³ /s / 237.6 m ³ /h
5 metre	4.9 m ³ /s	0.359 m ³ /s / 1,292.4 m ³ /h	1.4 m ³ /s	0.103 m ³ /s / 370.8 m ³ /h
6 metre	7.1 m ³ /s	0.52 m ³ /s / 1,872 m ³ /h	2 m ³ /s	0.146 m ³ /s / 525.6 m ³ /h
7 metre	9.3 m ³ /s	0.68 m ³ /s / 2,448 m ³ /h	2.7 m ³ /s	0.198 m ³ /s / 712.8 m ³ /h
8 metre	12.3 m ³ /s	0.9 m ³ /s / 3,240 m ³ /h	3.5 m ³ /s	0.257 m ³ /s / 925.2 m ³ /h
9 metre	15.3 m ³ /s	1.1 m ³ /s / 3,960 m ³ /h	4.5 m ³ /s	0.33 m ³ /s / 1,188 m ³ /h

For a system pressure of 25 mbar, aperture sizes to give releases above are approximately:

Hazardous Zone radius	Q _{rc} - Diffusive characteristic	Aperture area	Circular aperture diameter (Cd 0.75 to 0.99)
1 metre	0.055 m ³ /s	63 to 82 mm ²	9 to 10 mm
2 metre	0.22 m ³ /s	251 to 331 mm ²	18 to 20 mm
3 metre	0.5 m ³ /s	568 to 751 mm ²	27 to 31 mm
4 metre	0.9 m ³ /s	1,023 to 1,351 mm ²	36 to 41 mm
5 metre	1.4 m ³ /s	1,592 to 2,102 mm ²	45 to 52 mm
6 metre	2 m ³ /s	2,270 to 3,002 mm ²	54 to 62 mm

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7 metre	2.7 m ³ /s	3,070 to 4,052 mm ²	62 to 72 mm
8 metre	3.5 m ³ /s	3,979 to 5,253 mm ²	71 to 82 mm
9 metre	4.5 m ³ /s	5,116 to 6,753 mm ²	80 to 93 mm

For general small aperture (up to 10mm diameter for a circular hole) biogas loss of containment scenarios, a release rate of approx. 0.004m³/s, giving a Hazardous Zone radius of 1 metre, is credible.

For general mid-size aperture (up to 30mm diameter for a circular hole) biogas loss of containment scenarios, a release rate of approx. 0.37m³/s, giving a Hazardous Zone radius of 3 metres, is credible.

Note 10b:

For outdoors congested plant areas, operating under adverse conditions (corrosive atmosphere and moving machinery elements), where dilution air flow availability may be poor, IGEM/SR/25 states a discrete zoning distance of up to 1.5 metres at Zone 2.

Note 11:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.2.1 – Over and under pressure protection

Every container in which biogas is produced, processed or stored (e.g., fermenter, post-fermenter, gas storage tank, fermentation residue store) must be equipped with at least one overpressure and one under pressure safety device. In the case of containers that are only used to store biogas and for which the manufacturer certifies that no dangerous conditions can occur due to negative pressure, there is no need for a negative pressure safety device.

Hydraulic over- and under pressure safety devices must be designed in such a way that the sealing liquid is prevented from draining when the safety function is activated. If there is a risk of freezing, only liquids that are completely miscible with water and that can withstand the temperatures to be expected may be used as sealing liquids cannot freeze. The fluid levels of hydraulic over- and under-pressure protection must be visually controllable.

The relief capacity of the overpressure protection must correspond to the maximum gas yield of the biogas plant.

There must not be any shut-off devices in the supply lines to the over- and under-pressure safety devices. With the exception of the outlet pieces of the relief lines, over- and under-pressure safety devices must be designed to be technically leak-proof in the long term.

The outlet pieces of discharge lines are to be arranged outdoors in such a way that any escaping gas cannot get into buildings or shafts. The opening must be at least 3.0 m above the adjacent ground level and secured against the ingress of foreign bodies and rainwater. In addition, the outlet opening must be located at least 1.0 m above the roof surface or the upper edge of the container and be at least 5.0 m away horizontally from buildings or traffic routes that do not belong to the biogas plant.

It must be ensured that the gas outlet and the outlet for overpressure and vacuum protection of the container cannot be blocked by substrate or foam formation. This is to be ensured by arranging these outlets at the highest point of the tank, if possible. If this cannot be guaranteed (e.g., fermenter with attached membrane gas storage), it must be ensured that a safety distance of at least 1.0 m is maintained between the outlets and the highest substrate level. This safety distance must be monitored, whereby the monitoring must be independent of the fill level control.

The redundant gas-consuming device (e.g., gas flare, backup boiler) must already burn off excess gas before the overpressure protection trips (controlled by the filling level of the gas storage tank or the overpressure of the gas system; the response pressure of the redundant gas-consuming device must be below the response pressure of the overpressure protection).

Note 12:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.2.2 – Digesters and Gas Storage

“In the case of gas storage tanks that are located between the fermenter and the gas flare or gas-consuming devices (main circuit, which is the norm), a gas storage bypass line must be provided. This bypass line is intended to ensure further gas utilization in the event of a temporary shutdown of the gas storage facility, e.g., for maintenance work.

In the same way, fermenters arranged in series in the direction of gas flow must also be equipped with bypass lines to maintain gas utilization.

The bypass lines at the gas storage facility and at the fermenter are to be equipped with shut-off devices that can be actuated manually.

Flushing connections between the tank and the first shut-off valve must be provided for degassing storage tanks and fermenters. At least one measuring point per container is to be provided for the use of mobile gas warning devices.

The filling level of the gas storage tank is to be measured. Irrespective of this measurement, the fill level of the gas storage tank must be visually controllable (e.g., sight glass, draw-wire indicator).

Measures to avoid floating layers

In systems in which long and fine-fibrous raw materials, such as grass or green waste, are used, gas-tight floating layers can form in a very short time (within 1 hour) if the agitator fails. These floating layers can prevent gas discharge and mechanically destroy the container despite the overpressure protection. Such raw materials have to be crushed before being introduced into the fermenter. In addition, in this case, at least two independent agitators must be present in fermenters with the introduction of solids, of which at least one must be connected to the safety power supply.”

Note 13:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.2.3.4 – Shut-off devices,

“Shut-off devices must be installed in the gas pipelines on the gas-carrying containers and on gas storage tanks as well as before entry into the building.

These shut-off devices are to be arranged outdoors. They must be manually operable and easily accessible.

The shut-off devices and the "OPEN" and "CLOSED" positions must be clearly marked.

No shut-off valves may be installed between the container or gas storage tank and the associated over- and under-pressure protection.

To safely isolate the tank or the gas storage tank from the gas system (e.g., for the pressure test), a second shut-off device must be installed a short distance after the first shut-off device so that the gap between the two

Shut-off devices located section of line can be vented, removed or closed with a blind washer.

See Section 7.2.8 (Gas appliances) for further provisions on shut-off devices.”

Note 14:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.2.5 – Gas conditioning

Desulfurization by adding air to the gas spaces of fermentation tanks:

The air dosing pump must be set so that it delivers a maximum volume flow of 6% of the biogas volume generated in the same period. A non-return device is required in the supply line to the gas compartment. The line between the non-return valve and the gas compartment is to be designed in accordance with 7.2.3.3.

Desulfurization with ferrous masses or activated carbon:

If biogas is desulfurized using masses containing iron or activated carbon, there is a risk of self-heating during regeneration. To avoid this, the manufacturer's safety instructions must be observed.

With regard to the substances used in desulfurization with aqueous salt solutions, the manufacturer's safety instructions for storage and handling must be observed.

Gas drying:

Wastewater produced during the drying of the gas must be fed back into the process or disposed of properly.

Note 15:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.2.6 – Gas Analysis

Gas analysis lines are to be designed according to point 7.2.3.3.

The opening of the discharge line must be led outside to a place where no hazards are to be expected.

The analysis device is to be set up according to the manufacturer's instructions and selected in such a way that no danger can arise. The installation room must be equipped with ventilation in accordance with 7.3.8.

Note 16:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.2.7 – Flame arrester

A flame arrester must be installed in front of each gas appliance. It is to be situated in such a way that it can be easily cleaned. Flame arresters that are not an integral part of a machine or gas appliance must comply with ÖNORM EN ISO 16852.

Note 17:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.7.3.5 – Gas storage

Outdoor gas storage

”The interior of the gas holder (gas space) is classified as Zone 1.

If air is blown in (desulphurisation), the area up to 3 m around the point of injection is considered zone 0 (see "Fermenter").

When installing single-walled membrane gas storage tanks outdoors is one area from 1 m around the membrane as Zone 1 and the area up to a distance of 3 m on all sides around the membrane as Zone 2.

In the case of double membrane gas storage tanks with supporting air blower, the area between the inner and outer membrane as zone 1. Around each opening of the outer membrane (e.g. pressure control valve) applies to Zone 1 up to a distance of 1 m and an area up to 3 m as Zone 2. For the area around the outer membrane up to Zone 2 applies to a distance of 2 m.

In the case of single-walled membrane gas accumulators, which are equipped with an additional membrane as weather protection, the area between the inside and outside applies membrane as Zone 1. Around each opening in the outer membrane (e.g. ventilation openings) Zone 1 applies up to a distance of 1 m and an area up to 3 m as Zone 2. For the area around the outer membrane up to a distance of 2 m applies Zone 2. The area between the membrane gas storage tank and the membrane for the weather protection is natural with constantly effective ventilation openings providing ventilation. In any case, there is a ventilation opening at the highest point to be provided.

In the case of gas tanks, which are partly made of concrete and are only formed by membranes in the upper part, the explosion zones are to be calculated on all sides from the membrane surface.”

Note 18:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.7.3.6 – Fermentation residue storage

“Gas-tight covered storage for fermentation residues should always be treated like fermenters.

Particular care must be taken to ensure that when fermentation residue is removed, no negative pressure can develop in the fermentation residue store and no removal takes place from the gas area.”

Note 19:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.7.3.7 – Over and under pressure fuses

“A hazardous area must be identified around the mouth of the discharge lines. The area with a radius of 1 m is considered zone 1 and the further area up to a radius of 3 m is considered zone 2.”

Note 20:

Technische Grundlage für die Beurteilung von Biogasanlagen – BMWFW, 2017

7.7.3.8 – Condensate separator

“In the case of drainage taps or open water seals, the formation of a dangerous, potentially explosive atmosphere is to be expected as a result of puncture or drying out of the water seals or as a result of incorrect operation.

When using water seals, the liquid seal must be set in such a way that it is ensured that the overpressure protection in the gas system responds earlier than this water seal. This is ensured when the height of the liquid column is 5 times higher than with the overpressure protection.

If condensate separators are arranged in an underground shaft, the shafts must be vented, see Chapter 7.2.4

In the case of natural ventilation, the inside of the condensate duct is considered zone 1, and the area of 1 m around the mouth of the vent line is considered zone 2.

With permanently effective mechanical ventilation, the interior of the condensate shaft is classified as Zone 2.

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If closed drainage systems are designed as sluices with double shut-off valves or automatic drainage systems, the interior of the shaft with natural ventilation is classified as Zone 2.

Around the mouth of separator vent lines outdoors, 1 m is considered Zone 1 and an additional 2 m is considered Zone 2.

When installing closed drainage systems as sluices with double shut-off valves or automatic drainage systems in above-ground rooms with at least natural ventilation near the floor and ceiling, there are no explosion zones in the installation room.”

Note 21:

Gas holder condensate trap

The maximum gas flow rate to the gas holder and condensate trap is stated as 500 m³/hr, as per the Biogen SCADA system scaling.

From BS EN IEC 60079-10-1:2021, Q_g of 500 m³/hr stated, and this will be non-choked, or subsonic, giving 0.139 m³/s

Characteristic of release, Q_c is given by $Q_g / \text{LFL} = 0.139 \text{ m}^3/\text{s} / 7.33\% (0.0733) = 1.896 (1.9) \text{ m}^3/\text{s}$

Plotting the above release rate on Figure D1, gives a Hazardous Area Zone radius as:

The release type is secondary, with natural ventilation at low level of at least 0.3 m/s, giving medium dilution, with good availability.

Appropriate line to use is Diffusive - for a diffusive jet release with low velocity (typically a subsonic release), or a jet that loses its momentum due to the geometry of the release or impingement of the jet on nearby surfaces

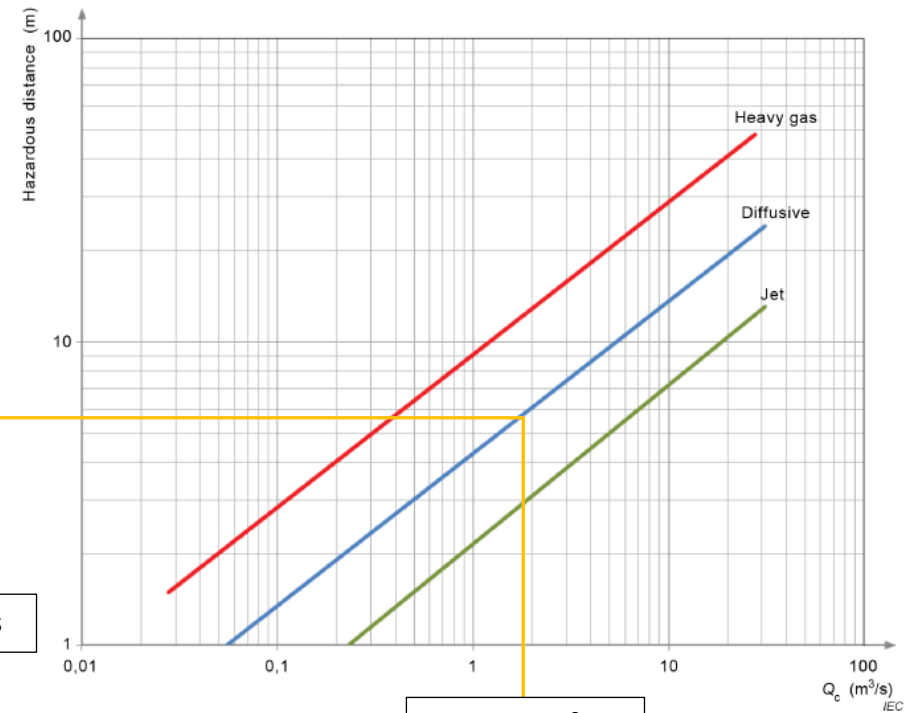
The buoyancy of the gas is neutral due to components and moisture content, therefore Zone 2 of approx. 5.7 metre hemi-spherical radius around the condensate trap.

IEC 60079-10-1:2020 © IEC 2020

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For diffusive gas ~ 5.7 metre radius

$Q_c = 1.9 \text{ m}^3/\text{s}$



Note 22:

7.7.3.9 – Technically sealed biogas-carrying plant components

“Outside of biogas-carrying plant parts (e.g., gas lines, fittings, measuring devices), which are considered technically tight, no potentially explosive areas have to be provided outdoors or in rooms with natural ventilation. Enclosed rooms without ventilation with such system parts are classified as zone 2.

Exception: Rooms with welded metallic pipes without other installations are considered zone-free even without ventilation.”

Note 23:

7.7.3.10 – Compressor for biogas

“The enclosure in which compressors are set up must be equipped with constantly effective cross-ventilation to the outside.

In the case of compressors that are permanently technically sealed due to their design (e.g., compressors with magnetic coupling), the designation of Ex zones can be dispensed with.

For compressors that are not permanently classified as technically tight, the area of 1 m around the compressor is zone 1, the rest of the enclosure is zone 2.

If there is a gas warning system, which automatically activates technical ventilation of the room at 20% LEL with at least 5 air changes per hour, the entire installation room is considered zone 2. The gas detector head is to be located directly at the compressor.

If the gas supply is also automatically shut off outside the installation room when 40% LEL is reached, it is not necessary to designate Ex zones in the installation room.

For compressors that are not permanently classified as technically tight and that are installed outdoors in a well-ventilated location, the area of 2 m around the compressor is considered Zone 2.

Inside, a hazardous, potentially explosive atmosphere can be expected to form if air is sucked in (e.g., via the vacuum safety device). The interior of the compressors is therefore considered Zone 1. Therefore, fans and compressors must meet one of the following requirements:

- Execution in explosion-proof construction (6 bar) and arrangement of flame-proof fittings in the supply and discharge lines (see GUV-I 8594, collection of examples of explosion protection measures when working in the area of waste water systems) or
- Proof of suitability through manufacturer's declaration for the delivery of biogas and zone 1 inside.”

Note 24:

7.7.3.11 – Gas engines and gas engine installation rooms

“The rooms where gas engines are installed must be equipped with constantly effective cross-ventilation to the outside.

The free minimum cross-section "A" per opening of the supply and exhaust air opening results from the equation with natural ventilation:

$$A = 10P + 175$$

A ... free cross-section in cm²

P ... maximum electrical power output from the generator in kW

However, the free cross-section of the supply air opening must be at least 1% in relation to the floor area of the installation room, but at least 400 cm².

The free cross-section of the exhaust air opening must also be at least 1% in relation to the floor area of the installation room, but at least 400 cm². Alternatively, permanent mechanical ventilation of the room with at least 2 air changes per hour is possible. If there is no natural ventilation, the function of the mechanical ventilation must be monitored (flow monitor, differential pressure monitor or similar) and the gas supply must be switched off automatically if the ventilation outside the installation room fails.

In principle, a gas warning system with triggering of safety functions must be provided in the CHP installation room, unless the installation conditions of the manufacturer of the CHP plant state otherwise.

The installation of equipment or systems in the CHP installation room, which would result in the definition of explosion protection zones in the room (e.g., compressors), is not permitted without additional technical measures (gas warning system with automatic triggering of safety functions).

If a lower threshold value (20% LEL) is exceeded, the gas warning system must trigger an alarm and put a mechanical vent into operation. The exhaust air fan must be suitable for zone 1 and ensure 5 air changes per hour. If an upper threshold value (40% LEL) is exceeded, the gas supply to the gas engine installation room must be automatically shut off by activating a shut-off device located outside this room; mechanical venting must continue. The shut-off device must be closed automatically in the event of a power failure. At least two gas detectors (near the gas engine near the floor and ceiling) must be installed.

If the odorous air from the closed reception pit is extracted via the CHP, technical measures must be taken to ensure that there is no backfire in the reception pit.”

Note 25:

7.7.3.12 – Gas warning systems

“Gas warning systems are used to detect potentially explosive atmospheres or to identify the risk of suffocation and poisoning.

Gas warning systems for detecting potentially explosive atmospheres (biogas) must be calibrated to detect methane. Due to the composition of the biogas, the gas detector heads must always be installed close to the point of origin near the ceiling and near the floor.

It must be ensured that the gas warning system remains active even in the event of a gas alarm. This requires that the gas detector heads are suitable for use in an explosive atmosphere (zone suitability for zone 1).

If the general power supply fails, gas warning systems must continue to function until a safe operating state is reached.

The response of the gas warning system is to be signalled outside the protected area (optically, acoustically) and the associated safety functions are to be triggered automatically. In any case, it must be forwarded to a permanently manned position or to responsible persons who can be contacted at all times.

The calibration and maintenance of the gas warning system, in particular the gas detector heads, must be carried out according to the manufacturer's instructions.

Gas warning systems are to be provided depending on the system constellation.”

Note 26:

7.7.3.13 – Requirements for safety devices to ensure security primary explosion protection

“The gas warning devices described above, from which technical measures (ventilation, shutting off the gas supply) are derived when alarm thresholds are reached, are a combination of safety devices (safety system, SIS) that prevent the occurrence of explosive atmospheres in the gas engine installation or compressor room target.

The aim is to be able to classify the respective room as “zone-free”. This is a technical necessity due to the presence of the permanent sources of ignition in a gas engine installation room (hot surfaces).

In this case, the SIS consists of gas sensor(s), an evaluation device, the ventilation control, the ventilation and the shutdown of the gas supply. The SIS must meet certain quality requirements.

In terms of OVE-R 24 "Requirements for safety devices to ensure primary explosion protection", the following specifications apply:

When using an SIS with qualification SIL 2 or using a control that is also safe when two independent faults occur, a zone classification can be made in the installation room of the compressor and the entire installation room is considered zone-free.

Annotation:

Since this is a two-stage system (1st stage: ventilation activation, 2nd stage: shutting off the gas supply), the same safety level is alternatively achieved in this case if the SIS is replaced by two independent SIS in the SIL 1 qualification (per stage) is realized.”

Note 27:

7.3.8 – Room ventilation

“Rooms in which plant components carrying biogas, with the exception of welded ones metallic pipelines, or rooms in which there is gas (biogas, CO₂, H₂S, etc.), are directly into the with air inlet and outlet openings free to equip, so that an effective ventilation of the entire room is achieved. In section 7.7.3. “Special systems” are also special requirements specified for certain systems and rooms.

An even distribution of several ventilation openings is important for large to strive for spaces. These ventilation openings must be directly in the floor and be arranged near the ceiling. If there is only one inlet and one outlet air opening, these are there if possible, to be arranged diagonally across the room.

Ventilation openings are provided with weather protection, intrusion protection (e.g. birds, small animals, dirt) and protection against UV radiation for gas storage membrane. When dimensioning the required Ventilation cross-section is the structural cross-section reduction through weather protection structures and grids must be taken into account.

Ventilation openings must not be blocked or blocked. Possibly are additional safety measures against unintentional locking, e.g., cover the ventilation opening with a slack gas storage membrane.

Inlet and exhaust air openings must not open into Ex zones in other parts of the system.

The free ventilation cross-sections must each be at least 400 cm², but in total at least 1% in relation to the floor area.

If sufficient natural ventilation is not possible, then mechanical ventilation is required ventilation system required.

Mechanical ventilation systems are available either as supply and exhaust air systems or as to implement mechanical exhaust air systems with natural air supply.

If rooms with gas-carrying system parts are only mechanically ventilated, so the ventilation system must be operated continuously. The function of the The ventilation system must be monitored (flow monitor or similar). If the suitable emergency functions are to be initiated in the ventilation system (alarm, external shutdown the biogas supply etc.). the ventilation systems must have a minimum of 2 times ensure air changes per hour.”

Note 28:

Flare unit

IGEM-SR-25

Table 2 - Outdoors congested location, normal operation, below 0.1 bar – 0.5 metre radius Zone 2 around louvres, with a Zone 2 for 0.5m radius around the venturi nozzle.

Note 29:

Gas pressure booster fan

IGEM-SR-25 – 5.2.6 gas boosters

Table 2 - Indoors adequately ventilated location, normal operation, below 0.1 bar – 0.5 metre radius Zone 2 around unsealed fan shaft

Note 30:

Connections may not be all durably technically tight (DTT) as per BS EN1127:2011: Annex B guidance.

In accordance with The HSE Research Report into Hazardous Area Classification for natural gas lines (RR630), it is stated that a Zone 2 NE around natural gas flanges is applicable if one of the following conditions is met:

The volume of the flammable cloud produced in the event of a leak, V_z , is less than 1% of the enclosure volume, V_o ;

Or the concentration C_{out} from the leak source is < 10% of the LEL.

If the above conditions are not met, then the Zone 2 area will extend for a radius of 1m around the equipment and flanges

Note 31:

CHP gas compressor PRV

IGEM-SR-25

As inlet pressure is less than 7 bar, a Zone 1 sphere of 0.5m radius exists around the vent outlet.

The vent is less than 2 metres above ground, appx. 25mm diameter, has no drain holes externally and is of non-ideal type.

Diameter is 25mm, design capacity is less than 0.002kg/s, with flow rate of less than 10m³/h, and relief stream capacity up to 500m³/h.

Therefore, from Table 27, spherical dispersion radius (X) is 2 metres around the vent outlet.

Note 32:

CHP enclosure external automatic isolation valve (AIV)

IGEM-SR-25

Table 2 - Outdoors congested location, normal operation, below 0.1 bar – 0.5 metre radius Zone 2 around AIV.

Note 33:

CHP enclosure external automatic isolation valve (AIV), and gas sampling point

IGEM-SR-25

Table 2 - Outdoors congested location, normal operation, below 0.1 bar – 0.5 metre radius Zone 1 around gas sampling point.

Note 34:

CHP gas enclosure PRV

IGEM-SR-25

As inlet pressure is less than 7 bar, a Zone 1 sphere of 0.5m radius exists around the vent outlet.

The vent is between 5 and 10 metres above ground, appx. 25mm diameter, has no drain holes externally and is of non-ideal type.

Diameter is 25mm, design capacity is less than 0.002kg/s, with flow rate of less than 10m³/h, and relief stream capacity up to 500m³/h.

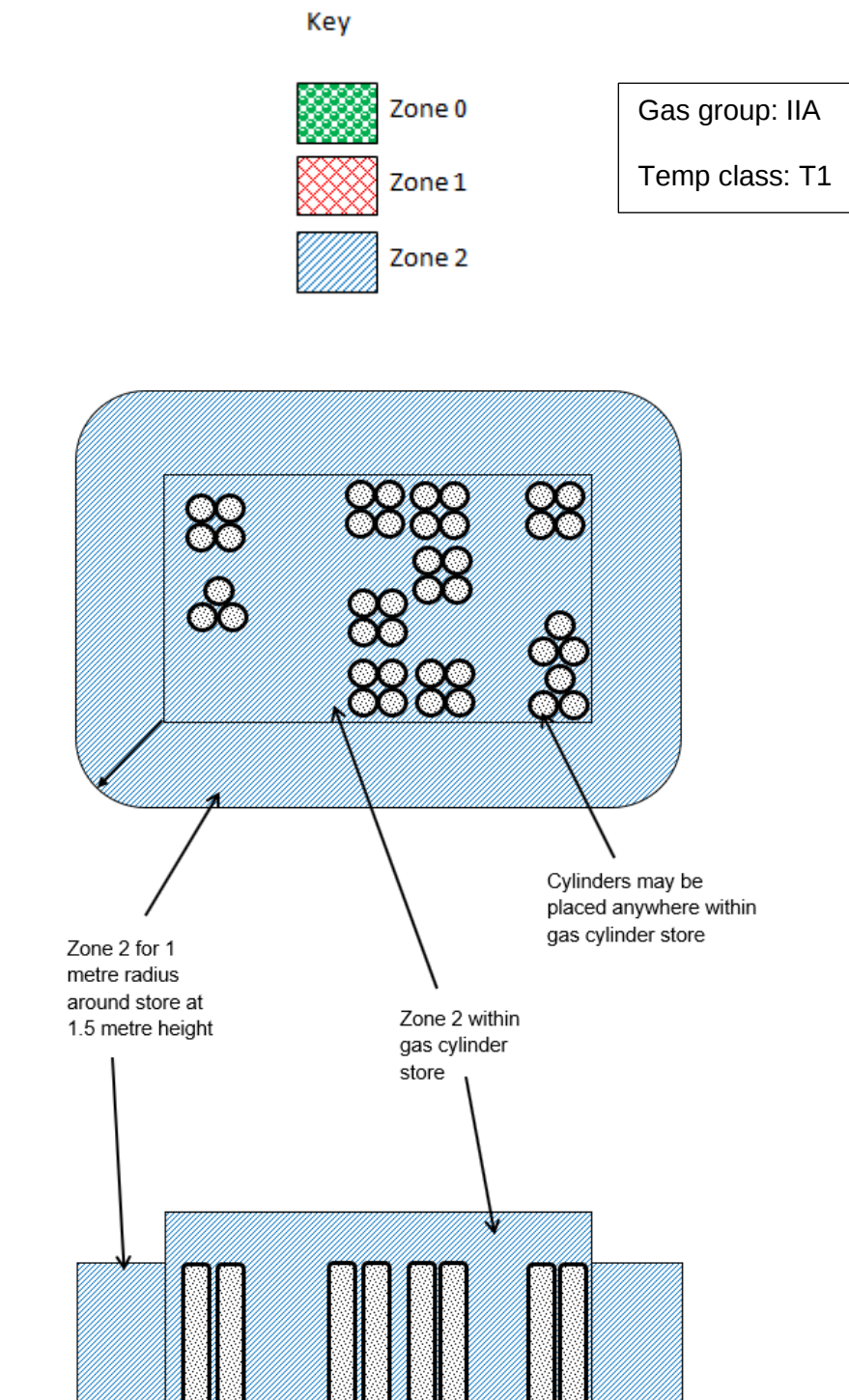
Therefore, from Table 25, spherical dispersion radius (X) is 2 metres around the vent outlet.

7.4 Hazardous Area Classification Drawings

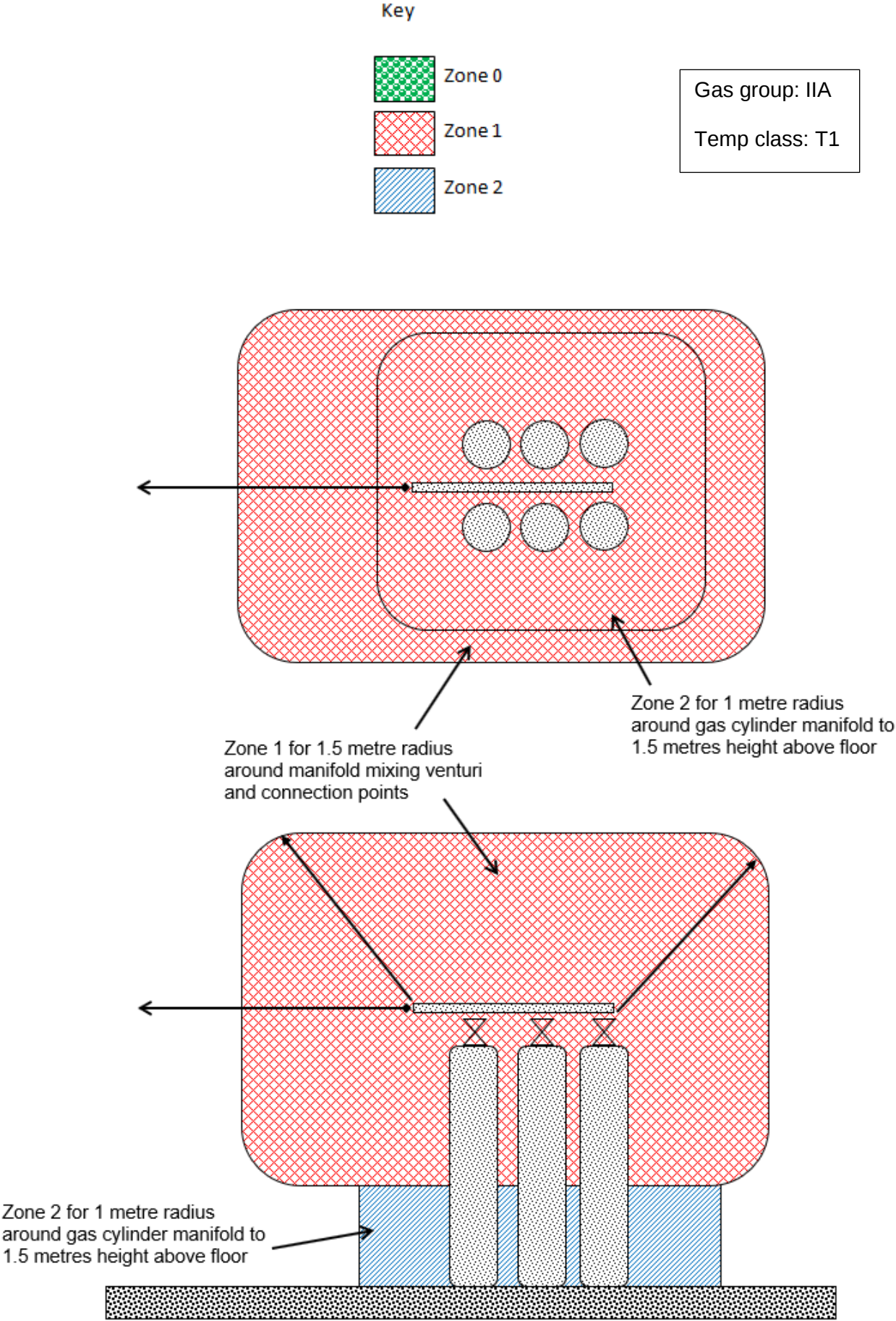
The classification and extent of particular Zones is indicated in the Hazardous Area Classification table above. Zone drawings are based upon recognised standards or direct examples, and reflect locations or facilities at the premises with the potential for significant hazardous substance release.

The site should engage a drafting service to overlay the schematics below onto the site plans and general arrangement drawings (RT31).

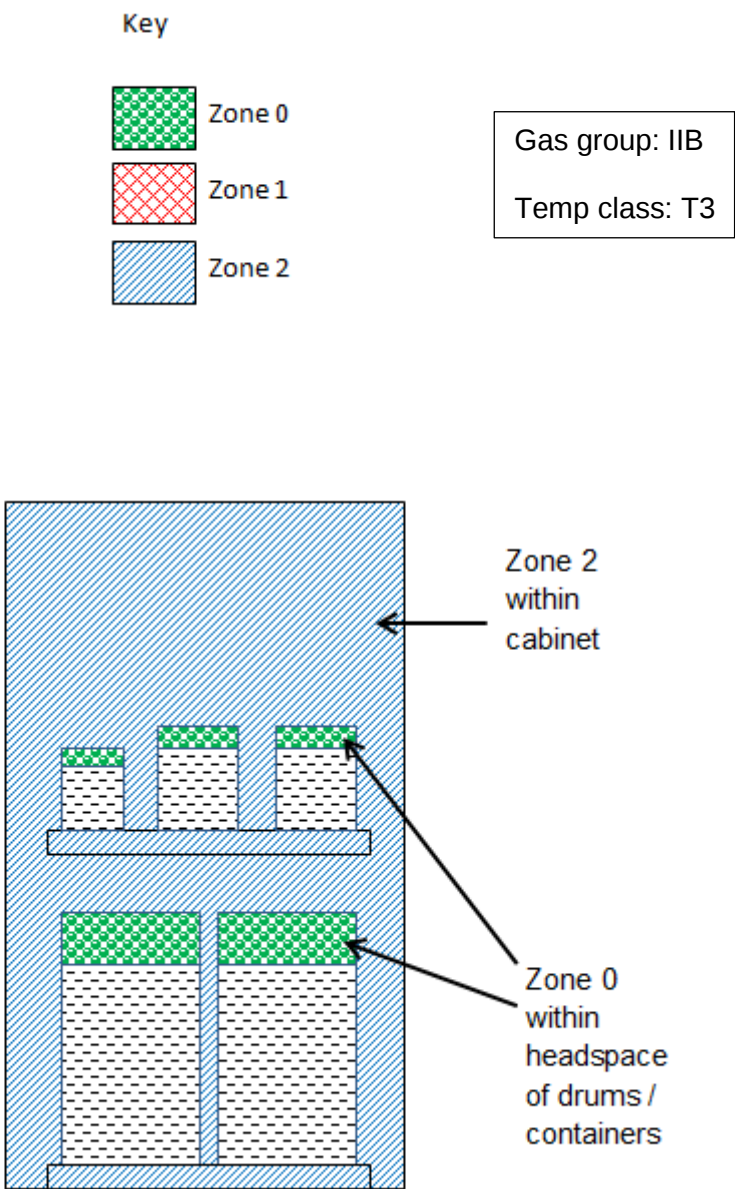
Drawing 1 – Flammable gas cylinder store



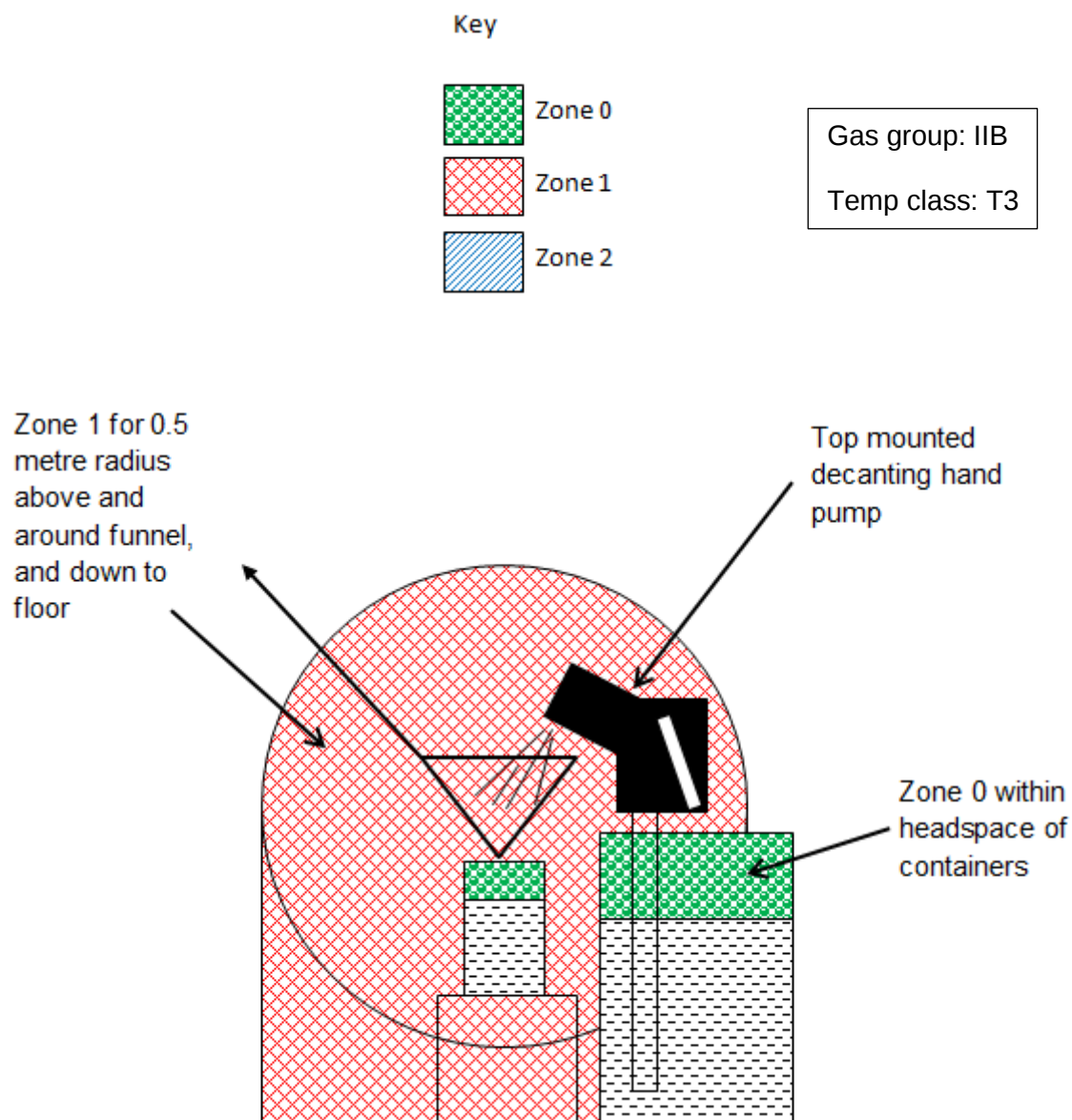
Drawing 2 – Flare LPG cylinder manifold



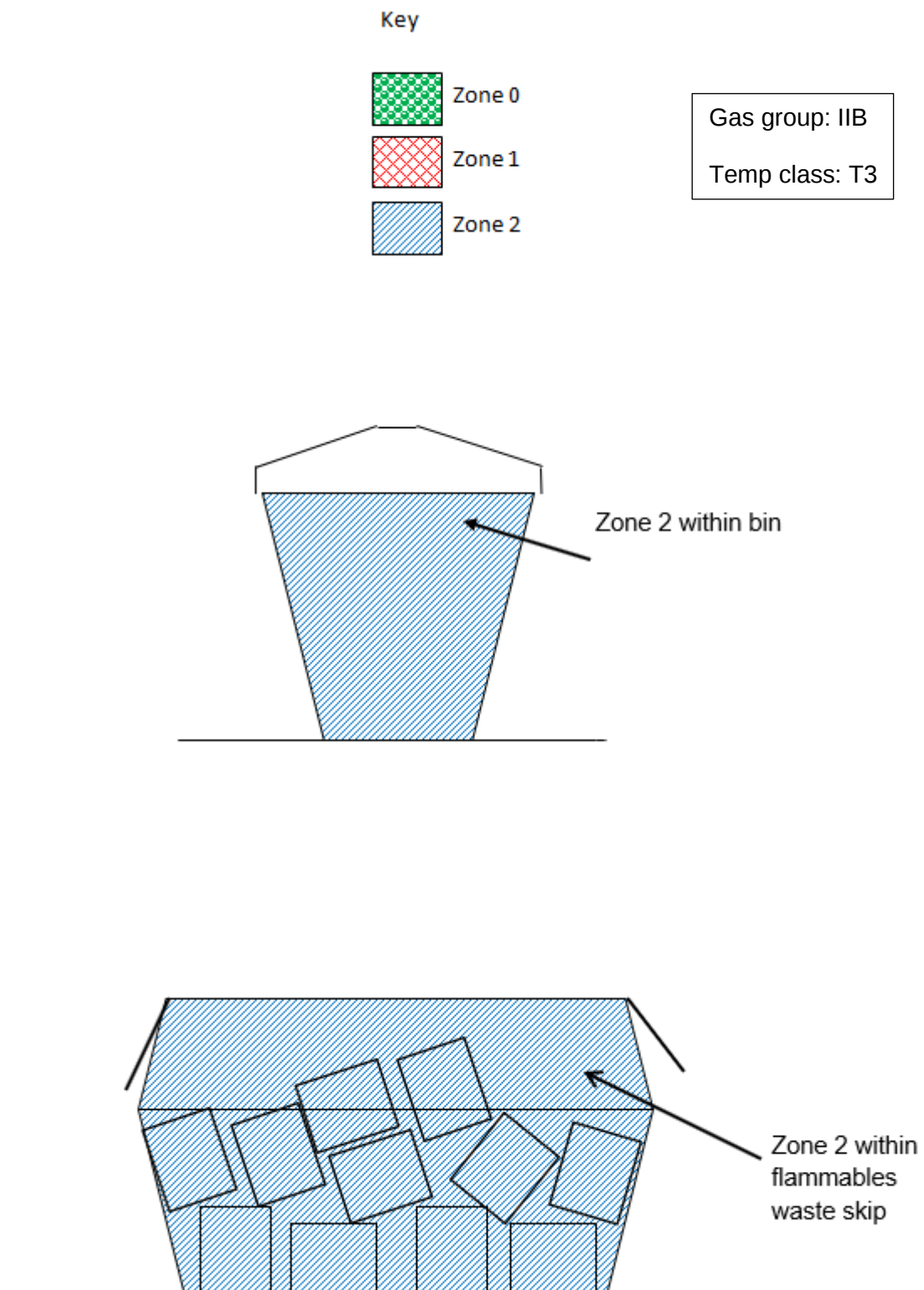
Drawing 3 – Flammables store / cabinet



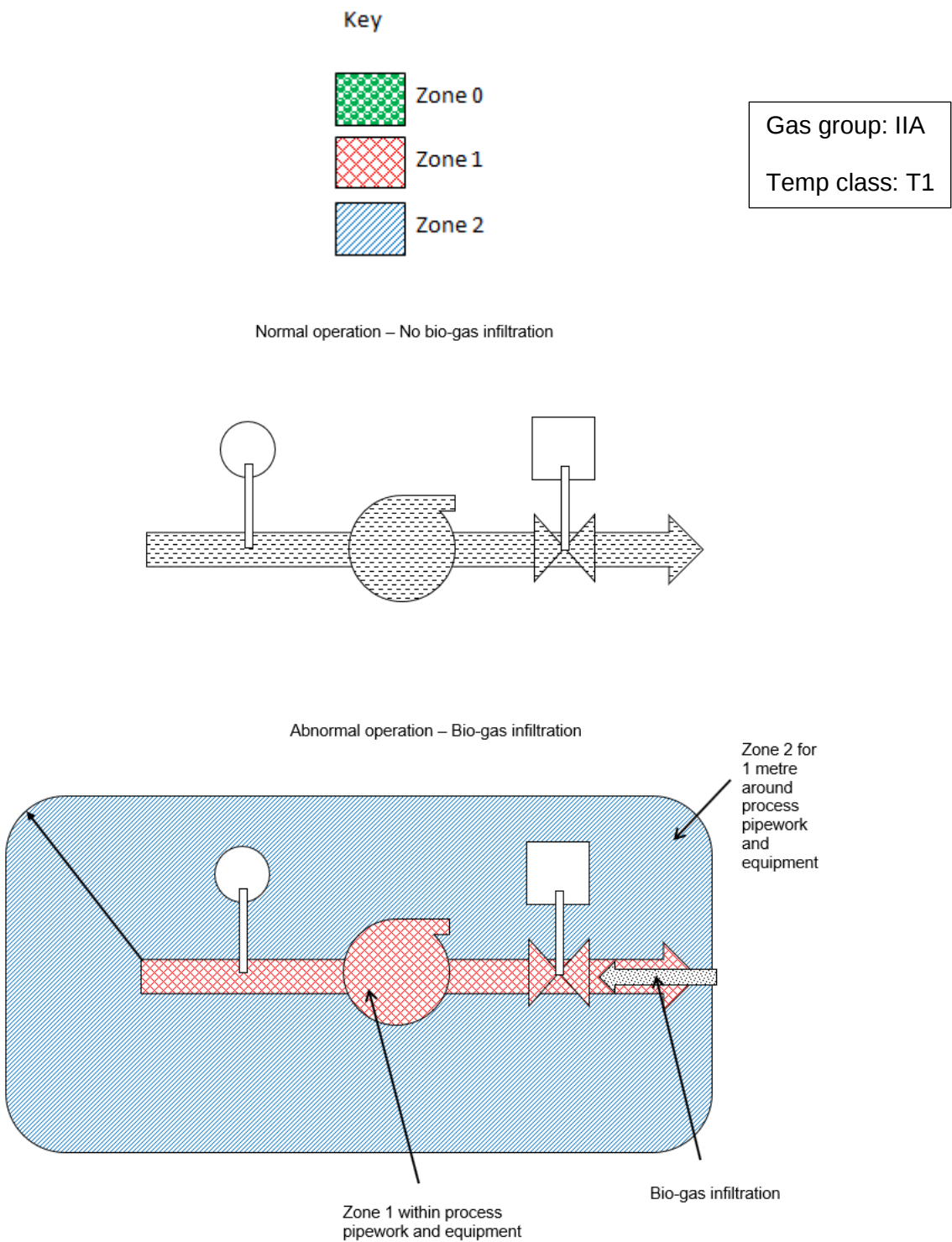
Drawing 4 – Flammables decanting – Medium ventilation



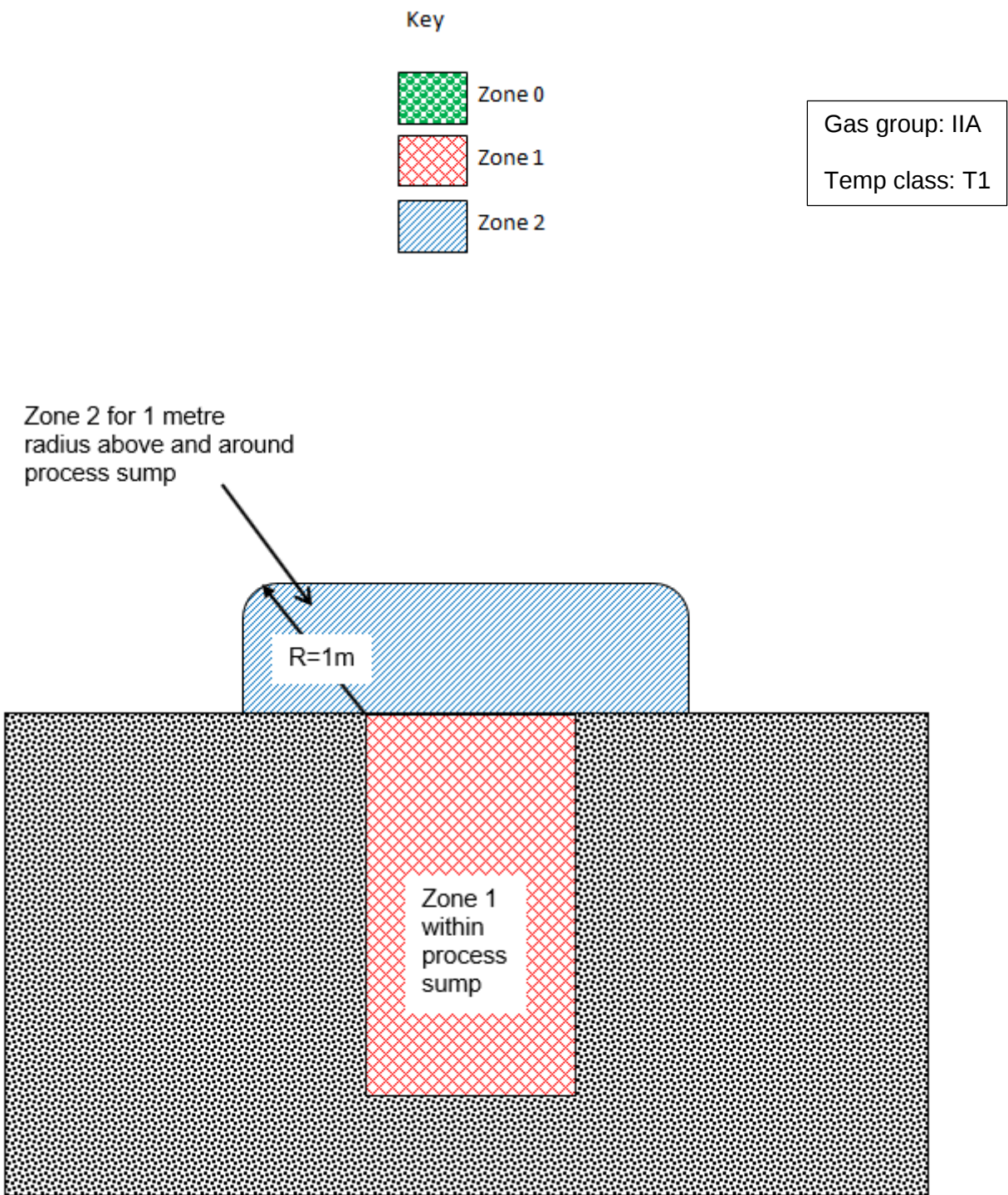
Drawing 5 – Flammables waste bin / skip



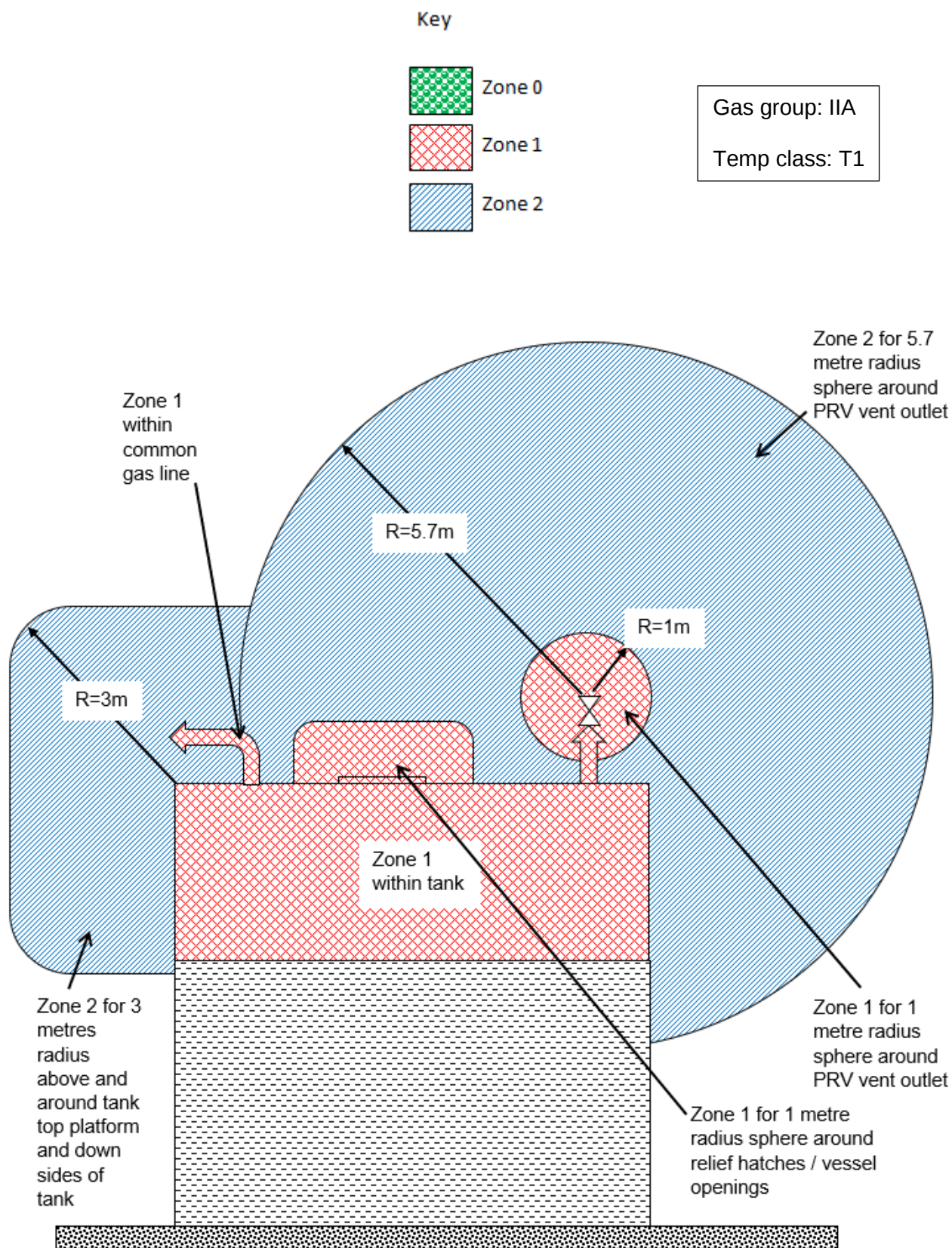
Drawing 6 – Slurry feed system and spent digestate system – in event of biogas leak



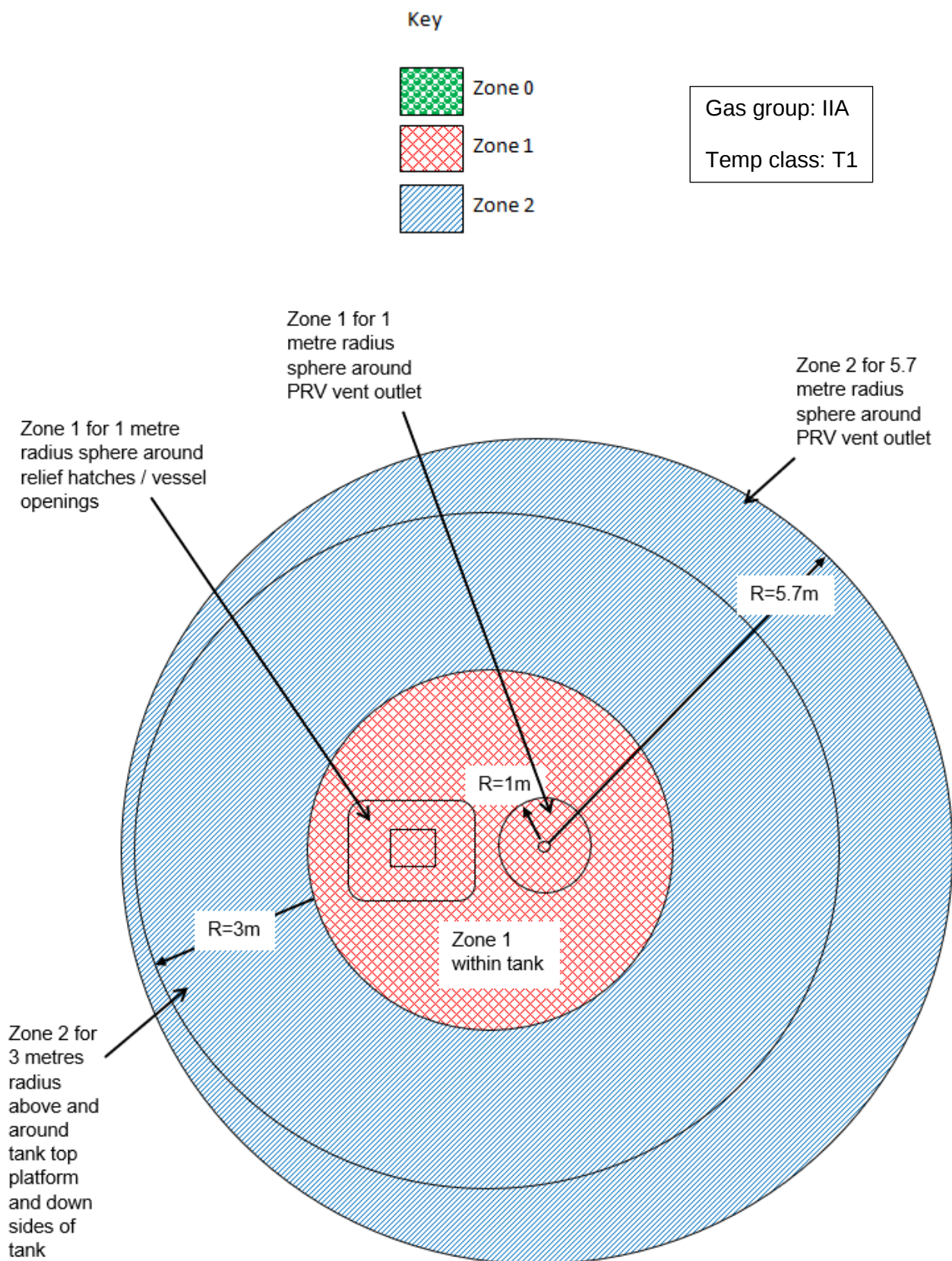
Drawing 7 – Process sumps



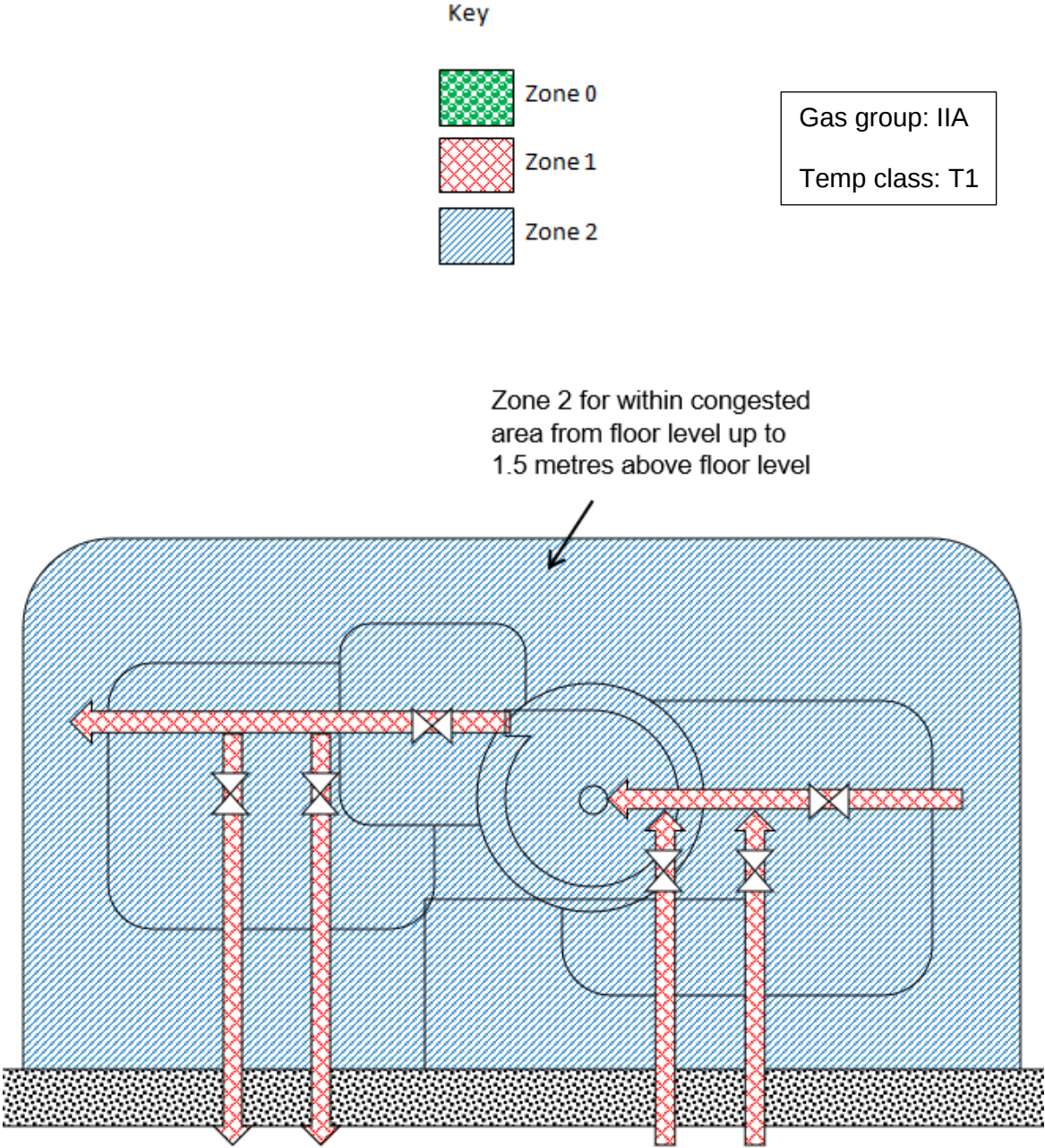
Drawing 8a – Anaerobic digester plant – typical process vessel – side



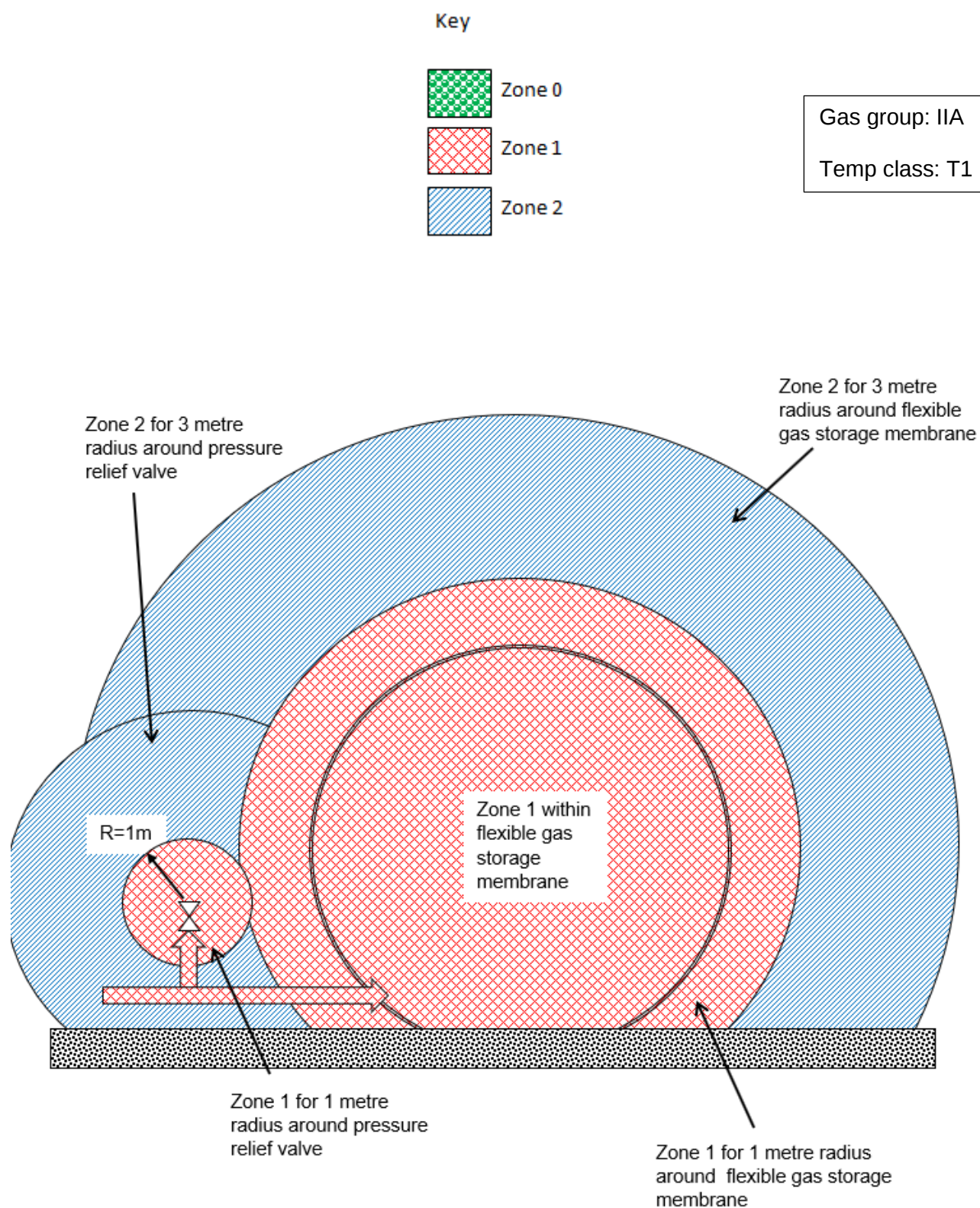
Drawing 8b – Anaerobic digester plant – typical process vessel – plan



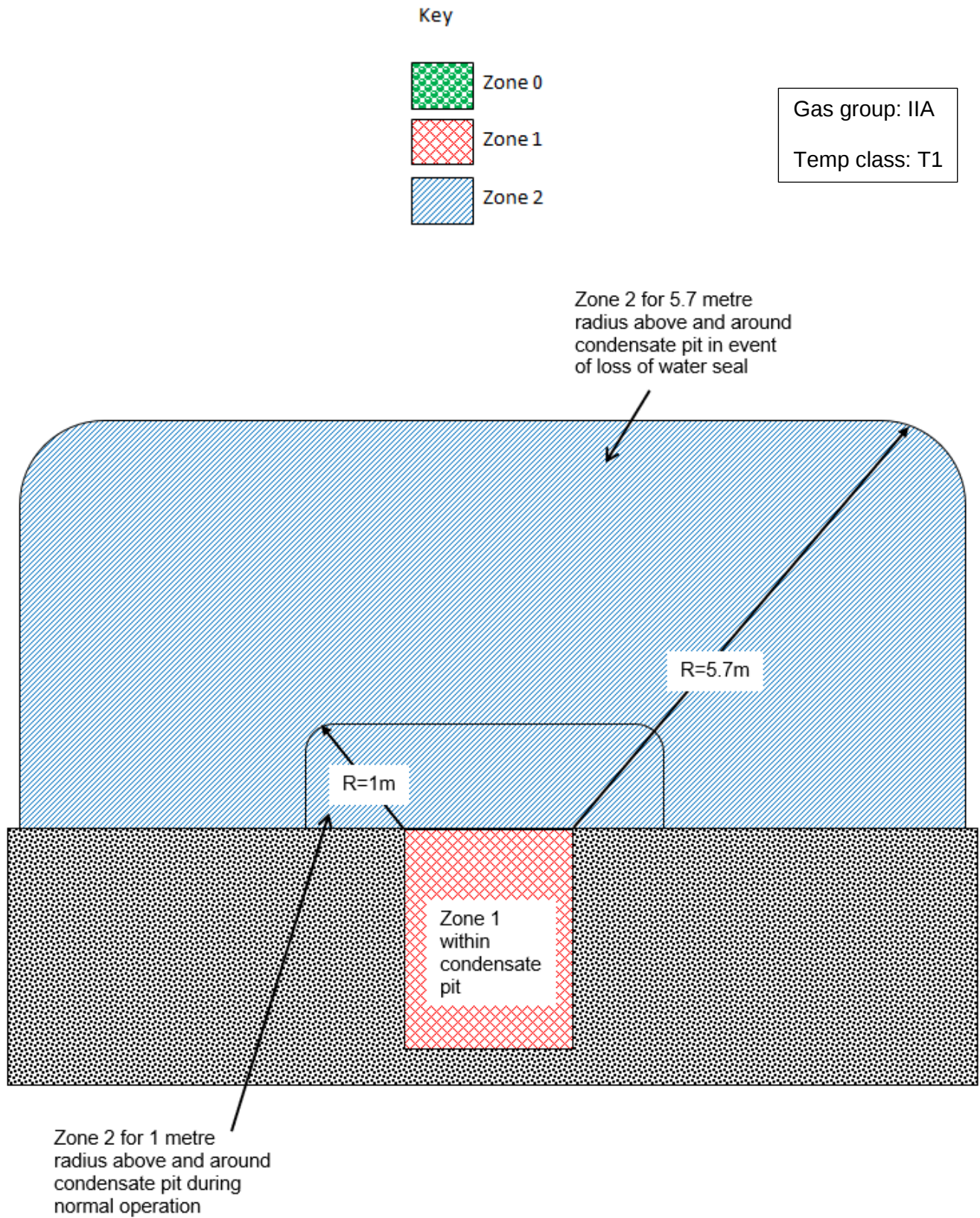
Drawing 8c – Anaerobic digester plant – congested plant area



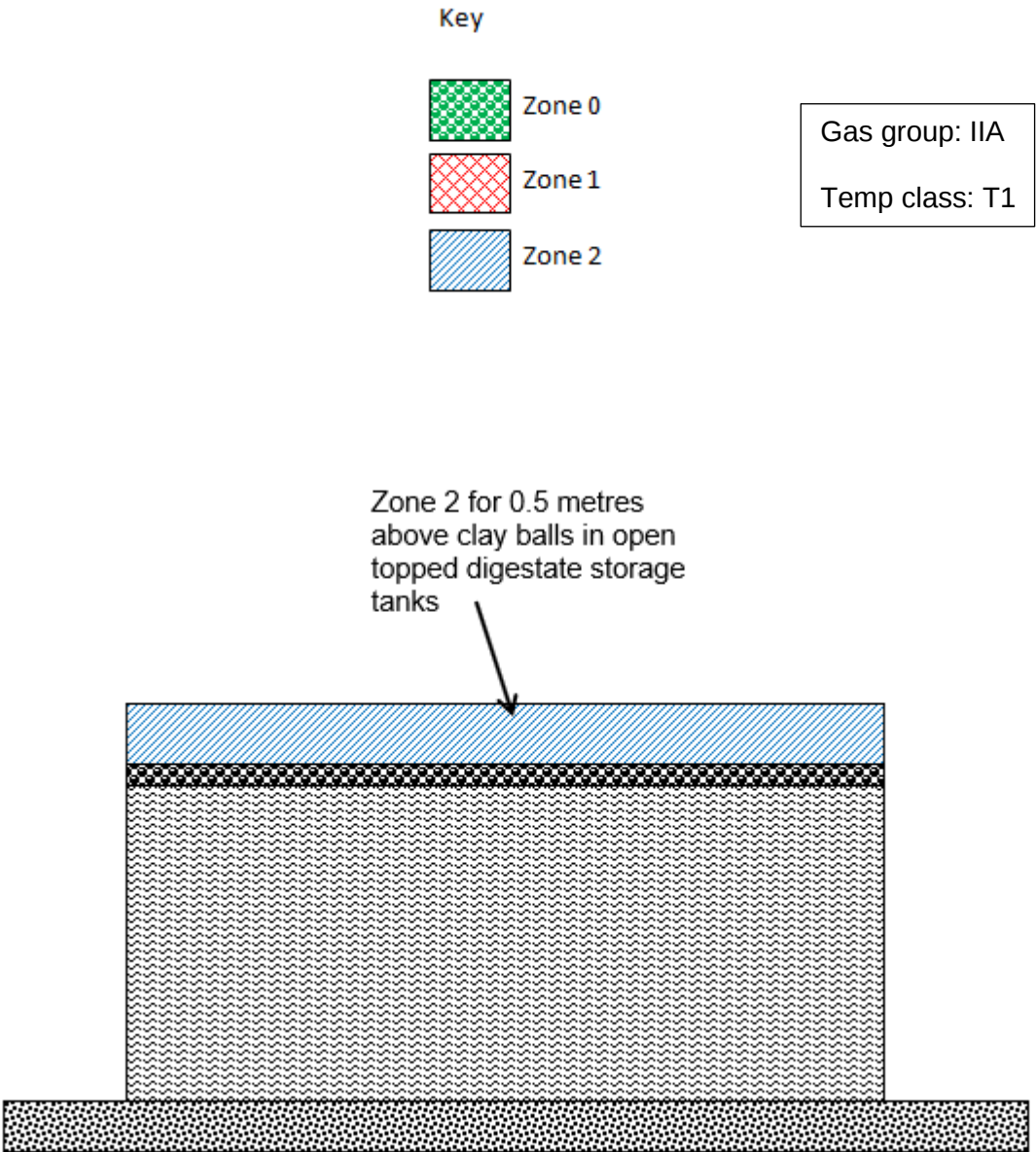
Drawing 9 – Flexible gas storage membrane



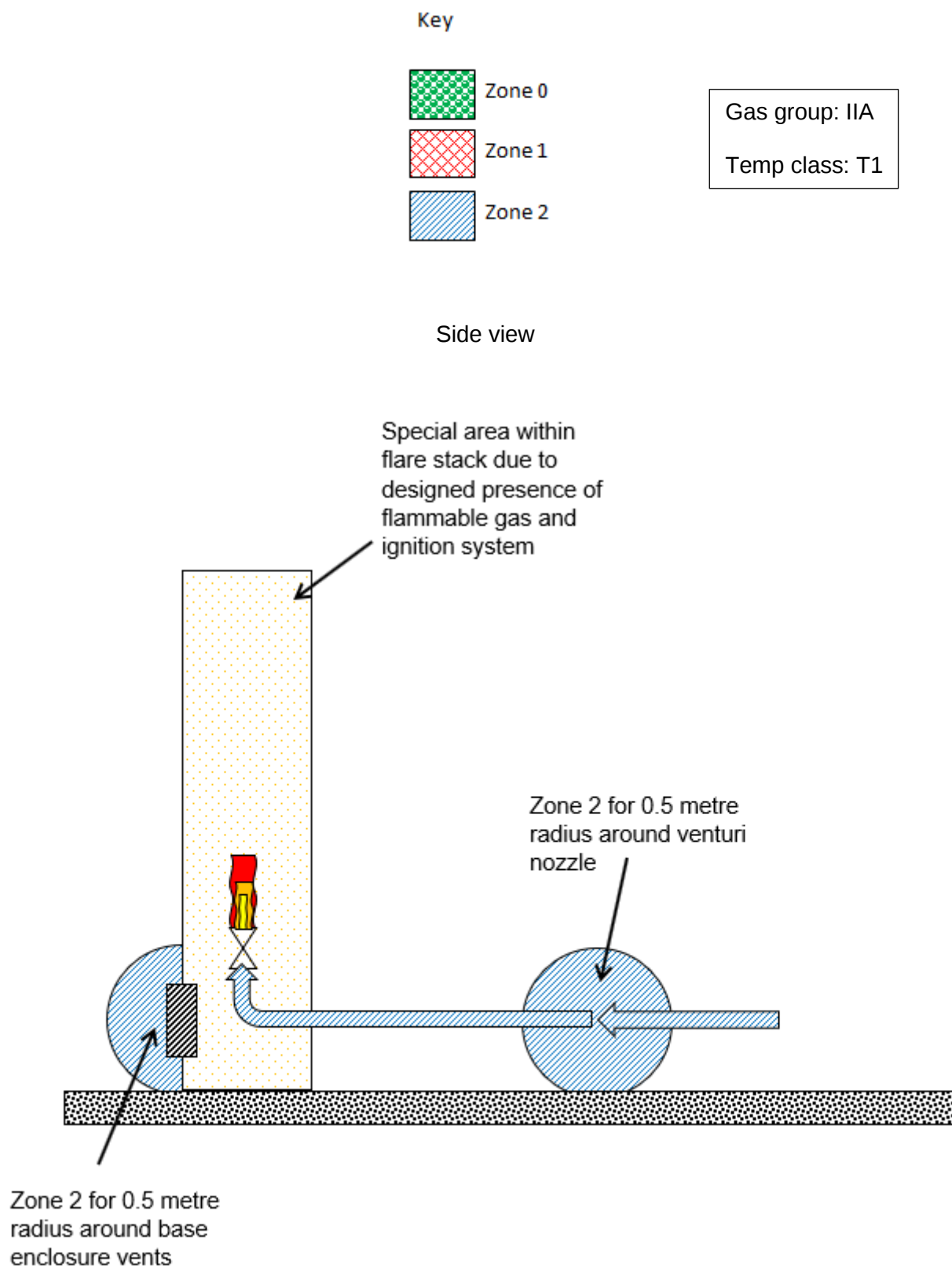
Drawing 10 – Gas storage condensate trap / pit



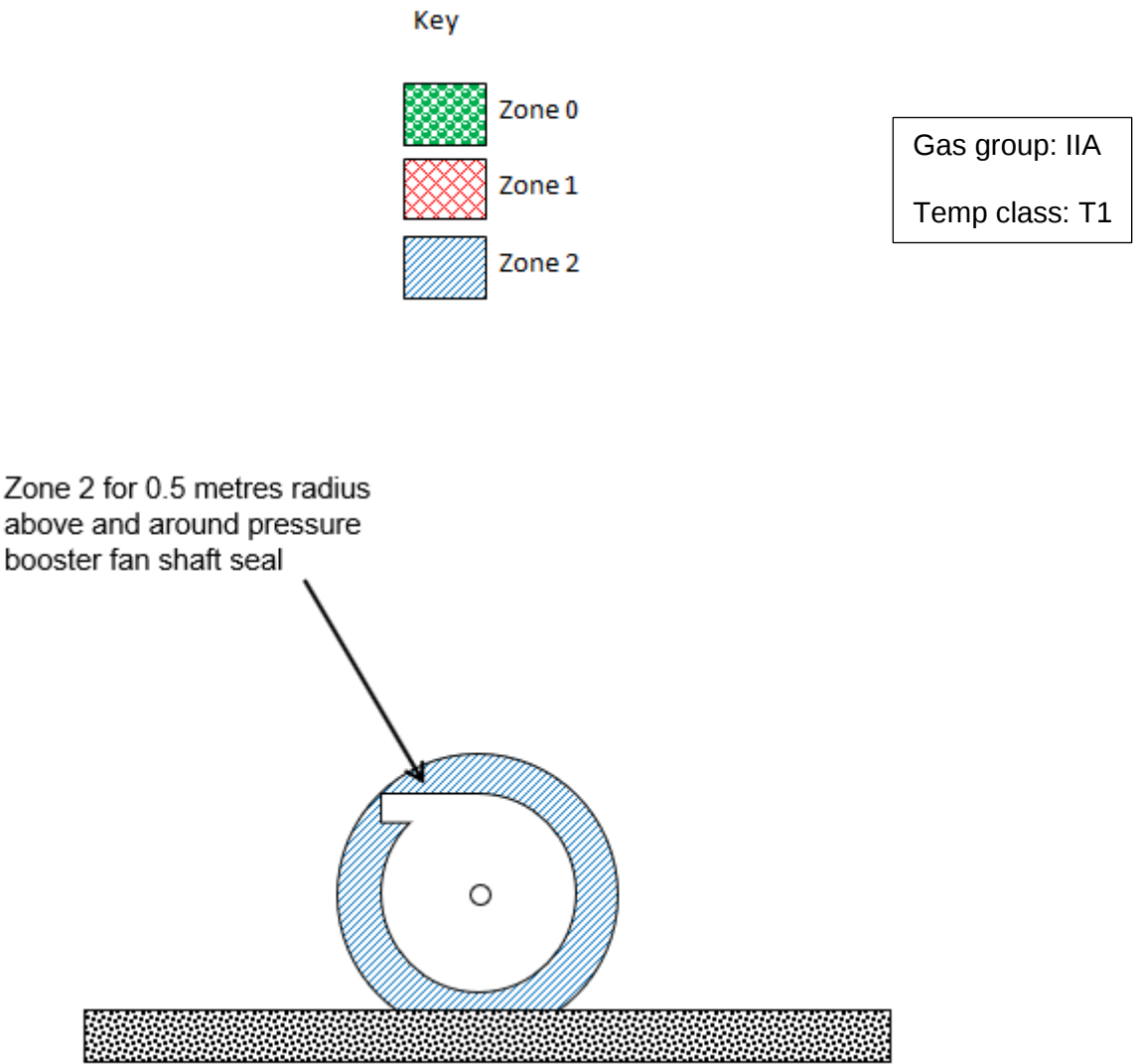
Drawing 11 – Digestate storage tank – side



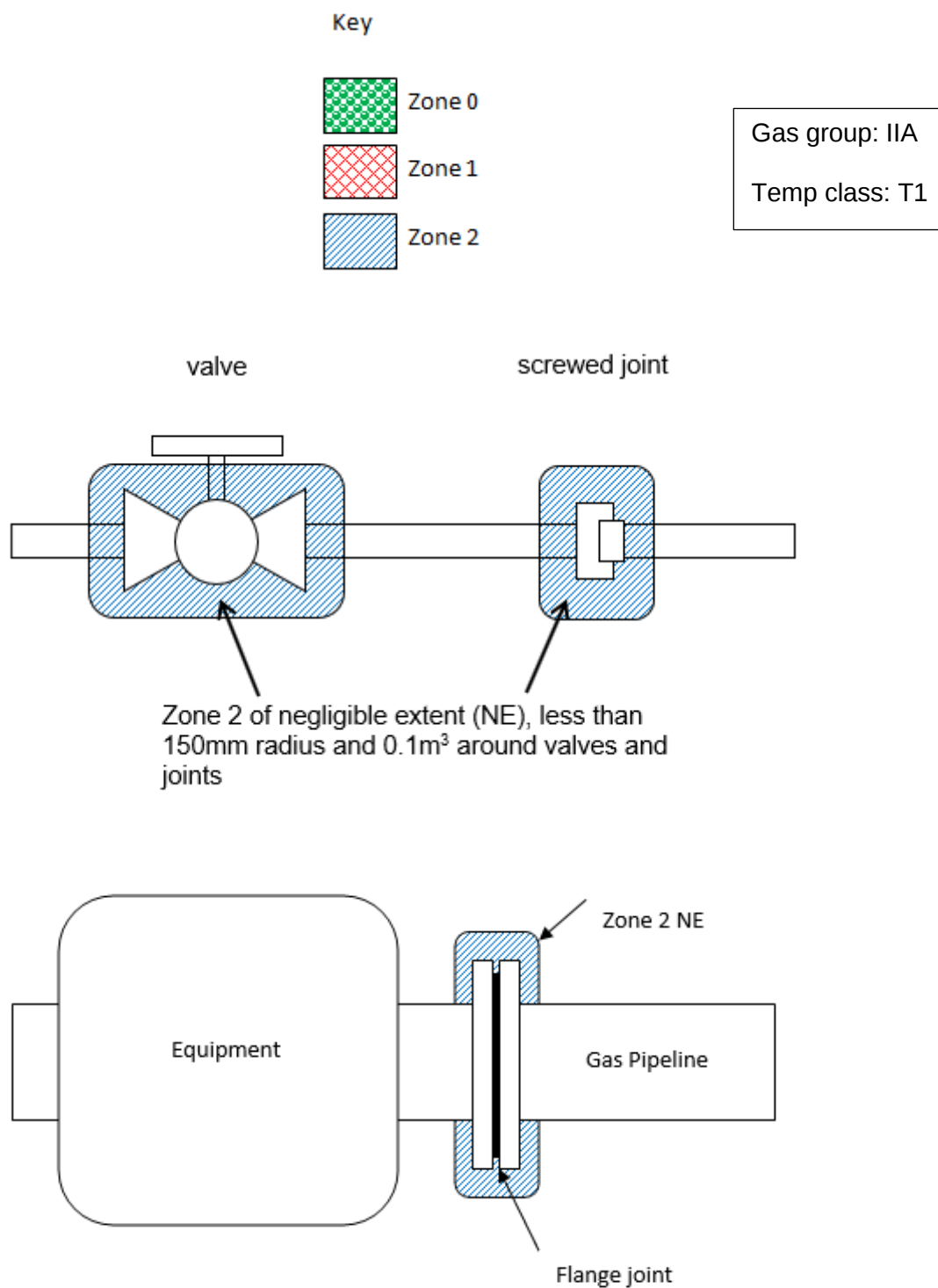
Drawing 12 – AD plant flare unit



Drawing 13 – Boiler enclosure gas pressure booster fan – non-sealed shaft

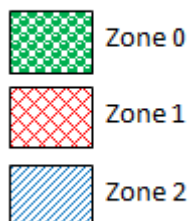


Drawing 14 – Gas distribution to fired equipment – more than adequately ventilated

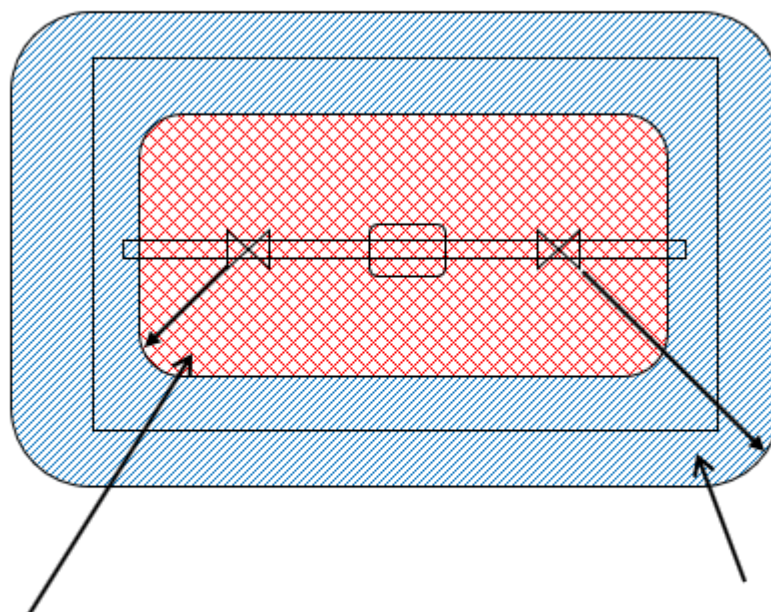


Drawing 15 – CHP gas compressor

Key



Plan view



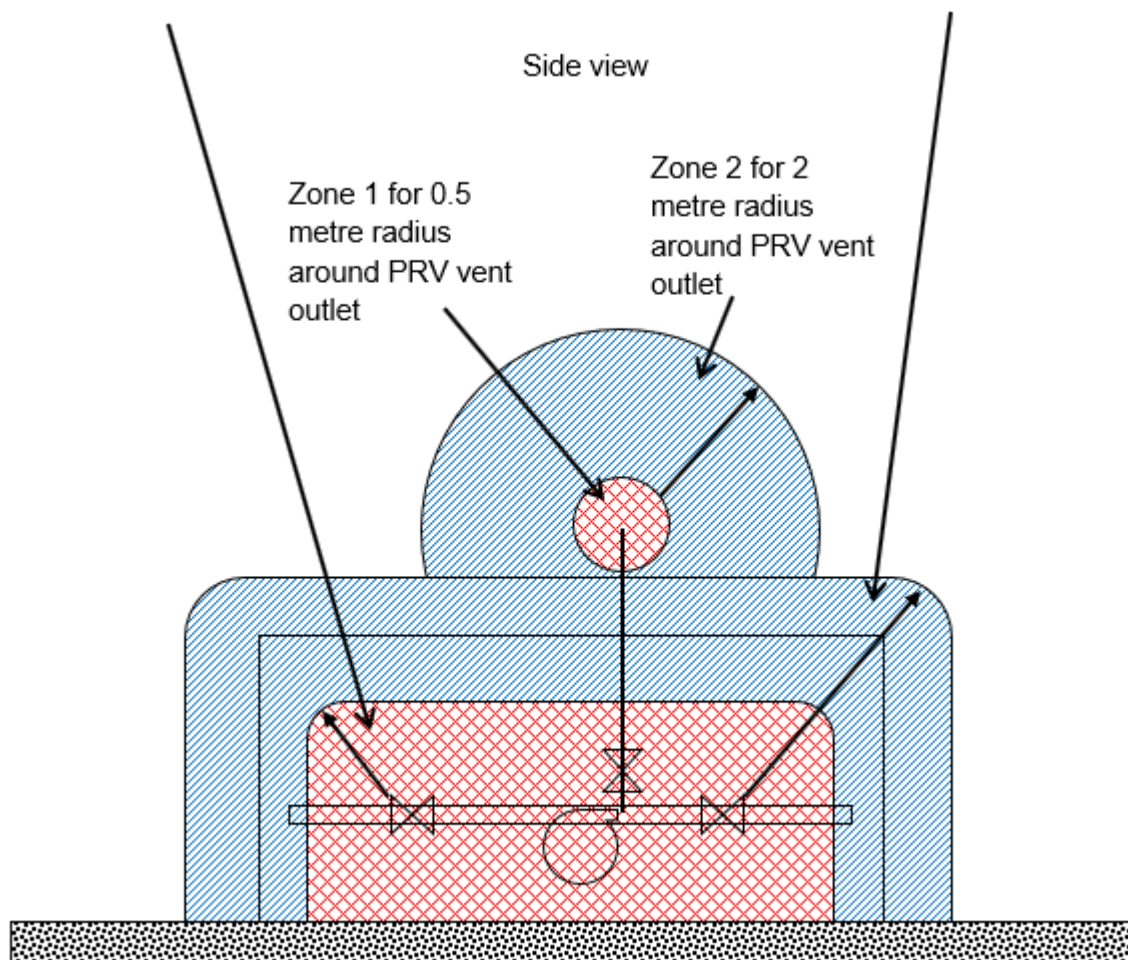
Gas group: IIA

Temp class: T1

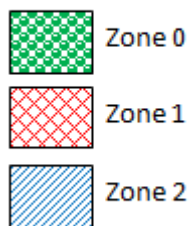
Zone 1 for 1 metre radius
above and around gas
compressor equipment

Zone 2 for 2 metre radius
above and around gas
compressor equipment

Side view



Key

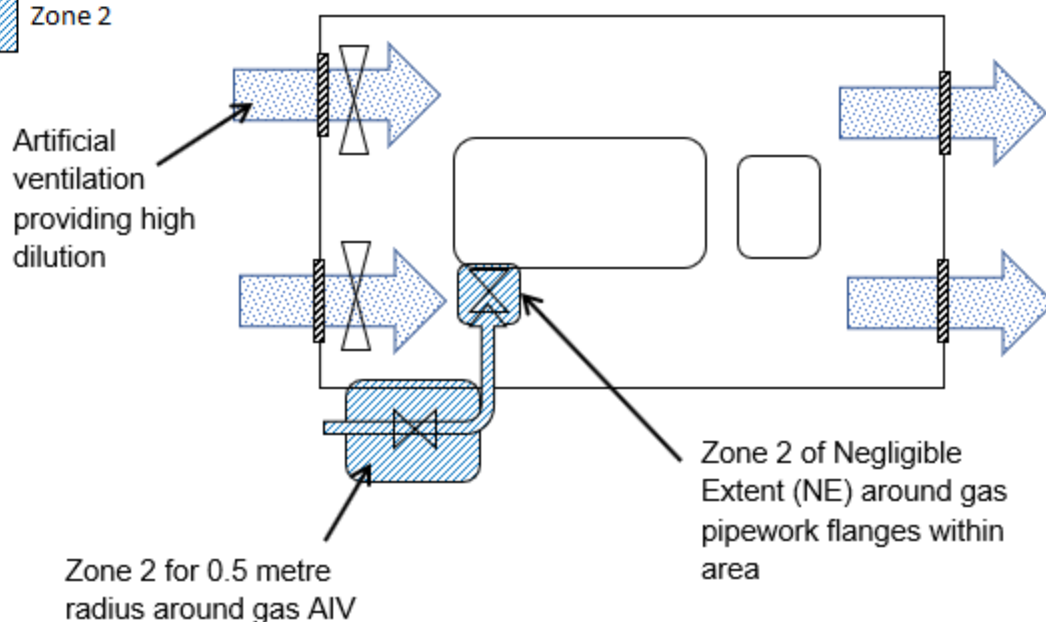


Drawing 16 – CHP gas engine enclosure

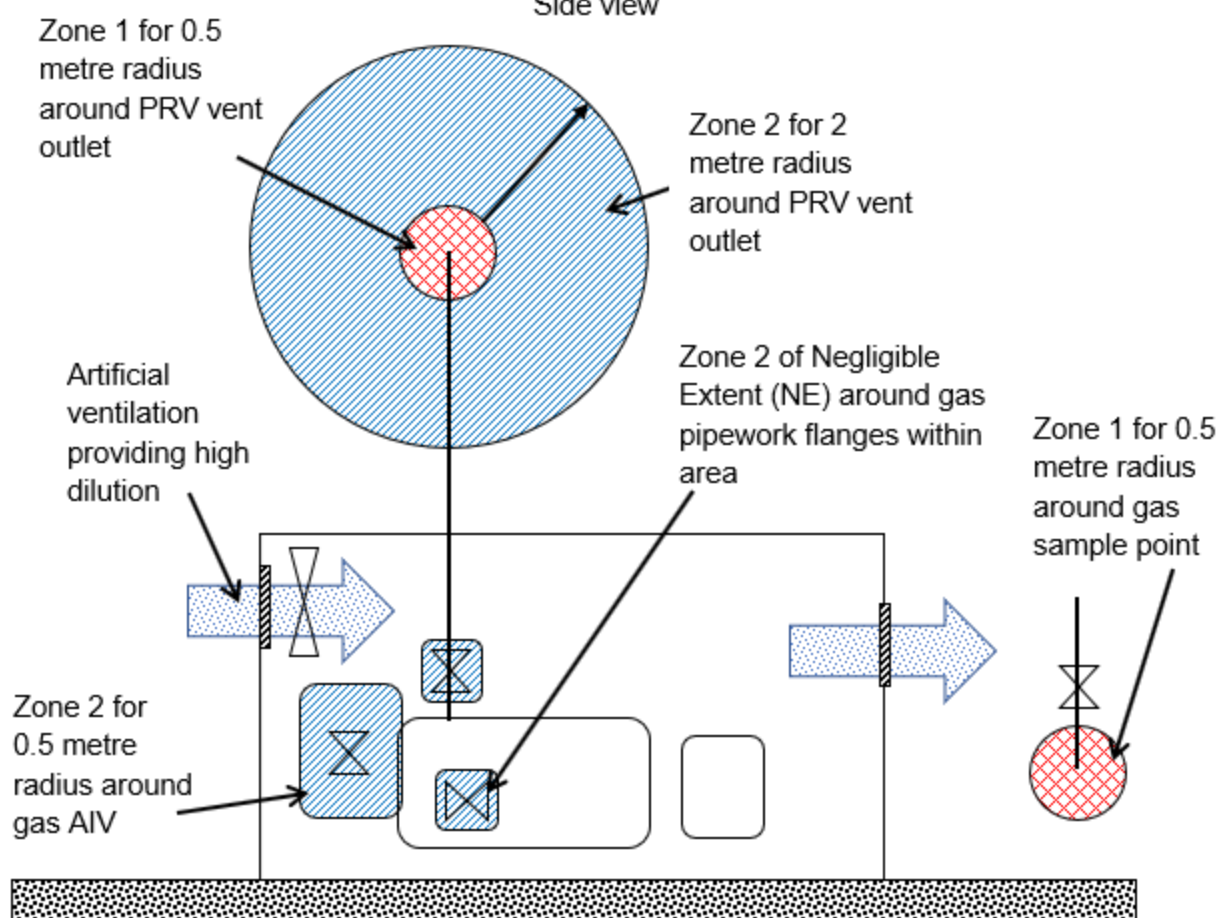
Gas group: IIA

Temp class: T1

Plan view



Side view



Note: Above drawings are not intended to replicate scale diagrams provided to aid implementation of specific Zones identified by Hazardous Area Classification, but are observations at time of survey. A margin of safety is built into calculations as hazardous release source may vary with ventilation efficiency and scale of operation.

8.0 RISK ASSESSMENT

8.1 Risk Assessment Methodology

DSEAR requirements are based on established risk assessment principles for management of significant hazard in order to maintain a safe system of work for all relevant persons. This is a systematic process and entails key steps. The emphasis is on identifying significant fire and explosion hazards that might cause harm, and taking appropriate measures to eliminate or reduce the risk.

The requirements for safe systems of work associated with hazardous substances should be built into established processes or site rules and all relevant persons should be made aware of the findings.

8.2 Qualitative Risk Assessment

DSEAR risk assessment is an examination of specific fire / explosion hazard factors and the documentation of significant findings. Identified hazards from the assessment process in the report and the potential for harm are evaluated, using a matrix approach, to aid quantification of residual risk:

8.3 Matrix

Hazard Likelihood	S0 – Negligible threat / hazard	S1 – Slight threat / hazard	S2 – Moderate threat / hazard	S3 – Severe threat / hazard	S4 – Major threat / hazard	S5 – Catastrophic threat / hazard
F0 – Extremely Unlikely $<10^{-6}$ ($<1,000,000$ yr)						
F1 – Very Unlikely $10^{-6} < 10^{-5}$ (1,000,000 to 100,000 yr)						R2P2
F2 – Improbable $10^{-5} < 10^{-4}$ (100,000 to 10,000 yr)					R2P2	R2P2
F3 – Remote $10^{-4} < 10^{-3}$ (10,000 to 1,000 yr)				R2P2	R2P2	
F4 – Possible 10^{-3} $< 10^{-2}$ (1,000 to 100 yr)						
F5 – Occasional $10^{-2} < 10^{-1}$ (100 to 10 yr)						
F6 – Probable 10^{-1} $< 10^0$ (10 to 1 yr)						
F7 – Frequent (greater than 1/yr)						

8.4 Consequences

SEVERITY	PEOPLE	ENVIRONMENT	ASSETS	REPUTATION	SECURITY
S5 Catastrophic	One or more off-site fatalities, or several fatalities on site, or several severe injuries off-site.	Catastrophic LoC with major offsite damage and international media attention (e.g., Seveso or Sandoz incidents).	>£10m, e.g., total loss of a process plant and cessation of business	Damage to corporate stakeholders, international media attention.	Impact with international media attention harming the corporate reputation, terrorist attack resulting in significant off-site effects as described in other categories.
S4 Major	Fatality: one fatality, or several severe injuries on site, or one severe injury off-site	Significant LoC which has to be reported to the authorities; with off-site impact and giving rise to public concern and regulator fine	<£10m, e.g., major damage to a process plant and inability to produce	Damage (including financial and quality of life) to BU/MU stakeholders. National media attention	Impact on company strategic objectives, kidnapping, extortion, fatal assault
S3 Severe	Severe injury: on-site injury to employees, contractors or members of the general public which leads to in-patient hospital treatment	LoC that is observable or has impact off-site and can give rise to public concern and regulator action	<£1m, e.g., severe damage to a process plant and disruption of output	Damage (including financial and quality of life) to local stakeholders (such as local suppliers or neighbours). Regional media attention	Sabotage with off-site consequences and media attention, bomb threat
S2 Moderate	Reportable injury; medical treatment injury, restricted work injury, or lost time injury not requiring in-patient hospital treatment	LoC almost certainly contained on site, not readily controlled, with no observable impact off-site; RIDDOR	<£100k, e.g., Partial damage to a process plant, or ability to produce	External complaint, affects local company reputation	Burglary, fraud or theft with significant financial impact including business interruption, non-fatal assault, robbery involving injury, sabotage with on-site effects only
S1 Slight	First aid treatment	LoC readily controlled, contained on site with no off-site impacts	<£10k, e.g., minor damage and costs	No damage to company reputation	Trespass, stalking, personal threats with no follow-up, burglary, robbery or petty theft with minor financial impact only (no injuries)
S0 Negligible	Near miss	Minor spill	<£1k, e.g., internal cost of clean-up	None	None

8.5 Frequency

For the frequency rating the matrix has seven different categories, each level with an increased frequency of 10, ranging from F0 (low frequency) to F6 (high frequency):

F0: Extremely unlikely; less than once per 1,000,000 years

F1: Very unlikely; between and equal to once per 100,000 years and once per 1,000,000 years

F2: Improbable; between and equal to once per 10,000 years and once per 100,000 years

F3: Remote; between and equal to once per 1,000 years and once per 10,000 years

F4: Possible; between and equal to once per 100 years and once per 1,000 years

F5: Occasional; between and equal to once per 10 years and once per 100 years

F6: Probable; between and equal to once per 1 year and once per 10 years

F7: Frequent; more than once per 1 year

In addition, to support qualitative assessments, a wording model is provided:

F0: Extremely unlikely; credible to occur, but requires several contributory factors and coincidental failures of layers of protection

F1: Very unlikely; foreseeable to occur, but requires the failure of more than one layer of protection

F2: Improbable; a singular incident in industry on similar technology has occurred

F3: Remote; not expected to occur during remaining plant lifetime

F4: Possible; could occur during remaining lifetime of plant

F5: Occasional; has occurred during lifetime of plant

F6: Probable; occurs within a process unit of a plant

F7: Frequent; occupational health hazard

Note 1: R2P2 hatched regions – Originally published in 2001, the HSE publication R2P2⁴⁶ suggested tolerability of fatality rates at 1 in 1,000 years ($<10^{-3}$) for a single employee fatality, and 1 in 10,000 years ($<10^{-4}$) for a single member of the public fatality; with less than 1 in 1,000,000 years ($<10^{-6}$) being broadly acceptable as an overall societal risk.

However, with workplace and societal expectation becoming more risk averse since 2001, it has been posited⁴⁷ that target frequencies for fatality to employees be adjusted as below:

Severity / Harm	Target Frequency (per year)	
	Existing Establishments	New Establishments
Injury (0.1 Fatality)	1E-03	1E-04
1 Fatality	1E-04	1E-05
2 Fatalities	5E-05	5E-06
10 Fatalities	1E-05	1E-06

⁴⁶ HSE R2P2 - Reducing Risk, Protecting People, HSE's decision making process, 2001

⁴⁷ IChemE Hazards 28, Paper 28 - Risk tolerability targets; misconceived, misunderstood and misapplied, 2018

8.6 Weighting

A – Red – Unacceptable, immediate action required before running process / equipment, reduction of risk to at least Low ALARP required. This means crossing 2 bands, so the term RRF (risk reduction factor) is used, and 2 bands equates to a RRF of 100.

B – Orange – High ALARP, Action required within 3 months, either by eliminating the risk, or arranging temporary controls while investment for permanent controls is approved, with reduction of risk to at least Low ALARP required. This means crossing 1 band, so a RRF of 10 is required.

C – Yellow – Low ALARP, Action required as soon as practicable (e.g., within 1 year) to reduce risk. This will include a consideration of costs and benefits in order to demonstrate whether Low ALARP is acceptable with controls or further risk reduction required to reduce to Acceptable region.

D – Green – Acceptable, no reduction in risk required as long as monitored as part of site Continuous Improvement plan.

Risk reduction measures may reduce either the Severity or Frequency, or both.

Thus, actions identified by the assessment process are readily prioritised and specific remedial actions proposed to reduce risk to an acceptable level - as outlined in the report recommendations.

Note 2: *This report applies to potential hazardous substance releases on-site and identifies potential for major incident or harm from materials, maintenance and other ancillary operations witnessed at time of visit. Any subsequent changes to plant and / or operations should be reviewed in regard to the DSEAR requirements.*

Report highlights significant issues associated with hazardous materials and DSEAR requirements particularly, but does not cover all risks from hazardous substances (such as those required under COSHH/CLP regulations).

Note 3: *It is recommended that Biogen develops and implements their own risk rating matrix along with attendant Consequences and Frequencies. The data supplied above is a starting point and is broadly representative of the level of risk that Biogen may be exposed to.*

8.7 Ignition Risk Assessment

EN 1127 Part 1 [4] Section 5 Clause 5.2 lists thirteen type of ignition source. Control measures for each are tabulated below.

Ignition source	Controls
8.7.1 Hot surfaces: If an explosive atmosphere comes into contact with a heated surface, ignition can occur. Not only can a hot surface itself act as an ignition source, but a dust layer or a combustible solid in contact with a hot surface and ignited by the hot surface can also act as an ignition source for an explosive atmosphere.	Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6). The site must operate a Safe System of Work for occasions where hot work might be required (RT4).
8.7.2 Flames and hot gases: Flames are associated with combustion reactions at temperatures of more than 1000°C. Hot gases are produced as reaction products and in the case of dusty and/or sooty flames, glowing solid particles are also produced. Flames, their hot reaction products, or otherwise highly heated gases can ignite an explosive atmosphere. Flames, even very small ones, are among the most effective ignition sources.	Rigorously control / separate flammables from personal sources of ignition (RF8). Review hot work permit system for AD facility (RT4).
8.7.3 Mechanically-generated sparks: As a result of friction, impact, or abrasion processes such as grinding, particles can become separated from solid materials and become hot due to the energy used in the separation process. If these particles consist of oxidisable substances, e.g., iron or steel, they can undergo an oxidation process, thus reaching even higher temperatures. These particles (sparks) can ignite combustible gases and vapours and certain dust/air mixtures (especially metal dust/air mixtures). In deposited dust, smouldering can be caused by sparks, and this can be a source of ignition for an explosive atmosphere.	Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition (RF6)(RT22)(RT24). Sparks and hot surfaces arising from engineering activities are to be controlled under a permit to work system (RT4).
8.7.4 Electrical apparatus: In the case of electrical installations, electric sparks and hot surfaces can occur as sources of ignition. Electric sparks for example can be generated: when electric circuits are opened and closed	Fixed installations should be inspected in accordance with guidelines in IEC TS 60079-32-1: Explosive atmospheres

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Ignition source	Controls
- by loose connections - by stray currents	Part 32-1: Electrostatic hazards, guidance (RF6)(RT22)(RT24).
8.7.5 Stray static currents, cathodic corrosion protection: Stray currents can flow in electrically conductive systems or parts of systems: - as return currents in power generating systems –in particular in the vicinity of electric railways and large welding systems – when, for example, conductive electrical system components that are laid in the ground, such as rails and cable sheathing, lower the resistance of this return current path - as a result of a short circuit or of a short circuit to earth in the event of faults in the electrical installations - as a result of magnetic induction (e.g., near electrical installations with high currents or radio frequencies)	The plant specification includes for earthing. Periodic inspections of earthing must be carried out in accordance with standards and codes of practice (RF2)(RT18).
8.7.6 Static electricity: Incendive discharges of static electricity can occur under given conditions. The discharge of charged, insulated conductive parts can easily lead to incendive sparks. With charged parts made of non-conductive materials, and these include most plastics as well as some other materials, brush discharges and, in special cases, during fast separation processes or due to a combination of conductive and non-conductive materials, propagating brush discharges are also possible. Cone discharges from bulk material and cloud discharges can also occur. Brush discharges can ignite almost all explosive gas and vapour atmospheres	The plant specification includes for earthing. Periodic inspections of earthing must be carried out in accordance with standards and codes of practice (RF2)(RT18).
8.7.7 Lightning: If lightning strikes in an explosive atmosphere, ignition will always occur. Moreover, there is also a possibility of ignition due to the high temperature attained by lightning conductors. Large currents flow from where the lightning strikes and these currents can produce sparks in the vicinity of the point of impact. Even in the absence of lightning strikes, thunderstorms can cause high induced voltages in equipment, protective systems, and components.	Ensure lightning protection systems installations completed to process tanks, and new lightning protection system installed around gas holder (RF20).
8.7.8 RF electromagnetic waves from 3×10^4 Hz to 3×10^{11} Hz: Electromagnetic waves are emitted by all systems that generate and use radio-frequency electrical energy (radio-frequency systems), e.g., radio transmitters or industrial or medical RF generators for heating, drying, hardening, welding, cutting, etc. All conductive parts located in the radiation field function as receiving aerials. If the field is powerful enough and if the receiving aerial is sufficiently large, these conductive parts can cause ignition in explosive atmospheres. The received radio-frequency power can, for example, make thin wires glow or generate sparks during the contact or interruption of conductive parts. The energy picked up by the receiving aerial, which can lead to ignition, depends mainly on the distance between the transmitter and the receiving aerial as well as on the dimensions of the receiving aerial at any particular wavelength and RF	Review mobile phone use policy on site in Hazardous Areas (RT23).

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Ignition source	Controls
power.	
8.7.9 Optical electromagnetic waves from 3×10^{11} Hz to 3×10^{15} Hz: Radiation in this spectral range can – in particular when focused, - become a source of ignition due to absorption by explosive atmospheres or solid surfaces. Sunlight, for example, can trigger an ignition if objects cause convergence of the radiation. In the case of laser radiation, even at great distances, the energy or power density of even an unfocussed beam can be so great that ignition is possible. Here, too, the process of heating up occurs mainly when the laser beam strikes a solid body surface or when it is absorbed by dust particles in the atmosphere or on dirty transparent parts.	None identified.
8.7.10 Ionising radiation: Ionizing radiation generated, for example, by X-ray tubes and radioactive substances can ignite explosive atmospheres (especially explosive atmospheres with dust particles) as a result of energy absorption. Moreover, the radioactive source itself can heat up owing to internal absorption of radiation energy to such an extent that the minimum ignition temperature of the surrounding explosive atmosphere is exceeded. Ionizing radiation can cause chemical decomposition or other reactions which can lead to the generation of highly reactive radicals or unstable chemical compounds. This can cause ignition.	None identified.
8.7.11 Ultrasonics: In the use of ultrasonic sound waves, a large proportion of the energy emitted by the electro-acoustic transducer is absorbed by solid or liquid substances. As a result, the substance exposed to ultrasonics heats up so intensely that, in extreme cases, ignition may be induced.	Unlikely to be present.
8.7.12 Adiabatic compression, shock waves, gas flows: In the case of adiabatic or almost adiabatic compression and in shock waves, such high temperatures can occur that explosive atmospheres (and deposited dust) can be ignited. The temperature increase depends mainly on the pressure ratio, not on the pressure difference. NOTE: In pressure lines of air compressors and in containers connected to these lines, explosions can occur as a result of a compression ignition of lubricating oil mists.	Seriously consider implementing flame arrestors to gas distribution network (RJ8).
8.7.13 Exothermic reactions, including self-ignition of dusts: Exothermic reactions can act as an ignition source if the rate of heat generation exceeds the rate of heat loss to the surroundings. Whether a high temperature can develop in the event of a reaction is dependent, among other parameters, on the volume/surface ratio of the reacting system, the ambient temperature, and the residence time. These high temperatures can lead to both the ignition of explosive atmospheres and the initiation of smouldering and/or burning. Such reactions include those of pyrophoric substances with air, alkali metals with water, self-ignition of combustible dusts, self-heating of feedstuffs induced by biological processes, the decomposition of organic peroxides, or polymerization reactions.	Review and maintain high standard of housekeeping (RA4). Ensure minimum separation distances between different classes of hazardous substances are observed (RH3).

8.8 Organisational Measures

In the context of DSEAR, there are procedural issues (referred to as ‘organisational measures’ under DSEAR) that are addressed below and since they apply to most if not all designated Hazardous Areas, they are not repeated in each section. The relevant organisational measures identified and discussed with Biogen are listed below. It should be noted that reference to any formal procedural document has not been made in this report but will be in the overall Risk Assessment Document or ‘Explosion Protection Document’ (EPD) required under DSEAR.

Each of these is discussed in turn below:

Organisational Measures	Compliance
8.8.1 Housekeeping Controls: Cleaning equipment is a particular ignition source that is often overlooked – vacuum cleaners or similar equipment may draw dust or vapour into an ignition source and result in a local fire or explosion incident. They need to meet appropriate category if used where flammable / combustibles are likely – or avoid their use in Hazardous Areas for example. This especially applies where equipment is used in areas containing potentially flammable dust deposits. • Relevant anti-static PPE may also apply within areas and confines of equipment during cleaning or similar non-production tasks where flammable material may be liberated from tank deposits etc. Man-made fibres should typically be avoided where persons are routinely exposed to flammables. An example ‘safe’ vacuum cleaner is shown below but EX floor cleaners, extraction fans and other similar equipment are available to minimise safety issues and avoid incidents within areas that may contain a local flammable atmosphere: • Fire prevention is a key objective and all information on safety data sheets (SDS) should be considered to avoid incident and incorporated into site procedures - e.g., requirement for earthing measures applies to most flammable solvents or combustible dust. Information for many solvents and gases also identifies that potential vapour is heavier than air and should be collected at source – thus low level or targeted, ideally explosion-proof, extract applies where such substances are handled in enclosed areas.	Review site materials SDS, and minimise inventories (RT1) Review, improve, and maintain high standard of housekeeping (RA4)
8.8.2 Emergency response e.g., response to spills of liquids etc.: The site to review its emergency response plan and include for flammable gases and liquids loss of containment, e.g. during delivery offloading or in maintenance areas.	Exists? DSEAR included? (RT2)
8.8.3 Delivery offloading procedures: The site to review its documented procedures for gases and solvents and delivery operations.	Exists? DSEAR included? (RT3)

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Organisational Measures	Compliance
8.8.4 Hot work procedures: As mentioned above, and re-iterated here because of importance. Evidence of a hot work permit system in addition to an associated permit to work procedure not seen. The procedure would have to include a list of activities on site which constitute hot work. The hot work permit would only be issued by the site engineering manager. Given the level of risk at site, it is thought that possession of a flammable gas detector for use in conjunction with the hot work permit to ensure that an area is 'gas free' before starting work and that it remains so throughout the work duration, would bring meaningful benefit.	Exists? DSEAR included? (RT4)
8.8.5 Safe isolation procedures Isolation of incorrect items or processes within Hazardous Areas may expose personnel to flammable substances, or sources of ignition, therefore correctly applied and documented safe systems of isolation are critical. Isolation methodologies to be reviewed, and ensured that plant items and processes to be isolated are readily identified, with isolation points correctly identified and operable. Means of securing the isolation point, such as locks to be used. Means of recording the isolation, such that isolation cannot be removed unless authorised to be ensured. A typical safe system of isolation is referred to as lock-out tag-out (LOTO).	Exists? DSEAR included? (RT5)
8.8.6 Change management / management of plant modifications: Operational change management procedures to be reviewed. Any plant or procedural modifications require formal controls and authorisation.	Exists? DSEAR included? (RT6)
8.8.7 Hazardous Area Classification Reviews: The site to develop a HAC review procedure within its asset care and safety management system.	Exists? (RT7)
8.8.8 Operating procedures / training: Work instructions to be reviewed. Scenario specific procedures to be developed. These are noted in the recommendations section. And it is expected that they will be implemented with due regard to regulatory requirements.	Exist? (RR2) (RT8)
8.8.9 DSEAR training: DSEAR awareness training to be provided for all relevant site personnel. The training requires being refreshed on a periodic basis.	Exists? (RR1) (RT9)
8.8.10 Incident investigation: Incident investigation procedures to be reviewed. All incidents to be formally investigated, with the level of investigation being proportional to the severity of the incident. All required actions are to be followed up. The site also to review requirement for a near miss reporting system and a first aid book for minor injuries. For example, problems with electrostatic shocks or breaks in an earthing connection would be reported by the near miss system.	Exists? DSEAR included? (RT10)

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Organisational Measures	Compliance
8.8.11 First aid: First aid procedures to be reviewed, although it is understood that the site has several trained first aiders and a first aid injury reporting system.	Exists? DSEAR scenarios included? (RT11)
8.8.12 Emergency training: Fire management procedure to be reviewed. Planned fire evacuation drills throughout the year are good practice. Additionally, it is recommended, in coordination with the local fire service, to carry out site emergency drills for critical areas. Fire extinguisher training to be reviewed, plus the appointment of fire wardens. Fire warden responsibilities to check all site extinguishers on a monthly basis as well as fire alarms and emergency lighting, etc. This to be backed up by formal periodic inspections by a competent external contractor. The fire alarm system to be serviced by an external competent contractor.	Exists? DSEAR included? (RT2) (RT12)
8.8.13 Procurement procedures: Site should review whether it has formal procedures for procurement of equipment to be located in Hazardous Areas. All purchases should be authorised by the engineering manager or a nominated competent person, who is familiar with the locations of Hazardous Areas and the need to purchase EX certified equipment.	Exists? DSEAR included? (RT13)
8.8.14 Calibration procedures: Any DSEAR safety critical measuring devices (e.g., a portable gas detector) to be part of a formal recorded schedule and procedure.	Exists? DSEAR included? (RT14)
8.8.15 Testing of footwear: The site should review the requirement to test static dissipative qualities of personnel footwear. If it is found that this is a requirement, then a footwear tester (e.g., Newson Gale 'Solemate') to be used and a formal recorded procedure implemented.	Exists? (RT15)
8.8.16 Proof testing: If any safety interlocks / Safety Instrumented Systems exist. If they do then proof testing is required to be carried out at specified intervals dependent upon criticality, as part of routine planned maintenance checks.	Exists? DSEAR included? (RT16)
8.8.17 Inspection of protection systems: If protection systems exist, such as flame arresters and explosion vents on filters, they should be on a recorded inspection and maintenance schedule.	Exists? DSEAR included? (RT17)
8.8.18 Earth testing: Where they exist, earth leads are to be tested monthly, which includes both a visual inspection and resistance measurement. Requires being a formal recorded procedure.	Exists? (RT18)
8.8.19 Inspection of vulnerable plant items: The site to review the use of vulnerable items, such as flexible hose, and include on a recorded inspection schedule by the maintenance team.	Exists? (RT19)

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Organisational Measures	Compliance
8.8.20 Bunding / Containment inspections: Where relevant, bunds and spill containment to be on a recorded inspection schedule by the maintenance team.	Exists? (RT20)
8.8.21 Inspection of low pressure storage tanks: Where relevant, tanks are required to be on a formalised inspection schedule. UK HSE guidance SPC/Tech/Gen/35 Integrity of Atmospheric Tanks to be followed.	Exists? (RT21)
8.8.22 Hazardous Area electrical equipment inspection: These will be required to be implemented to BS-EN 60079-17 by either in-house or an external competent contractor (COMPEX trained). The inspections to focus on electrical equipment in existing designated Hazardous Areas and their inspection programme. BS EN 60079-17:2014 Explosive atmospheres - Part 17: Electrical installations inspection and maintenance is the recognised UK standard for inspections and maintenance in Hazardous Zones. This can be supplemented by Energy Institute Guidelines for managing inspection of Ex electrical equipment ignition risk in support of BS EN 60079-17. ATEX specifies three grades of inspections following what is termed the “initial” inspection on commissioning. The three grades of inspection are: • Visual: inspection which identifies, without the use of access equipment or tools, those defects, such as missing bolts, which will be apparent to the eye. • Close: inspection which encompasses those aspects covered by a visual inspection and, in addition, identifies those defects, such as loose bolts, which will be apparent only by the use of access equipment. • Detailed: inspection which encompasses those aspects covered by a close inspection and, in addition, identifies those defects, such as loose terminations, which will only be apparent by opening the enclosure, and/or using, where necessary, tools and test equipment. The latest revision of BS EN 60079 Part 17 defines a possible regime based upon experience using continuous inspection defined as frequent attendance, inspection, service, care, and maintenance of the electrical installation by skilled personnel who have experience in the specific installation and its environment in order to maintain the explosion protection features of the installation in satisfactory condition. BS EN 60079-17 provides descriptions of competency required by people working in hazardous zones.	Exists? (RT22) Frequency for equipment within area: Zone 0/20 – 100% per year Zone 1/21 – 50% per year Zone 2/22 – initially 33% per year
8.8.23 Use of mobile phones and other portable communication equipment: The site should have a policy that no mobile phones are allowed in Hazardous Areas unless suitably certified.	Exists? (RT23)

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Organisational Measures	Compliance
8.8.24 Maintenance procedures on Hazardous Area non-electrical equipment: Where non-electrical equipment is installed within Hazardous Areas, planned maintenance procedures are required. For example, lubrication regimes.	Exists? (RT24)
8.8.25 Procedures for maintaining emergency equipment: Formal procedures to be reviewed, along with any schedules for recording these activities.	Exists? (RT25)
8.8.26 Competency of staff / contractors: This includes competency for tasks such as making up pipe connections, inspecting electrical equipment, maintaining mechanical equipment such as pumps, earth testing etc. The site to review its competency assessment system for maintenance staff, and retain records. External contractors should be required to demonstrate the competency of their staff before being awarded a contract.	Exists? (RT26)
8.8.27 Servicing of gas fired equipment: Where relevant, evidence of regular scheduled maintenance and written scheme examinations to be filed within the site's asset care and safety management system.	Exists? (RT27)
8.8.28 Procedures for risk assessment: Review of procedures for risk assessment to include DSEAR risk assessment.	Exists? DSEAR included? (RT28)
8.8.29 Safety auditing: Auditing of DSEAR compliance on an on-going basis should be integrated into the site's safety-auditing programme. A regular compliance audit should be conducted to ensure, for example, that procedures necessary to ensure the basis of safety in each area are being adhered to. This could be an extension of the existing safety-auditing programme rather than a standalone audit.	Exists? DSEAR included? (RT29)
8.8.30 DSEAR signage: Review and implement Regulatory requirement to place 'EX' signs at entry points to the designated Hazardous Areas.	Exists? (RQ2)(RT30)

8.9 Compliance with DSEAR Regulations 8 to 11.

Compliance with Regulation 8: Requirement for Emergency Procedures: Guidance

DSEAR Regulation 8 requires, for every *significant* hazard identified by a risk assessment:

- 1 Procedures, information, warning systems, remedial actions, escape facilities are in place in case of accidents, incidents, and emergencies
- 2 Liaison with the emergency services
- 3 Ensure situation is mitigated and restored after an incident, with access restricted to those who are rendering the area safe, who should have appropriate PPE and specialised safety equipment

Compliance with Regulation 9: Requirement for Information and Training: Guidance

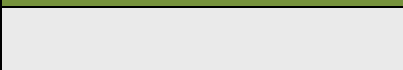
DSEAR Regulation 9 requires suitable and sufficient information, instruction and training on the appropriate precautions and actions to be taken by the employee in order to safeguard those at the workplace. The names, risks, data sheets and any legislative provisions of hazardous materials should be made available at the workplace, along with the significant findings of any risk assessments.

Suggested training requirements	
Who to train	Training requirement
Senior management	Their legal responsibilities
All personnel	The general DSEAR requirements. The hazardous materials on site and their locations.
All plant personnel working in hazardous areas and with flammable materials	An understanding of the hazards of the flammable materials, and the requirements to prevent ignition.
Project/maintenance personnel	The requirements for specification, installation and inspection of electrical and non-electrical equipment installed in hazardous areas.
Safety professionals, department managers	The safe systems of work to ensure continued compliance. Initial and refresher training requirements.

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Compliance with DSEAR Regulation 10 Requirement for Marking of Pipes and containers

DSEAR Regulation 10 requires the identification of pipes and containers, particularly those that are visible, to alert employees and others to the presence of a dangerous substance so that they can take the necessary precautions. Identification can also help to avoid confusion over contents and thereby avoid incorrect mixing of contents.

Basic identification colours			
Pipe Contents	Basic Identification Colour	BS Colour Reference BS 4800	Example
Air	Light blue - Cornflower blue / Corfu	20 E 51	
Water	Green - Dark laurel / Tundra / Sherwood	12 D 45	
Steam	Silver grey - Dawn grey / Sink grey / Flake grey	10 A 03	
Gases (except air) in either gaseous or liquefied state	Yellow ochre	08 C 35	
Acids & Alkalis	Purple	24 E 53	
Hazardous substances	Canary Yellow	10 E 55	
Fire water mains	Red	04 E 55	
Flammable & combustible liquids; mineral, vegetable, and animal oils	Brown - Saddle brown / Saddle	06 C 39	
Other fluids	Black	00 E 53	

DSEAR Regulation 10 requires that all containers and pipes carrying flammable liquids and gases should be marked accordingly. Containers of raw materials are labelled according to CLP Regulations⁴⁸.

⁴⁸ The CLP Regulation. European Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures came into force on 20 January 2009 in all EU Member States, including the UK. It is known by its abbreviated form, 'the CLP Regulation' or just plain 'CLP'

DSEAR Regulation 11: Requirement for Duty of Coordination

DSEAR Regulation 11 requires that where two or more employers share the same workplace where an explosive atmosphere may occur, the employer responsible for workplace shall co-ordinate the implementation of all measures required by DSEAR to protect employees and others at the workplace from any risk from the explosive atmosphere.

This requirement is usually satisfied as follows:

- Visitors are accompanied on site and sign in, either for treatment or to visit departments/wards.
- Contractor induction, RAMS, and permit to work.

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8.10 DSEAR RISK ASSESSMENT

8.10.1 Utilities and Maintenance areas

8.10.1.1 Fire and explosion at gas cylinder store

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.1.1	Fire and explosion at gas cylinder store / cylinder explosion	Fire and possible cylinder explosion, with: P - Potential severe injury to person in the area from thermal radiation. E - Release on-site, RIDDOR A - Damage to store area, minor business disruption. R - Regional media attention S - Intrusion and sabotage on site	Damage to cylinder, leak of gas, ignition by one of: Hot surfaces, naked flames, mechanically generated sparks, malfunctioning electrical apparatus, static	<table><tr><td>P</td><td>S3 / F5</td></tr><tr><td>E</td><td>S2 / F5</td></tr><tr><td>A</td><td>S2 / F5</td></tr><tr><td>R</td><td>S3 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S3 / F5	E	S2 / F5	A	S2 / F5	R	S3 / F5	S	S2 / F5	1 - Current controls as per Section 6.1.1 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F4</td></tr><tr><td>E</td><td>S2 / F4</td></tr><tr><td>A</td><td>S2 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S2 / F4	E	S2 / F4	A	S2 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.1.1 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Ensure gas cylinder inventory and storage and use arrangements in-line with BCGA guidance
P	S3 / F5																																						
E	S2 / F5																																						
A	S2 / F5																																						
R	S3 / F5																																						
S	S2 / F5																																						
P	S2 / F4																																						
E	S2 / F4																																						
A	S2 / F4																																						
R	S2 / F4																																						
S	S2 / F4																																						
P	S2 / F3																																						
E	S2 / F3																																						
A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

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8.10.1.2 Fire and explosion at air receivers

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.1.2	Fire and explosion at air receivers	Fire spread to air receivers, with: P - Potential moderate injury to person in the area from thermal radiation. E - Release on-site, RIDDOR A - Damage to store area, minor business disruption. R - External complaint, internal concern S - Intrusion and sabotage on site	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus, static	<table><tr><td>P</td><td>S2 / F5</td></tr><tr><td>E</td><td>S2 / F5</td></tr><tr><td>A</td><td>S2 / F5</td></tr><tr><td>R</td><td>S2 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S2 / F5	E	S2 / F5	A	S2 / F5	R	S2 / F5	S	S2 / F5	1 - Current controls as per Section 6.1.2 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F4</td></tr><tr><td>E</td><td>S2 / F4</td></tr><tr><td>A</td><td>S2 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S2 / F4	E	S2 / F4	A	S2 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.1.2 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Ensure air receivers PRVs inspected and tested periodically in line with PSSR
P	S2 / F5																																						
E	S2 / F5																																						
A	S2 / F5																																						
R	S2 / F5																																						
S	S2 / F5																																						
P	S2 / F4																																						
E	S2 / F4																																						
A	S2 / F4																																						
R	S2 / F4																																						
S	S2 / F4																																						
P	S2 / F3																																						
E	S2 / F3																																						
A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

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8.10.1.3 Fire and explosion at diesel storage tank

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.1.3	Fire and explosion at diesel storage tank	Flammable liquid ignition, fire spread, with: P - Potential severe injury to person within the building from smoke or thermal radiation. E - Release on-site, RIDDOR A - Damage to building, business disruption. R - Regional media attention S - Intrusion and sabotage on site	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus, static	<table><tr><td>P</td><td>S3 / F5</td></tr><tr><td>E</td><td>S2 / F5</td></tr><tr><td>A</td><td>S3 / F5</td></tr><tr><td>R</td><td>S3 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S3 / F5	E	S2 / F5	A	S3 / F5	R	S3 / F5	S	S2 / F5	1 - Current controls as per Section 6.1.3 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F4</td></tr><tr><td>E</td><td>S2 / F4</td></tr><tr><td>A</td><td>S2 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S2 / F4	E	S2 / F4	A	S2 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.1.3 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Risk reduction measures based on VICES principle: V entilation to disperse vapours / dusts I gnition avoidance controls C ontainment suitability E xchange hazardous materials for less hazardous alternatives S eparation of hazardous materials Manage the flammables areas in accordance with HSE guidelines HSG140: Safe use and handling of flammable liquids
P	S3 / F5																																						
E	S2 / F5																																						
A	S3 / F5																																						
R	S3 / F5																																						
S	S2 / F5																																						
P	S2 / F4																																						
E	S2 / F4																																						
A	S2 / F4																																						
R	S2 / F4																																						
S	S2 / F4																																						
P	S2 / F3																																						
E	S2 / F3																																						
A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

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8.10.1.4 Fire and explosion at emergency generator

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.1.4	Fire and explosion at emergency generator	Flammable liquid ignition, fire, with: P - Potential moderate injury to person in the area from thermal radiation. E - Release on-site, RIDDOR A - Damage to asset, business disruption. R - External complaint, internal concern S - Intrusion and sabotage on site	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus, static	<table><tr><td>P</td><td>S2 / F5</td></tr><tr><td>E</td><td>S2 / F5</td></tr><tr><td>A</td><td>S3 / F5</td></tr><tr><td>R</td><td>S2 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S2 / F5	E	S2 / F5	A	S3 / F5	R	S2 / F5	S	S2 / F5	1 - Current controls as per Section 6.1.4 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F4</td></tr><tr><td>E</td><td>S2 / F4</td></tr><tr><td>A</td><td>S2 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S2 / F4	E	S2 / F4	A	S2 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.1.4 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Ensure generator inspected and tested periodically in line with manufacturer's instructions
P	S2 / F5																																						
E	S2 / F5																																						
A	S3 / F5																																						
R	S2 / F5																																						
S	S2 / F5																																						
P	S2 / F4																																						
E	S2 / F4																																						
A	S2 / F4																																						
R	S2 / F4																																						
S	S2 / F4																																						
P	S2 / F3																																						
E	S2 / F3																																						
A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

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8.10.1.5 Fire and explosion due to flammable liquid spill

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.1.5	Fire and explosion due to flammable liquid spill	Flammable liquid ignition, fire spread, with: P - Potential severe injury to person within the building from thermal radiation. E - Release on-site, RIDDOR A - Damage to building, business disruption. R - Regional media attention S - Intrusion and sabotage on site	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus, static	<table><tr><td>P</td><td>S3 / F5</td></tr><tr><td>E</td><td>S2 / F5</td></tr><tr><td>A</td><td>S3 / F5</td></tr><tr><td>R</td><td>S3 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S3 / F5	E	S2 / F5	A	S3 / F5	R	S3 / F5	S	S2 / F5	1 - Current controls as per Section 6.1.5 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F4</td></tr><tr><td>E</td><td>S2 / F4</td></tr><tr><td>A</td><td>S2 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S2 / F4	E	S2 / F4	A	S2 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.1.5 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Risk reduction measures based on VICES principle: Ventilation to disperse vapours / dusts Ignition avoidance controls Containment suitability Exchange hazardous materials for less hazardous alternatives Separation of hazardous materials Manage the flammables areas in accordance with HSE guidelines HSG140: Safe use and handling of flammable liquids
P	S3 / F5																																						
E	S2 / F5																																						
A	S3 / F5																																						
R	S3 / F5																																						
S	S2 / F5																																						
P	S2 / F4																																						
E	S2 / F4																																						
A	S2 / F4																																						
R	S2 / F4																																						
S	S2 / F4																																						
P	S2 / F3																																						
E	S2 / F3																																						
A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

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8.10.2 Mechanical treatment areas

8.10.2.1 Fire in receiving hall and separation room

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.2.1	Fire in receiving hall and separation room	Fire with plant area, with: P - Potential severe injury to person within the building from smoke or thermal radiation. E - Release off-site, regulator action A - Damage to building, major business disruption. R - National media attention S - Intrusion and sabotage on site	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus	<table><tr><td>P</td><td>S3 / F5</td></tr><tr><td>E</td><td>S3 / F5</td></tr><tr><td>A</td><td>S4 / F5</td></tr><tr><td>R</td><td>S4 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S3 / F5	E	S3 / F5	A	S4 / F5	R	S4 / F5	S	S2 / F5	1 - Current controls as per Section 6.2.1 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F4</td></tr><tr><td>E</td><td>S2 / F4</td></tr><tr><td>A</td><td>S2 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S2 / F4	E	S2 / F4	A	S2 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.2.1 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Risk to be managed as part of site's existing FRA
P	S3 / F5																																						
E	S3 / F5																																						
A	S4 / F5																																						
R	S4 / F5																																						
S	S2 / F5																																						
P	S2 / F4																																						
E	S2 / F4																																						
A	S2 / F4																																						
R	S2 / F4																																						
S	S2 / F4																																						
P	S2 / F3																																						
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A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

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8.10.3 Anaerobic Digestion plant areas

8.10.3.1 Fire and explosion in AD plant

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.3.1	Fire at AD plant gas production, storage and/or equipment	Gas explosion, fire spread, with: P - Potential fatality / severe injuries to personnel within the plant from overpressure, smoke, or thermal radiation. E - Offsite release, regulator fine A - Catastrophic damage to plant, site shutdown due to rebuild. R - National media attention S - Intrusion and sabotage	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus, static, lightning	<table><tr><td>P</td><td>S4 / F5</td></tr><tr><td>E</td><td>S4 / F5</td></tr><tr><td>A</td><td>S5 / F5</td></tr><tr><td>R</td><td>S4 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S4 / F5	E	S4 / F5	A	S5 / F5	R	S4 / F5	S	S2 / F5	1 - Current controls as per Section 6.3.1 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S3 / F4</td></tr><tr><td>E</td><td>S3 / F4</td></tr><tr><td>A</td><td>S4 / F4</td></tr><tr><td>R</td><td>S3 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S3 / F4	E	S3 / F4	A	S4 / F4	R	S3 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.3.1 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Equipment to be operated and maintained as per HSE regulatory, IGEM, and EA guidelines, and manufacturer's instructions
P	S4 / F5																																						
E	S4 / F5																																						
A	S5 / F5																																						
R	S4 / F5																																						
S	S2 / F5																																						
P	S3 / F4																																						
E	S3 / F4																																						
A	S4 / F4																																						
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A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

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8.10.3.2 Fire and explosion in AD flare unit

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.3.2	Fire at AD flare unit	Gas explosion, fire spread, with: P - Potential fatality / severe injuries to personnel in area from overpressure, smoke, or thermal radiation. E - Offsite release, regulator fine A - Damage to asset, business disruption. R - Regional media attention S - Intrusion and sabotage	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus, static, lightning	<table><tr><td>P</td><td>S4 / F5</td></tr><tr><td>E</td><td>S4 / F5</td></tr><tr><td>A</td><td>S3 / F5</td></tr><tr><td>R</td><td>S3 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S4 / F5	E	S4 / F5	A	S3 / F5	R	S3 / F5	S	S2 / F5	1 - Current controls as per Section 6.3.2 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S3 / F4</td></tr><tr><td>E</td><td>S3 / F4</td></tr><tr><td>A</td><td>S3 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S3 / F4	E	S3 / F4	A	S3 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.3.2 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Equipment to be operated and maintained as per HSE regulatory, IGEM, and EA guidelines, and manufacturer's instructions
P	S4 / F5																																						
E	S4 / F5																																						
A	S3 / F5																																						
R	S3 / F5																																						
S	S2 / F5																																						
P	S3 / F4																																						
E	S3 / F4																																						
A	S3 / F4																																						
R	S2 / F4																																						
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8.10.3.3 Fire and explosion in AD gas boiler

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.3.3	Fire at AD gas boiler	Gas explosion, fire spread, with: P - Potential severe injury to person within the building from smoke or thermal radiation. E - Release on-site, RIDDOR A - Damage to asset, business disruption. R - Regional media attention S - Intrusion and sabotage on site	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus, static	<table><tr><td>P</td><td>S3 / F5</td></tr><tr><td>E</td><td>S2 / F5</td></tr><tr><td>A</td><td>S3 / F5</td></tr><tr><td>R</td><td>S3 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S3 / F5	E	S2 / F5	A	S3 / F5	R	S3 / F5	S	S2 / F5	1 - Current controls as per Section 6.3.3 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F4</td></tr><tr><td>E</td><td>S2 / F4</td></tr><tr><td>A</td><td>S2 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S2 / F4	E	S2 / F4	A	S2 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.3.3 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Equipment to be operated and maintained as per HSE regulatory, and IGEM guidelines, and manufacturer's instructions
P	S3 / F5																																						
E	S2 / F5																																						
A	S3 / F5																																						
R	S3 / F5																																						
S	S2 / F5																																						
P	S2 / F4																																						
E	S2 / F4																																						
A	S2 / F4																																						
R	S2 / F4																																						
S	S2 / F4																																						
P	S2 / F3																																						
E	S2 / F3																																						
A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

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8.10.3.4 Fire and explosion in AD CHP gas engines

Item No.	HAZARD	CONSEQUENCE	CAUSE	RAW RISK	EXISTING CONTROLS & MITIGATION	CURRENT RISK	FURTHER CONTROLS & MITIGATION	RESIDUAL RISK	FURTHER COMMENTS																														
8.10.3.4	Fire at AD CHP gas engines	Gas explosion, fire spread, with: P - Potential severe injury to person within the building from smoke or thermal radiation. E - Release on-site, RIDDOR A - Damage to asset, major business disruption. R - Regional media attention S - Intrusion and sabotage on site	Local ignition by one of: Naked flames, hot surfaces, mechanically generated sparks, malfunctioning electrical apparatus, static	<table><tr><td>P</td><td>S3 / F5</td></tr><tr><td>E</td><td>S2 / F5</td></tr><tr><td>A</td><td>S4 / F5</td></tr><tr><td>R</td><td>S3 / F5</td></tr><tr><td>S</td><td>S2 / F5</td></tr></table>	P	S3 / F5	E	S2 / F5	A	S4 / F5	R	S3 / F5	S	S2 / F5	1 - Current controls as per Section 6.3.4 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S3 / F4</td></tr><tr><td>E</td><td>S2 / F4</td></tr><tr><td>A</td><td>S3 / F4</td></tr><tr><td>R</td><td>S2 / F4</td></tr><tr><td>S</td><td>S2 / F4</td></tr></table>	P	S3 / F4	E	S2 / F4	A	S3 / F4	R	S2 / F4	S	S2 / F4	1 - Implement control measures as per Section 6.3.4 2 - Implement ignition control measures as per Section 8.7 3 - Implement organisational measures as per Section 8.8 The above measures reduce the severity and frequency of the risk	<table><tr><td>P</td><td>S2 / F3</td></tr><tr><td>E</td><td>S2 / F3</td></tr><tr><td>A</td><td>S2 / F3</td></tr><tr><td>R</td><td>S2 / F3</td></tr><tr><td>S</td><td>S2 / F3</td></tr></table>	P	S2 / F3	E	S2 / F3	A	S2 / F3	R	S2 / F3	S	S2 / F3	Equipment to be operated and maintained as per HSE regulatory, IGEM, and EA guidelines, and manufacturer's instructions
P	S3 / F5																																						
E	S2 / F5																																						
A	S4 / F5																																						
R	S3 / F5																																						
S	S2 / F5																																						
P	S3 / F4																																						
E	S2 / F4																																						
A	S3 / F4																																						
R	S2 / F4																																						
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P	S2 / F3																																						
E	S2 / F3																																						
A	S2 / F3																																						
R	S2 / F3																																						
S	S2 / F3																																						

9.0 RECOMMENDATIONS

9.1 Recommendations

DSEAR Hierarchy: Address the hierarchy of risk reduction measures

Firstly, preventative - A to H

Secondly, protective - I to P

Third, indicative - Q to T

Priority ranking guide:

- A Prior to use / as soon as possible
- B Implement or place on Corrective Action Plan within 3 months
- C As soon as practicable (12 months)

Item	Action Ref.	Report Section	Recommendations against DSEAR 2002 hierarchy	Action Priority	Completed (Date / Sign)
1	RA1	6.1.1 6.1.3 6.1.5	Review and ensure types and quantities of substances do not exceed activity requirements	B	
2	RA2	6.1.1	Ensure temporary gas cylinder stores are at external, secure, and well ventilated locations	B	
3	RA3	6.1.1	Arrange for prompt disposal of flammable gas cylinders from site	B	
4	RA4	6.1.3 6.1.5 6.2.1 8.7.13 8.8.1	Review, improve, and maintain high standard of housekeeping	B	
5	RA5	6.1.5	Review inventory of legacy hazardous substances and remove redundant stocks	B	
6	RA6	6.1.5	Ensure a maximum of 250 litres of flammable liquids only is stored in one location, of which 50 litres may be highly flammable	B	
7	RA7	6.1.5	Remove not in use containers of flammable liquids to secure, spill containing, fire resistant cabinets / chests	B	
8	RA8	6.1.5	Review and ensure bins emptied regularly	B	
9	RB1	6.1.1	Ensure cylinder stores locked when not in use	B	
10	RB2	6.1.1	Ensure cylinders chained upright	B	
11	RB3	6.1.1 6.1.2 6.3.1 6.3.2 6.3.3 6.3.4	Ensure pipework adequately identified	B	
12	RB4	6.1.1	Ensure gas cylinder equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor	C	

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13	RB5	6.1.3	Implement robust impact protection barrier around tank	B	
14	RB6	6.1.3 6.1.4 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Review and ensure satisfactory operation of excess high / low condition switches and alarms	B	
15	RB7	6.1.3 6.1.4 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Ensure alarm switches placed on critical items register and recorded service contracts arranged with specialist sub-contractor	C	
16	RB8	6.1.3 6.1.4 6.2.1 6.3.1 6.3.3 6.3.4	Review maintenance and leak prevention for rotating equipment	B	
17	RB9	6.1.3 6.1.4 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Review maintenance and leak prevention for equipment connections and access hatches	B	
18	RB10	6.1.3	Ensure hose stowed away from roadway when not in use	B	
19	RB11	6.1.5	Ensure hazardous liquids stood on secondary spill containing pallets / trays	B	
20	RB12	6.1.5	Ensure substances stored appropriately in single layers within storage enclosures	B	
21	RB13	6.2.1 6.3.1 6.3.2	Ensure process equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor	C	
22	RB14	6.3.1	Ensure pipework is maintained in good condition	B	
23	RB15	6.3.2	Ensure flare unit is maintained in good condition	B	
24	RB16	6.3.2	Ensure stack refractory lining is maintained in good condition	B	
25	RC1	6.1.1	Ensure gas cylinder valves are closed during storage	B	
26	RC2	6.1.1 6.1.2 6.1.3 6.3.1 6.3.2	Ensure isolation valves are identified and operable	B	

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		6.3.3			
27	RC3	6.1.1	Ensure flashback arrestor installed	B	
28	RC4	6.1.2	Ensure receiver tank and distribution system placed on critical items register and ensure recorded service contracts arranged with specialist sub-contractor	C	
29	RC5	6.1.3 6.1.4 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Review and ensure satisfactory operation of control system inputs and outputs and associated control equipment	B	
30	RC6	6.1.3	Ensure tank and dispenser placed on critical items register and ensure recorded inspection and service contract arranged with specialist sub-contractor	C	
31	RC7	6.1.4	Ensure generator placed on critical items register and recorded inspection and service contract arranged with specialist sub-contractor	C	
32	RC8	6.1.5	Ensure storage enclosures locked when not in use	B	
33	RC9	6.1.5	Decanting: Flammable solvent inventory within the area should be minimised / controlled at all times	B	
34	RC10	6.1.5	Decanting: Utilise secondary containment / bunded trays or similar for holding flammable containers	B	
35	RC11	6.1.5	Decanting: Ensure adequate ventilation for dispensing / decanting of flammable solvents.	B	
36	RC12	6.1.5	Decanting: Ensure adequate earthing for dispensing / decanting of flammable solvents.	B	
37	RC13	6.1.5	Decanting: Use only metallic containers	B	
38	RC14	6.1.5	Decanting: Limit the flow rate	B	
39	RC15	6.1.5	Decanting: Avoid splashing where possible	B	
40	RC16	6.1.5	Decanting: Avoid open containers / faulty containers and subsequent vapour potential at all times	B	
41	RC17	6.1.5	Ensure use of top mounted dispensing pumps for medium and large containers	B	
42	RC18	6.2.1 6.3.1 6.3.2	Ensure process control equipment placed on critical items register and recorded service contracts arranged with specialist sub-contractor	C	

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43	RC19	6.3.2	Implement approved AIV to gas incomer	B	
44	RC20	6.3.2	Ensure overheat / fusible link implemented above boiler	B	
45	RC21	6.3.2 6.3.3 6.3.4	Ensure emergency gas isolation equipment placed on critical items register and recorded service contract arranged with specialist contractor	C	
46	RD1	6.1.1	Ensure gas cylinders are stored in adequately ventilated locations	B	
47	RD2	6.1.5	Ensure ventilation to enclosed and open stores is adequate and achieves 0.1m/s and 5ACH	B	
48	RD3	6.1.5	Ensure hazardous waste stored in external well ventilated location	B	
49	RD4	6.2.1	Ensure MEV systems are interlocked to functioning of required machinery	B	
50	RD5	6.2.1	Review and ensure satisfactory performance of MEV systems	B	
51	RD6	6.2.1 6.3.1	Ensure installed gas detection and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor	C	
52	RD7	6.3.1	Seriously consider implementing nitrogen purging to process tanks during start-up and shut-down	B	
53	RD8	6.3.2 6.3.3 6.3.4	Ensure measures to prevent formation of an explosive atmosphere are documented, and reviewed periodically	C	
54	RD9	6.3.3	Implement local alarm indication outside of boiler enclosure	B	
55	RD10	6.3.3	Consider replacing gas pressure booster fan with enclosed / separated seal type	B	
56	RE1	6.1.1	Observe minimum separation distances for gas cylinder stores	B	
57	RE2	6.1.3 6.1.4 6.1.5	Ensure spill kits available in areas	B	
58	RE3	6.2.1	Review and ensure satisfactory performance of odour control and containment measures	C	
59	RE4	6.2.1	Use vacuum cleaner as required to ensure surfaces and ledges are regularly cleaned to remove dust accumulations	B	
60	RE5	6.2.1 6.3.1 6.3.2	For releases of a dangerous substance, ensure measures to contain or collect or remove to a safe place are documented, and reviewed periodically	C	

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61	RE6	6.3.1	Review and ensure satisfactory performance of relief systems	B	
62	RE7	6.3.1	Ensure scrubber arrangements to gas storage membrane are fit for purpose	B	
63	RE8	6.3.2 6.3.3 6.3.4	Review and ensure satisfactory performance of flue systems	B	
64	RE9	6.3.4	Review and ensure satisfactory performance of ventilation systems	B	
65	RF1	6.1.1 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Ensure all plant, equipment and structures adequately earthed	B	
66	RF2	6.1.1 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4 8.7.5 8.7.6	Where earth connections exist, these should be on a recorded schedule of earth resistance measurement	C	
67	RF3	6.1.1 6.1.3 6.1.4 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Verify earth resistance of circuit protective conductors for any electrical equipment	B	
68	RF4	6.1.1 6.1.3 6.1.4 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Ensure electrical circuits adequately identified	B	
69	RF5	6.1.1 6.1.3 6.1.4 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Ensure adequate identification of main isolation points	B	

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70	RF6	6.1.1 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4 6.4.1 8.7.1 8.7.3 8.7.4	Ensure electrical and mechanical equipment properly maintained so as to prevent being a source of ignition	C	
71	RF7	6.1.1 6.1.3 6.1.4 6.1.5 6.3.1 6.3.2 6.3.3 6.3.4	Utilise static dissipative footwear and clothing, mats, and floor coatings	B	
72	RF8	6.1.1 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4 8.7.2	Rigorously control / separate flammables from personal sources of ignition	B	
73	RF9	6.1.1	Ensure no sources of ignition within separation distance of flammable gas stores	B	
74	RF10	6.3.1 6.3.2 6.3.3 6.3.4	Ensure earthing system for EX electrical installation is TN-S, IT or TT, not TN-C, TN-C-S	B	
75	RF11	6.3.1 6.3.2 6.3.3 6.3.4	Ensure electrical switches, contactors and relays remove power from both phase and neutral conductors	B	
76	RF12	6.3.1 6.3.2 6.3.3 6.3.4	Ensure electrical and mechanical equipment within Hazardous Areas is suitably EX rated	B	
77	RF13	6.3.1 6.3.2 6.3.3 6.3.4	Ensure EX equipment is installed as per the X conditions on accompanying ATEX certificates	B	
78	RF14	6.3.1 6.3.2 6.3.3 6.3.4	Ensure robust barriers installed to cable and pipework routes between Hazardous Areas and non-Hazardous Areas	B	
79	RF15	6.3.1 6.3.2 6.3.3	Ensure electrical installation within area is approved by EX certified electrical supervisor	B	

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		6.3.4			
80	RF16	6.3.1 6.3.2 6.3.3 6.3.4	Place EX equipment on critical items register and ensure recorded service contracts arranged with specialist sub-contractor	C	
81	RF17	6.1.3	Implement delivery tanker earthing point	B	
82	RF18	6.1.3	Ensure vehicle ignition systems switched off during refuelling	B	
83	RF19	6.3.1	Ensure no uncontrolled sources of ignition within separation distance of gas storage membrane	B	
84	RF20	6.3.1 8.7.7	Ensure lightning protection systems installations completed to process tanks, and new lightning protection system installed around gas holder	B	
85	RF21	6.3.1	Ensure lightning protection system placed on critical items register and recorded service contracts arranged with specialist sub-contractor	C	
86	RF22	6.3.2	Replace damaged junction boxes with suitably heat resistant items	B	
87	RF23	6.3.3	Remove or relocate non-EX equipment from Hazardous Areas	B	
88	RF24	6.3.4	Ensure non-EX equipment is safely isolated in event of gas alarm activation	B	
89	RG1	6.1.1 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Ensure adverse conditions are avoided by use of appropriate detection, isolation, ventilation and if necessary, PPE	B	
90	RG2	6.1.1 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Ensure employee exposure limits are not exceeded by use of appropriate barriers, ventilation and if necessary, PPE	B	
91	RG3	6.1.5	Ensure flammable liquids containers shielded from sunlight if stored externally	B	
92	RH1	6.1.3 6.1.5 6.2.1 6.3.1	Ensure hazardous waste disposed using licenced waste carrier with consignment note received	B	

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93	RH2	6.1.4 6.1.5 6.2.1 6.3.1	Ensure structural steelwork protected from spill of corrosive substances	B	
94	RH3	6.1.5 6.2.1 6.3.1 8.7.13	Ensure minimum separation distances between different classes of hazardous substances are observed	B	
95	RH4	6.1.5 6.2.1 6.3.1	Ensure different waste types are effectively managed to separate waste streams	B	
96	RI1	6.1.1 6.1.2 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Review and minimise personnel attendance at location	B	
97	RI2	6.3.2	Implement fixed barrier at internal AD plant entrance to flare unit area	B	
98	RJ1	6.1.1	Ensure no flammable or combustible materials stored in gas cylinder storage areas	B	
99	RJ2	6.1.3	Ensure combustible material removed from storage tank area	B	
100	RJ3	6.1.3	Consider relocating tank to exterior of building	B	
101	RJ4	6.1.3	If not feasible, then ensure adequate separation distances, or implement adequate fire rated barrier	B	
102	RJ5	6.1.5	Ensure combustible material removed from storage areas	B	
103	RJ6	6.1.5	Ensure stores are located such that propagation of fires or explosion is contained as required for the facility	B	
104	RJ7	6.1.5	Ensure bins / skips are suitably fire resistant	B	
105	RJ8	6.3.1 6.3.3 6.3.4 8.7.12	Seriously consider implementing flame arrestors to gas distribution network	B	
106	RJ9	6.3.1 6.3.2 6.2.3 6.3.4	Ensure measures to avoid propagation of fires and explosions are documented, and reviewed periodically	C	
107	RJ10	6.3.3 6.3.4	Ensure combustible material removed from gas installation areas	B	

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108	RK1	6.1.2 6.3.1	Ensure pressure relief valves on critical items register and checked by specialist sub-contractor at appropriate interval	C	
109	RK2	6.3.1	Ensure relief hatches on critical items register and checked by specialist sub-contractor at appropriate interval	C	
110	RN1	6.1.1	Ensure authorised contractors adhere to site PPE rules	B	
111	RO1	6.1.1 6.1.5 6.3.2 6.3.3	Ensure means of raising alarm readily identifiable and operable from a safe place implemented	B	
112	RO2	6.1.1 6.1.2 6.1.3 6.3.1 6.3.2 6.3.3 6.3.4	Ensure means of shutting down systems from a safe place provided and readily identified	B	
113	RO3	6.1.1 6.1.2 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Ensure emergency shutdown and alarm systems are placed on critical items register and service contracts arranged with competent specialist sub-contractor	C	
114	RP1	6.1.1 6.1.4 6.1.5 6.3.2 6.3.3	Ensure adequate illumination provided for non-daylight hours or emergency working	B	
115	RP2	6.1.1 6.1.4 6.1.5 6.3.3	Ensure adequate fire-fighting equipment provided in area	B	
116	RQ1	6.1.1 6.1.2 6.1.3 6.1.4 6.1.5 6.3.1 6.3.2 6.3.3 6.3.4	Affix appropriate warning signage at hazardous locations	B	
117	RQ2	6.1.1 6.1.5 6.3.1 6.3.2 6.3.3 6.3.4 8.8.30	Ensure specific EX signage present at entrances to or around Hazardous Areas	B	

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118	RR1	6.1.1 6.1.2 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4 8.8.9	Train staff in COSHH & DSEAR risks	C	
119	RR2	6.1.1 6.1.2 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4 8.8.8	Develop or review procedures for safe operation and maintenance	C	
120	RS1	6.1.1 6.1.3 6.1.4 6.1.5	Provide inventories of dangerous substances	C	
121	RS2	6.1.1 6.1.2 6.1.3 6.1.4 6.1.5 6.2.1 6.3.1 6.3.2 6.3.3 6.3.4	Identify hazardous locations on site emergency response plan	C	
122	RS3	6.3.1 6.3.2 6.3.3 6.3.4	Gas distribution schematic to be produced	B	
123	RT1	8.8.1	Review site materials SDS, and minimise inventories	C	
124	RT2	6.4.2 8.8.2 8.8.12	Review site emergency response plan and include DSEAR risks	C	
125	RT3	8.8.3	Review flammable gases, liquids and dusts delivery offloading and handling procedures	C	
126	RT4	8.7.1 8.7.2 8.7.3 8.8.4	Review work instructions (PTW) and hot work permit arrangements	C	
127	RT5	8.8.5	Review and ensure safe isolation procedures in place and applied correctly	C	
128	RT6	8.8.6	Review Management of Change procedures	C	

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129	RT7	8.8.7	Review DSEAR arrangements & controls after a significant plant change and/or a period of THREE years has elapsed	C	
130	RT8	8.8.8	Review work instructions for DSEAR activities	C	
131	RT9	8.8.9	Provide DSEAR training at appropriate levels	C	
132	RT10	8.8.10	Review incident investigation processes to include consequences and causes from Hazardous materials and scenarios	C	
133	RT11	8.8.11	Review first aid arrangements to include DSEAR scenarios	C	
134	RT12	8.8.12	Review first aid arrangements to include DSEAR scenarios	C	
135	RT13	8.8.13	Review procurement procedures for Hazardous Area equipment	C	
136	RT14	8.8.14	Review calibration procedures for Any DSEAR safety critical measuring devices (e.g., a portable gas detector)	C	
137	RT15	8.8.15	Review whether a formal recorded procedure for testing of footwear is required	C	
138	RT16	8.8.16	Review requirements for proof testing of any safety interlocks/trips, and associated schedules and procedures	C	
139	RT17	8.8.17	Review requirements for inspection and testing of safety relief devices, and associated schedules and procedures	C	
140	RT18	8.7.5 8.7.6 8.8.18	Review inspection and testing arrangements for earth leads and clips	C	
141	RT19	8.8.19	Review arrangements for inspection of vulnerable plant items from a DSEAR perspective	C	
142	RT20	8.8.20	Review arrangements for inspection of bunds and spill containment measures	C	
143	RT21	8.8.21	Review arrangements for inspection of low pressure storage tanks in line with ACOP	C	
144	RT22 RT24	8.7.3 8.7.4 8.8.22 8.8.24	Implement registers of equipment in Hazardous Areas (mech & elec), and carry out inspections and planned preventative maintenance at appropriate intervals	C	
145	RT23	8.7.8 8.8.23	Review mobile phone use policy on site in Hazardous Areas	C	
146	RT25	8.8.25	Review arrangements for maintaining emergency equipment	C	
147	RT26	8.8.26	Review competency of staff and contractors for Hazardous Area working	C	

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148	RT27	8.8.27	Review servicing and maintenance arrangements for gas / fuel fired equipment	C	
149	RT28	8.8.28	Review procedures for risk assessment to include DSEAR risks	C	
150	RT29	8.8.29	Include DSEAR auditing in site safety audit system	C	
151	RT30	8.8.30	Review implementation of EX signage	C	
152	RT31	7.4	The site should engage a drafting service to overlay the HAC schematics onto the site plans and general arrangement drawings	C	

Note – some actions included only to reinforce requirements / safe system of work or to provide guidance

Appendix A – Site Photographs

Contained in separate photo index

Appendix B – Additional DSEAR Information

DSEAR is a set of regulations concerned with protection against risks from fire, explosion and similar events arising from dangerous substances used or present in the workplace. This particularly includes materials classified as explosive, oxidising, extremely flammable, highly flammable, or flammable and conditions such as elevated temperature or pressure.

A 'dangerous substance' includes any substance or preparation, which due to its properties or use, could cause harm to people from fires and explosions - e.g. paints; varnishes; solvents and dusts which when mixed with air could cause an explosive atmosphere. An explosive atmosphere does not always result in an explosion, but if it caught fire the flames would quickly travel through it and if this happened in a confined space (e.g. in plant or equipment) the rapid spread of the flames or rise in pressure could also cause an explosion.

The DSEAR regulations require:

- a risk assessment of any work activities involving dangerous substances;
- measures to eliminate or reduce risks as far as is reasonably practicable (regulation 5 & 6);
- classification of places where explosive atmospheres may occur into zones & mark if necessary (regulation 7);
- provide equipment and procedures to deal with accidents and emergencies (regulation 8);
- provide information and training to employees (regulation 9)

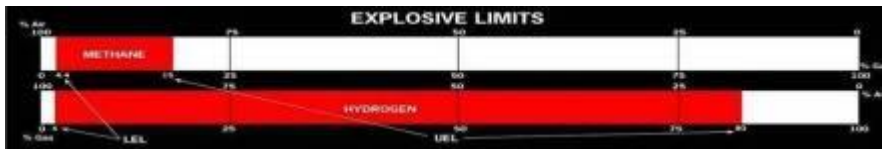
Overall, DSEAR clarifies the existing requirements to manage fire and explosion risks which are set out in the Management of Health and Safety at Work Regulations 1999 (Management Regulations). Risk of ignition is real wherever flammable dust, vapour or gases are present unless affected areas have sufficient extract or suppression controls. Mixed with air such materials potentially create a flammable or explosible atmosphere.

Not all flammable gas, vapour or dust concentrations in air will burn or explode - limiting data is available. Generally those that will do so have a specific flammable or explosible concentration range – and the diagram below illustrates how this 'range' equates to explosion limits for two particular gaseous components.

LOWER FLAMMABILITY LIMIT (LFL) is the lowest concentration of 'fuel' in air which will burn (< 5% by volume for most flammable solvents). So there is a high risk of explosion even if relatively small concentrations are present. Note: LFL for combustible dusts is measured in g/m³ and should not be exceeded in process areas. A typical LFL for combustible dust of 50 g/m³ would be very dense and affect immediate visibility.

UPPER FLAMMABILITY LIMIT (UFL) is the maximum concentration of 'fuel' in air which will burn or explode. At levels above this UFL there is insufficient atmospheric oxygen available and fuel will not burn. Values differ significantly for combustible dusts and are rarely calculated – vision is difficult even at LFL concentration!

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Fire or explosion hazard arises when flammable vapour or dust attains a sufficient concentration in air where there may also be an ignition source - such as unprotected electrical equipment. The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) **impose** a requirement to eliminate or reduce risks to safety from fire, explosion or other events arising from use of hazardous substances in the workplace. The employer **must** carry out a suitable and sufficient assessment of the risk to employees etc.

Appendix C – Hazardous Area Classification

OVERVIEW

Hazardous Area Classification is required where there may be a flammable gas, vapour, mist, or dust cloud present during normal operation with significant potential for formation of a flammable atmosphere. This excludes events such as the catastrophic failure of tanks or rupture of pipework, but includes foreseeable leaks or loss of containment, such as those from flanges, joints etc. - as well as emissions from vents.

There is no set volume that triggers hazardous area classification, and clearly very small quantities of dangerous substances are not always likely to present a hazard in normal circumstances of use (e.g., use of solvent-based paint in a well-ventilated workplace). Ballpark quantities of 50 litres outdoors or 25 litres indoors are often used as the DSEAR threshold volume for flammable substances - but are dependent on many factors.

The DSEAR regulations require identification of potentially explosive atmospheres and suitable control of storage, handling & access to hazardous substances within discrete zones. Areas classified as zones must then be protected from any ignition sources and entry points marked with a specified 'Ex' sign – this is particularly of benefit where clearly marked zones may assist in reducing residual risk.



For Flammable Gases, Vapours and Mists the zone classifications are based upon probability:

- **Zone 0.** A place in which an explosive atmosphere consisting of a mixture of air and flammable (dangerous) substances in the form of a gas, a vapour or mist is present continuously, or for long periods or **frequently**
- **Zone 1.** A place in which an explosive atmosphere consisting of a mixture of air & flammable (dangerous) substances in the form of gas, vapour or mist is likely to occur in normal operation - but only **occasionally**
- **Zone 2.** A place in which an explosive atmosphere consisting of a mixture of air & flammable (dangerous) substances in the form of gas, vapour or mist is unlikely to occur during normal operations but, if it does occur, will persist **for a short period only** (typically less than 10 hours / year).

Similar zone classifications also apply to dust clouds:

- **Zone 20.** A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or **frequently**
- **Zone 21.** A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation – but only **occasionally**
- **Zone 22.** A place in which an explosive atmosphere in the form of a combustible dust cloud in air is unlikely to occur in normal operation but, if it does occur, will persist **for a short period only** (<10 hours / year)

A hazardous area classification sheet is normally produced under DSEAR to indicate the

location and extent of identified zones and reflects the likelihood of an explosive atmosphere in a given area during *normal* operation. Drawings aid front-line interpretation and show the extent of classified zones - including a degree of safety.

Generally, hazardous zones are not appropriate if a flammable atmosphere does not persist in

the workplace - unless control measures such as ventilation, maintenance or housekeeping are deemed inadequate - or upset conditions such as a leak may occur. Hazardous zones are typically assigned within confines of equipment, with a degree of safety around those items where a leak of vapour may result in a flammable atmosphere.

METHODOLOGY

Potential Sources of Release

For the purpose of Hazardous Area Classification, a release source is defined as a point from which flammable gas, vapour or dust may be released into the atmosphere. The release grade is dependent solely on the frequency and duration but is independent of the rate and quantity, degree of ventilation or fluid characteristics - although these are factors in considering extent of hazard travel and thus dimensions of the Hazardous Area.

Three grades of release are defined in terms of their likely frequency and duration:

Continuous Grade: A release that is continuous or nearly so, or occurs frequently for short periods. This most often leads to a zone 0 classification – for example vapour within headspace of a confined storage tank.

Primary Grade: A release that is likely to occur periodically or occasionally in normal operation i.e., a release which is anticipated to occur, e.g. from vents, and most often leads to a zone 1 classification.

Secondary Grade: A release that is unlikely to occur in normal operation and, in any event, will do so infrequently & for short periods. Such releases may be of known size e.g., pipe fracture, or unknown size e.g. corrosion hole. Most often this may lead to a zone 2 classification – e.g., a small leak from a pipework flange.

In assessing Hazardous Areas, information from site procedures, industry practice and survey feedback has been considered – and underpinned by methodology in recognised standards listed below:

- BS EN 60079-10-1:2021 Classification of Areas – Explosive gas atmospheres
- BS EN 60079-10-2:2015 Classification of areas – Combustible dust atmospheres
- Energy Institute Model Code of Safe Practice IP15 - Area Classification Code 2015 (4th Edition)

Crucial to above methods is the identification of hazardous substance releases and their physical properties. These standards also provide relevant guidance on the extent of zoning and electrical safety arrangements where flammable dust or vapour etc. are handled, and also assist in determining the hazardous zone classification in circumstances where concentrations in air are likely to fall within the flammable range.

BS EN 60079-10:2015

This is the generic Euro-norm standard for Area Classification. It is a useful standard which provides a relatively large number of typical Area Classification examples and it is widely accepted that they incorporate a significant margin of safety. In the case of solvent vapour this margin is generally based upon levels <25% LFL value.

Hazardous Area Classification is determined by consideration of the availability, degree, and type of ventilation in addition to the grade of release. Limited guidance is provided for determining these parameters, and in many cases subjective decisions are inevitable in the analysis – as to whether ventilation is effective or not.

Further evaluation may be necessary for applications significantly dissimilar to examples provided in the standard. This is especially relevant when considering effects of a pressurised liquid source of release as spray or a fine mist may be formed. Guidance on performing such further analysis is not fully provided in the standard.

EI Model Code of Safe Practice - Part 15:2015 (formerly IP Code)

This standard is similar in application to BS EN 60079-10 as one method of classification is also based on comparison by direct example. The point source release method is also presented which enables classification of areas where pressurised contents release may occur - specialist standards or numeric methods are available.

FACTORS AFFECTING HAZARDOUS AREA CLASSIFICATION

- i. The phase of a release (liquid, vapour or two-phase) affects the size and shape of the flammable zone
- ii. The rate of release for the substance affects the overall size of the flammable zone
- iii. The temperature of a released substance may affect its buoyancy and the potential for condensation
- iv. Flow and availability of ventilation have a key effect on the size and duration of a flammable mixture and may be critical where a release occurs inside an enclosure reliant on forced ventilation – though where both flow and availability are good, then it may be classed as similar to 'natural' ventilation. For outside locations or open plant structures ventilation is classed as 'natural and with 100% availability'.
- v. Three basic grades of release are used in zone classification; continuous, primary, or secondary
- vi. The flammable range for a given substance is relevant to the potential size of a hazardous zone. Limits may vary widely depending on the material but also vary (increase) with temperature and pressure.
- vii. Minimum ignition energy (MIE) is a measure of how easy a particular flammable mixture may ignite. A lower MIE substance is easier to ignite and is reflected by 'Gas Group' for relevant

materials, while the MIE is also used often to specify precautions needed to avoid electrostatic ignition of dusts.

- viii. Auto Ignition Temperature is a measure of how easy it is to ignite a mixture without a flame present e.g., from a hot surface such as a motor. This is utilised for ‘Temperature Classification’ of equipment.
- ix. Layer Ignition Temperature is a measure of the ease of ignition for a layer of dust or powder on a flat, hot surface and is the temperature at which smouldering or combustion occurs. Generally, it decreases as the layer thickness increases. Standard tests are carried out in the EU with a 5mm thick layer.
- x. For dusts and non-conductive liquids conductivity is a measure of the potential for the material to become charged and thus cause a static electricity ignition hazard.

Hazardous area classification is normally used to select fixed electrics, though it also assists with control of other potential ignition sources such as portable equipment, hot surfaces, or vehicles etc. Consideration of EX zones is also paramount during maintenance and / or breakdown conditions in order to maintain the basis of safety and prevent inadvertent introduction of an ignition source. However, it is not always possible to avoid sources of ignition and another basis of safety may be available such as limiting flammable inventory.

All equipment and machinery used in hazardous areas assigned under DSEAR must meet appropriate category to comply with classified zones. It is critical that electrical testing and earthing arrangements are effective and it is not just motors, lighting and switches that cause heat or sparks – but all associated pumps, hoses, extraction systems, cleaning kit, tools & probes etc. should also meet strict safety specification to avoid incident.

Static too may be a source of fire and routine fixed circuitry testing often incorporates continuity testing to ensure a path to earth for all electrostatic bonding – while PAT test & inspection regime is also important along with management of personal appliances. Fault reports and subsequent remedial actions should be logged with regular review of compliance or reliability issues that arise in regard to any electrical circuits.

It is a DSEAR requirement that relevant hazards are eliminated / reduced to as low as is reasonably practicable (ALARP). Given that combustible or flammable materials are fundamental to site activity and cannot be completely avoided, there are few opportunities to reduce or indeed eliminate their use. NOTE: A few litres of volatile, flammable liquid may result in a much larger, explosive vapour cloud and a major DSEAR hazard.

HAZARDOUS AREA ZONE CLASSIFICATION SUMMARY

The extent of hazardous zones calculated for potential release sources and flammable atmospheres identified above is based on detailed consideration of the release type and ventilation level. Ventilation is paramount but any openings in compartments or equipment also exert an influence on the hazardous area.

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The Hazardous Area Classification process is explained fully in standards, but above information is included to assist in demonstrating factors associated with calculation and extent of specific hazardous zones.

Appendix D – Management of Hazardous Areas

SAFETY MANAGEMENT SYSTEM

Safety management for hazardous areas is important. Specific recommendations are highlighted in the DSEAR ACOP L138 to ensure that a sustainable Safety Management System is in place to address hazardous area issues throughout the life of the facility. Key requirements relate to the management of materials, processes, and equipment so that hazardous areas and associated operations are clearly identified.

Ongoing requirements typically include equipment maintenance, inventory management and control of ignition sources. Area classification is designed to prevent installation of unsuitable electrical and mechanical equipment, while also avoiding unsafe hazardous substances or uncontrolled changes in operation practice that affect the basis of safety. Portable equipment and maintenance are particular areas requiring formal safety management arrangements throughout the life of the plant.

EQUIPMENT FOR USE IN HAZARDOUS AREAS

Equipment used in hazardous areas has to be of the correct temperature classification and Gas Group to maintain the basis of safety. Temperature Classification (or maximum surface temperature) reflects the lowest 'auto-ignition' temperature (AIT) of material present, while the Gas Group depends on the minimum ignition energy of materials.

Incorrect specification of equipment can result in an ignition if the surface temperature is too high, or because the energy level may lead to spark. The maximum surface temperature of equipment should ideally, be no more than 70% of the theoretical AIT to allow a margin of safety. The tables below illustrate the relationship between surface temperature and T Class, along with a range of Gas Group and ignition energy factors.

Maximum Surface Temperature (°C)	Temperature Class (T Class)
450	T1
300	T2
200	T3
135	T4
100	T5
85	T6

Hazardous Substance	Gas Group	Minimum Ignition Energy (mJ)
Acetylene	IIC	0.02
Hydrogen	IIC	0.02
Ethylene	IIB	0.06
Propane	IIA	0.18

All new equipment for use in hazardous areas must be designed and constructed to the correct standard. It must also have the correct labelling containing information such as the relevant temperature classification, gas group, etc. Additionally, all EX compliant equipment must be accompanied by a relevant certificate and the certificate must be kept for the service life of the equipment.

EQUIPMENT CATEGORY

EX / ATEX equipment is categorised 1, 2 or 3, which is now being superseded by Equipment Protection Levels (EPL). This defines the level of protection that equipment provides against ignition sources, with category 1 equipment providing the highest level of protection. Equipment is also categorised for Gases or Dusts and will have a one or both letters on the EX label depending on the suitability i.e. “G” for Gases, “D” for dusts or “GD” for equipment suitable for gases and dusts.

Hazardous Zone		Zoning Definitions	EX Category (typically gas group II)	IP Rating (as relevant)
Gas	Dust			
EN 60079-10 0	EN 61241-10 20	A place in which an explosive atmosphere is continually present	1G / EPL Ga Equipment suitable for zone 0 1D / EPL Da Equipment suitable for zone 20	EN 60529-10 IP6X
1	21	A place in which an explosive atmosphere is likely to occur in normal operation occasionally	2G / EPL Gb Equipment suitable for zone 1 2D / EPL Db Equipment suitable for zone 21	IP6X
2	22	A place in which an explosive atmosphere is not likely to occur in normal operation, but if it does, only occurs for short periods	3G / EPL Gc Equipment suitable for zone 2 3D / EPL Dc Equipment suitable for zone 22	IP5X*

*IP6X if material conducting. The “X” should be replaced by a number rating equivalent to required liquid ingress protection for the area.

In summary all electrical equipment in Hazardous Area is defined by **three** main criteria, these being:

Type of hazard – i.e., gas / vapour / dust / fibre (Group II gases based on amount of energy needed for ignition)

Auto-ignition temperature of hazardous material (or “T” class - lowest temperature at which vapour will ignite)

The likelihood of the hazard being present in flammable concentrations (defines zone arrangements)

The IP rating should be stamped on the label for all new equipment for use in hazardous areas. It is incumbent upon management to ensure suitably protected equipment is installed and used in classified hazardous zones.

EQUIPMENT MAINTENANCE

Inspection, maintenance, and repair of electrical equipment for use in Hazardous Areas must be done by qualified and competent personnel. A 'standard' 17th Edition qualified electrician or similar is not competent to carry out the inspection or repair of hazardous area equipment because the training does not cover the special protection methods used in hazardous area equipment.

Maintenance of EX equipment by non-qualified personnel may result in a breach of the basis of safety for the equipment. Electrical technicians trained and competent to inspect, maintain & repair hazardous area equipment are CompEx qualified. This is a special training course which specifically covers the ignition protection properties of Hazardous Area equipment. Non-CompEx trained electricians should not be allowed to carry out work on EX rated electrical equipment.

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It is important that all protective equipment installed to support safety within classified hazardous zones are also maintained by competent persons in line with supplier recommendations. Specifically, explosion suppression, pressure relief or other protective devices should also undergo any recommended function tests to confirm satisfactory operation. **Note:** where it is necessary to isolate systems (or parts) to avoid inadvertent operation during such testing, any impairment should be subject to local management or permit system.

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Appendix E – Additional reference material

1	DSEAR Regulations 2002. Approved Code of Practice and guidance 2013. L138 (Second edition)
2	Pressure Systems Safety Regulations 2000. Approved Code of Practice L122 (Second Edition) Published 2014
3	The Regulatory Reform (Fire Safety) Order 2005 and all associated guidance documents
4	The Equipment and Protective Systems for Use in Potentially Explosive Atmospheres Regulations 1996
5	The CLP Regulation. European Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures
6	BS EN 60079-10-1:2015 Explosive atmospheres. Classification of areas. Explosive gas atmospheres
7	BS EN 60079-10-2:2015 Explosive atmospheres. Classification of areas. Combustible dust atmospheres
8	BS EN 60079-0:2012 Explosive atmospheres. Equipment - general requirements
9	BS EN ISO 80079-36:2016 Explosive atmospheres. Non-electrical equipment for explosive atmospheres. Basic method and requirements
10	BS EN ISO 16852:2010 Flame arresters. Performance requirements, test methods and limits for use
11	BS EN 14470-1:2004 Fire safety storage cabinets. Safety storage cabinets for flammable liquids
12	BS EN 14470-2:2006 Fire safety storage cabinets. Safety cabinets for pressurised gas cylinders
13	BS 5908-2:2012 Fire and explosion precautions at premises handling flammable gases, liquids & dusts
14	IEC TS 60079 Part 32-1, Explosive Atmospheres. Electrostatic hazards, guidance. 2013
15	Energy Institute. Model Code of Safe Practice Part 15 Area Classification Code for flammable fluids Published July 2015. (Fourth Edition)
16	Energy Institute. Model Code of Safe Practice Part 16 Tank cleaning safety code Published 2008 (Third edition)
17	Institute of Gas Engineers IGE/SR/25 Hazardous Area Classification : IGEM/SR/25 Hazardous Area Classification of Natural Gas Installations Edition 2. Communication No. 1748
18	HSG 51 – Storage of flammable liquids in containers
19	HSG 71 – The Storage of packaged dangerous goods
20	HSG 103 – Safe handling of combustible dusts
21	HSG 140 – Safe use and handling of flammable liquids
22	HSG 176 – Storage of flammable liquids in tanks
23	HSG 178 – Spraying of Flammable Liquids – withdrawn – currently under review
24	HSG 250 – Guidance on permit-to-work systems for the petroleum, chemical and allied industries
25	HSG 258 – Controlling airborne contaminants at work: A guide to local exhaust ventilation (LEV)
26	INDG 227 – Safe working with flammable liquids
27	INDG 370 – Controlling fire and explosion risks in the workplace: A brief guide to DSEAR (HSE Leaflet)
28	INDG 408 – Clearing the air: A simple guide to buying and using local exhaust ventilation (LEV)(First published May 2008.).
29	INDG 428 – Inspecting, maintaining, or replacing buried metal pipework carrying LPG vapour. (Publication 2009)
30	UKLPG Code of Practice 1. Bulk LPG Storage at Fixed Installations: Design, Installation and Operation of Vessels located above ground. January 2009 (amended 2012 and 2013)
31	UKLPG Code of Practice 7. Storage of Full and Empty LPG Cylinders and Cartridges (March 2004)
32	UKLPG Code of Practice 12. Safe Practice in the Design and Operation of LPG Cylinder Filling Plants (2005)
33	BCGA CP44 – The Storage of Gas Cylinders
34	BCGA GN13 – DSEAR Risk Assessment (2010)
35	SIA Guidance Note 54: Guidance for the Storage of Liquids in Intermediate Bulk Containers
36	Guidelines for Quantitative Risk Assessment (Purple Book)
37	Guidance for design of occupied buildings on chemical sites. Chemical Industries Association
38	BMWFW – Technische Grundlage für die Beurteilung von Biogasanlagen, 2017

Note: Above list is not intended to be exhaustive & other Legislation, Regulations & Guidance may also apply.

END OF DOCUMENT