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Title: Dangerous Substances and Explosive Atmospheres Regulations (DSEAR)
Compliance Assessment for Haworth Scouring Limited AD Plant

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Summary

This report summarises compliance with the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) for Haworth Scouring (BD3 9SX) anaerobic digestion (AD) process.

The CHP engine is to be procured by Haworth Scouring outside of Fre-energy scope of supply and is included in the report at Rev 0 as a 'generic' assessment based on previous work for a Clarke Energy Series 3 installation. If Haworth provides details of the CHP engine procured and the suppliers' standard risk assessment / zoning document to PDA we can incorporate it into the report.

The principal codes of practice used are the HSE Code of Practice for DSEAR L138 and BS60079-10-1: 2021 Classification of areas Explosive gas atmospheres supported by the Environmental Services Industry Codes of Practice for DSEAR for the Waste Management Industry. Other codes of practice have been used as referenced.

A summary table for the HAC is presented below:

Zone	Location	Extent
Zone 0	• N/A	None.
Zone 1	• Digester Pressure Relief Valve (PRV) • Biogas Bag PRV	• 1m radius of outlet • 1m radius of outlet
Zone 2	• Digester • Digester PRV • Biogas Bag • Digester Overflow • Biogas Bag PRV • Gas mixing compressors	• Ullage Space • 4.5m radius of outlet • Between layers of bag and 1m of inflation air outlet • 3.5m radius of outlet • 3.5m radius of outlet • 0.5m radius of gas mixing compressor seals
Zone 2 Negligible extent (NE)	• Flanged connections on piping and equipment	• Negligible extent. For clarity a zone of negligible extent means that any leak, if ignited, would be too small to have hazardous effects on people or equipment. ATEX certified equipment is not required in zones of negligible extent which are (to all intents and purposes) non – hazardous.

These four documents are to be considered as part of this one to make a suite of process safety documents.

- Hazard Identification Study (HAZID) PDA-HAW-HAZ-24001
- Hazard and Operability Study (HAZOP) PDA-FRE-HS-25001
- Fire Risk Assessment Strategy ADH.24.031C.EE4
- CFD Gas Dispersion Study for HS new AD Plant ADH.24.031C.EE4
- Haworth Scouring New SD Plant LPRAs Study. ADH.24.031C.EE4
 - Appendix A, LPRAs StrikeRisk Results summary for Structure 1. ADH.24.031C.EE4
 - Appendix B, LPRAs StrikeRisk Results summary for structure 2. ADH.24.031C.EE4

As prescribed by the DSEAR, this report shall be reviewed and updated at least every 5 years or when changes are made to the process and / or equipment. Any change in feed, wastes, equipment or processes requires review of this DSEAR assessment.

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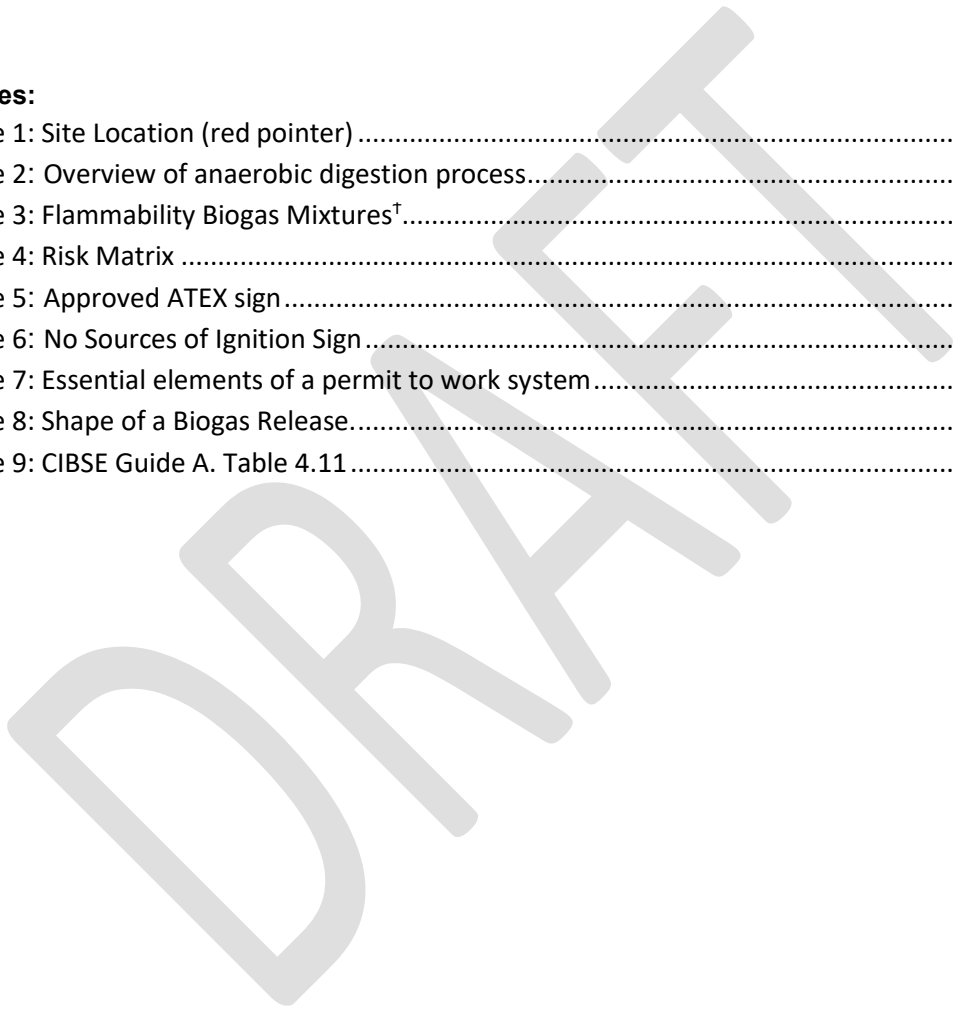
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Quality Assurance

Revision History

Rev	By	Date	Revision Details
P1	P L Durrant	25/09/2025	Issued for comment
0			

Document Control

This revision procedure shall apply to all documents, datasheets, reports etc.

Documents issued for information shall carry P status for preliminary. When documents are changed but remain preliminary the revisions shall be increased from initial issue P1 to P2, P3 etc.

When information becomes firm then the document shall be revised to revision 0 which is *issued for design* or *issued for construction* depending upon the type of document. On each subsequent change the revision number shall be increased to 1, 2, 3, 4 etc.

Whenever a document is revised and reissued the changes shall be identified in the revision history table. Changes shall be identified by a description of the change and shall indicate where it appears. For example, a datasheet shall identify the page number and line number. A report shall identify the page and paragraph number.

HOLDS

The following HOLDS require further client information / confirmation to finalise report: None

Confidentiality:

This document is for the use of Haworth Scouring Limited and their authorised agents and may contain confidential company information

If you are not the intended recipient any use, dissemination, distribution or copying of this document and any accompanying material is prohibited. In this case please destroy all copies of this document and accompanying material.

Disclaimer

This report has been prepared based on information, data, and specifications provided by the client. The engineering assessments, opinions, and recommendations contained herein rely on the accuracy and completeness of that information. No independent verification of the supplied data has been undertaken, and the authors accept no responsibility for any errors, omissions, or inaccuracies arising from such information.

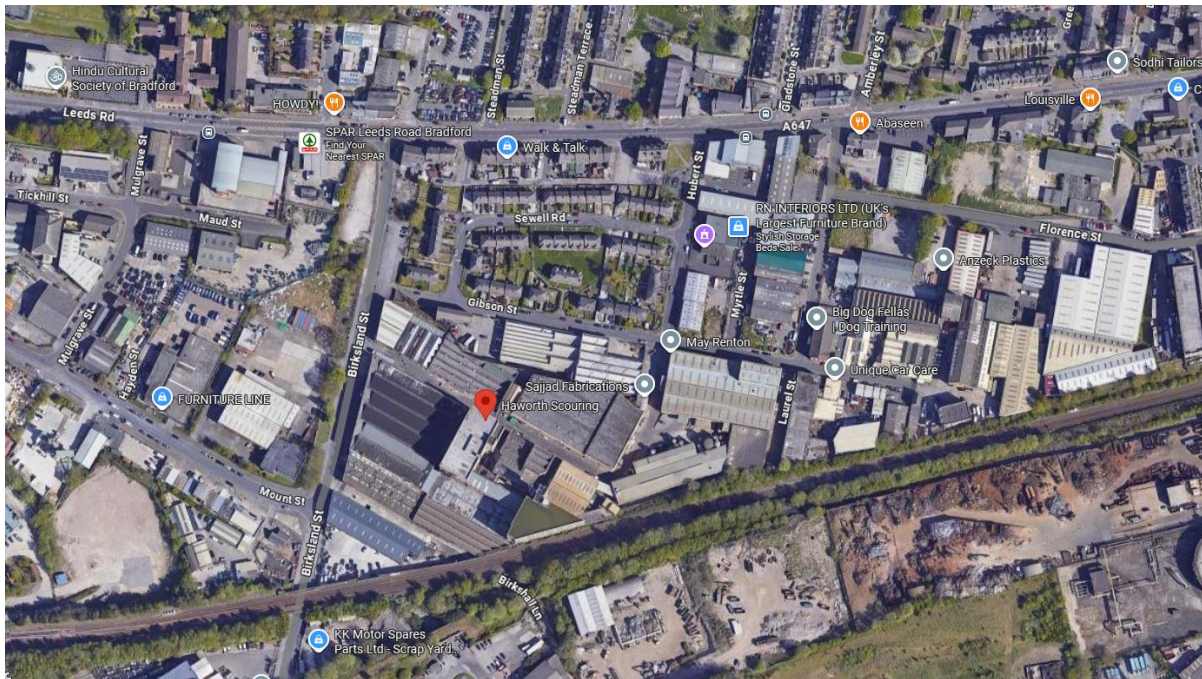
The findings and advice in this report are intended for the sole use of the client and for the specific project and purpose stated. They should not be applied to other projects or circumstances without further review. The authors disclaim any liability for losses, damages, or consequences resulting from the use or reliance on this report beyond the stated scope of services.

1 Introduction

1.1 Overview of Operations

Haworth Scouring Limited (postcode BD3 9SX) in Bradford and processes large quantities of raw wool of various grades.

Figure 1: Site Location (red pointer)



The site is in a mixed environment of businesses and residential properties.

The AD process is moderate risk having possible high severity risks with low probabilities of occurrence.

These are considered in the risk assessment parts of each process section.

Haworth has been proactive in having these studies done:

- Hazard Identification Study (HAZID) PDA-HAW-HAZ-24001
- Hazard and Operability Study (HAZOP) PDA-FRE-HS-25001
- Fire Risk Assessment Strategy ADH.24.031C.EE4
- CFD Gas Dispersion Study for HS new AD Plant ADH.24.031C.EE4
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These four documents are to be considered as part of this one to make a suite of process safety documents.

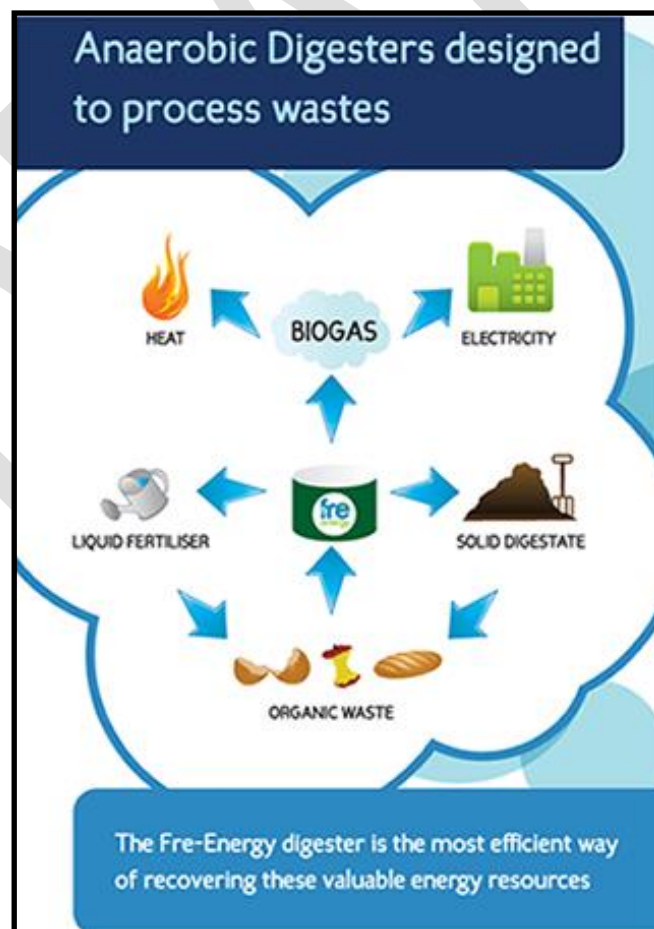
The scouring process is described in these steps:

- Greasy wool containing wool grease (lanolin), dirt and other vegetable material is loaded onto a large conveyor and pre-blended in an accumulator bin.
- Excess dirt and vegetable matter are removed from the wool prior to washing without damage to the fibre.
- The greasy wool is conveyed through a series of temperature controlled wash bowls containing biodegradable detergent which removes the wool greasy and dirt and debris from the fibres before going through a series of rinse bowls.
- A series of specific temperature controlled dryers dries the wool, and a moisture management system provides a best fit for specified moisture regain values requested by a customer.
- Wool is press packed in bales of approximately 300-350kg and stored for export to the customer.

Site effluent is rich in organic matter removed during scouring. This incurs significant costs to the business in the form of trade effluent costs for chemical oxygen demand (COD). To reduce these costs Haworth Scouring has asked Fre-energy to design and install a suitable anaerobic digestion system to reduce COD and hence trade effluent costs.

The AD process is depicted in overview below:

Figure 2: Overview of anaerobic digestion process



The main operating steps are:

- Receive feed (scouring wastes) into a buffer tank
- Put the mix into a series of sealed tanks with agitation and heat to approximately 40°C
- The bacteria present break down the organic parts releasing biogas (typically 55% methane and 45% carbon dioxide – varies depending on bacteria and feedstock)
- The gas is used to generate heat and renewable electricity by fuelling a combined heat and power plant (outside of the Fre-energy scope and outside of the scope of this report).

The waste product from digestion is called digestate, this is used as a bio-fertiliser with its nutrients in a readily available state.

The plant is controlled using a PLC, which can be viewed locally by the operators and remotely by Fre-energy for diagnostics purposes.

We have used many Technical References to compile this report. They are recorded in footnotes as used in the report and listed in Section 8.

The principal references are:

1. L138 HSE Code of Practice for DSEAR
2. BS60079-10-1: 2021 Classification of areas Explosive gas atmospheres
3. ESA¹ ICoP 1: DSEAR Implementation for The Waste Management Industry
4. ESA ICoP 2: Area Classification for Landfill Gas Extraction, Utilisation and Combustion
5. ESA ICoP 3: Area Classification for Leachate Extraction, Treatment and Disposal

1.2 Applicable Legislation

The DSEAR (Statutory Instrument SI 2002 No. 2276), imposes certain statutory duties on the “employer” where chemicals are stored or processed that could give rise to energy releasing events such as fires or explosions. In the sense of DSEAR, Haworth Scouring is the *employer* as owner of the facility.

DSEAR applies to any substance or preparation (mixture of substances) with the potential to create a risk to persons from energetic (energy-releasing) events such as fires, explosions, thermal runaway from exothermic reactions etc. Such substances, which are known in DSEAR as dangerous substances, include: petrol, liquefied petroleum gas (LPG), paints, varnishes and certain types of combustible and explosive dusts produced in, for example, machining and sanding operations.

Under Regulation Five of the DSEAR the employer of any process handling flammable or explosive substances has a mandatory obligation to assess the risk of fire and explosion to workers and the public. Other duties assigned under DSEAR are listed below:

- put control measures in place to either remove any identified risks or, where this is not possible, control them
- put controls in place to reduce the effects of any incidents involving dangerous substances

¹ Environmental Services Agency

- prepare plans and procedures to deal with accidents, incidents and emergencies involving dangerous substances
- make sure employees are properly informed about and trained to control or deal with the risks from the dangerous substances
- identify and classify areas of the workplace where explosive atmospheres may occur and avoid ignition sources (from unprotected equipment, for example) in those areas

The relevant regulations are:

- DSEAR Regulation 5 requirement for risk assessment
- DSEAR Regulation 6 requirement for risk elimination / reduction
- DSEAR Regulation 7 requirement to classify the workplace into zones
- DSEAR Regulation 8 requirement for emergency procedures
- DSEAR Regulation 9 information and training
- DSEAR Regulation 10 requirement for marking of pipes
- DSEAR Regulation 11 requirement for duty of coordination

This document satisfies the requirements for DSEAR Regulations 5, 6 and 7 and outlines how Haworth Scouring can fulfill requirements under Regulations 8, 9 10 and 11 to comply with the DSEAR as laid down in L138 DSEAR and its equivalent ICoP for the waste industry ESA ICoP 1.

The Effect of Brexit on the DSEAR.

The UK left the EU on January 1st, 2021. DSEAR is unchanged as the primary legislation regulating flammable hazards from a worker protection perspective. ATEX CE certification was to be replaced by a new UK conformity assessment (UKEX) termed UKEX. In August 2023 the UK government reversed this. CE marked ATEX certified equipment is acceptable indefinitely. UKEX certified products can be used alongside ATEX CE marked ones in line with the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (EPS).

In the report 'certified' equipment is assumed to be ATEX CE or UKEX compliant interchangeably.

Control of Engineering Change.

It is vital that plant and procedural Risk Assessments are reviewed from time to time and especially when any change to the design or operation takes place. 'Change control' is a vital part of plant safety and must be recorded like all other assessments. If a 'Change' is proposed, the Change Control Assessment should be performed before carrying out the proposed change.

If there are any significant process or equipment changes this report must be updated – a change of feed or equipment must be assessed.

Regulatory Reform (Fire Safety) Order 2005

The Regulatory Reform (Fire Safety) Order 2005 is separate and complimentary to the DSEAR. The Order requires that a fire risk assessment (FRA) is carried out. The FRA is concerned with life safety and means of escape whereas the DSEAR is concerned with fire and explosion hazards arising from the process. The FRA is covered by ADH Report ADH.24.031C.EE4.

2 Method

The primary reference for this study is the International Standard BS EN 60079-10-1: 2021 Explosive atmospheres. Classification of areas. Explosive gas atmospheres. Where deviations are made, these are noted in the text with alternative references or justification provided.

Definitions relating to HAC are listed in Appendix One. Those unfamiliar with HAC should read that section first.

HSE advice for which codes and standards can be used for different situations is:

Gases:

- Quadvent2
- EI15 Energy Institute model code of safe practice Part 15 (EI15) Area classification for installations handling flammable fluids Edition 4
- Communication 1748

Liquids:

- EI15

Mist:

- EI15

Gas Cylinder Store:

- Quadvent2
 - Industry guidance from the British Compressed Gases Association (BCGA) Codes of Practice, Guidance Notes etc.

Solvent Store:

- EI15 – pool evaporation

Pumping a Flammable Liquid:

- EI15 – pressurised releases
- Applicable for releases at temperature > flashpoint and mists

Two methods can be used for hazardous area classification; these are the direct example or point source methods; these are applied as appropriate to the situation in the report.

Direct examples are taken from standards and apply to such equipment as storage tanks containing flammable liquids, piping and pumping containing flammable liquids and gases and loading and unloading road tankers.

The point source method is applied with the following steps:

- Identify the point source and process conditions
- Determine the grade of release
- Identify the fluid category
- Declare the zone classification

- Estimate the hazard radii. Quadvent is used where possible to underpin zone extents
- Determine the extent and shape of the hazardous area
- Combine multiple release points if it is sensible to do so into a 'blanket' zone

Availability of Ventilation:

In the report availability of natural ventilation for outdoors areas is generally assessed as "good" as endorsed by BS EN 60079-10-1 C.3.7.2 "In open air situations the degree of dilution is generally considered as medium while the availability of ventilation in terms of wind presence may be considered as good unless there is restricted ventilation such as within pits, dykes or areas surrounded by high structures". For inside tanks and areas where outdoor ventilation could be restricted such as trenches and sumps ventilation is assessed as "fair". Where artificial ventilation is provided by duplicated fans with alarms this is classified as "good".

The review considered the following information:

The hazardous properties of the substances present referring to Material Safety Datasheets and BS EN 60079-20-1: 2010 Explosive atmospheres. Material characteristics for gas and vapour classification. Test methods and data;

Information on safety provided by the site operator and equipment suppliers;

The circumstances of the work including:

- the work processes and substances used and their possible interactions;
- the amount of the substance involved;
- where the work will involve more than one dangerous substance, the risk presented by such substances in combination; and
- the arrangements for the safe handling, storage and transport of dangerous substances and of waste containing dangerous substances;
- activities, such as maintenance, where there is the potential for a high level of risk;
- the effect of measures that have been or will be taken pursuant to DSEAR;
- the likelihood that an explosive atmosphere will occur and its persistence;
- the likelihood that ignition sources, including electrostatic discharges, will be present and become active and effective;
- the scale of the anticipated effects of a fire or an explosion;
- any places which are or can be connected via openings to places in which explosive atmospheres may occur; and
- other additional safety information that was needed to complete the risk assessment.

3 Conclusions and Actions

3.1 Conclusions

1. HAC has been carried out in accordance with HSE L138, ESA ICoP's and standards as referenced.
2. A risk assessment has been carried out in accordance with Regulation 5 of the DSEAR. These documents should be read in conjunction with the report:
 - a. Hazard Identification Study (HAZID) PDA-HAW-HAZ-24001
 - b. Hazard and Operability Study (HAZOP) PDA-FRE-HS-25001
 - c. Fire Risk Assessment Strategy ADH.24.031C.EE4
 - d. CFD Gas Dispersion Study for HS new AD Plant ADH.24.031C.EE4
 - e. Haworth Scouring New SD Plant LPRAs Study. ADH.24.031C.EE4
 - i. Appendix A, LPRAs StrikeRisk Results summary for Structure 1. ADH.24.031C.EE4
 - ii. Appendix B, LPRAs StrikeRisk Results summary for structure 2. ADH.24.031C.EE4
3. DSEAR Regulation 6 requirement for risk elimination / reduction is satisfied by this document.
4. DSEAR Regulation 7 requirement to classify the workplace into zones is satisfied by this document. Section 6 provides further detail.
5. Guidance for compliance with DSEAR Regulations 8, 9, 10 and 11 shall be satisfied by Haworth Scouring procedures. Section 10 provides further detail.
6. Engines risk assessment is carried out by reference to previous similar studies as the hazards and mitigation are similar.
7. Zoning for gas pipes has been carried out by reference to IGEM SR25² with Quadvent2 used to determine zone extents.

3.2 Actions

	Ref	Action
1.	5.3	Haworth Scouring shall operate a hot work permit system (safe system of work) for maintenance of the equipment provided by Fre-energy. Guidance is provided in HS(G) 250 - See Section 10.6.
2.	5.3	Haworth Scouring shall ensure that mobile phones and other items of portable equipment not suitable for use in DSEAR zones are prohibited from hazardous areas indicated by EX signage unless controlled by a Safe System of Work / hot work permit.
3.	5.3	All equipment in hazardous zones shall be installed, maintained and inspected by competent persons and must comply with the EPS and BSEN 60079-17. Replace any non – compliant items. A suitable measure of competence is CompEX training.
4.	5.3	Annual fixed wire electrical testing is required to Electrical testing to Codes and Standards - IET Wiring Regulations 18 th Edition. Tests should be recorded for auditing.

² Institute of Gas Engineers and Managers (IGEM) SR/25 Edition 2 Hazardous area classification of natural gas installations

	Ref	Action
5.	5.3	All earthing should be checked at least annually, and results recorded for inspection
6.	5.3	Antistatic safety footwear should be worn when operating and maintaining the site in the defined hazardous areas. Outer clothing – such as hi vis vests and jackets - must not be removed in hazardous areas because of the risk of static.
7.	5.5.3	Gas burners must be inspected at least annually by a competent person.
8.	5.5.4	Safe operation of the flare requires ongoing vigilance with respect to maintenance of the system in general, controls and interlock, and the flashback arrestor.
9.	6.1	H ₂ S is highly toxic and can be fatal if inhaled at high concentration. Any spills below ground level should be considered toxic and the area not entered without a test to ensure a breathable atmosphere.
10.	6.1	Housekeeping is an important control measure for DSEAR safety. Ensure that combustible materials are not stored in hazardous areas.
11.	6.3	Ensure that people who enter hazardous areas wear anti-static footwear and do not use portable uncertified equipment like mobile phones in hazardous areas.
12.	6.4	Any change in feed, wastes, equipment or processes requires review of this DSEAR assessment.
13.	9	EX signs required at the following locations: <ul style="list-style-type: none"> • Top of Digester Stairways • Near to Biogas Storage • Near to gas booster skid
14.	10.1	A simple written fire emergency plan should be written. The plan should have the following elements: <ul style="list-style-type: none"> • schematic layout of the site showing location of flammable substances • a clear passageway to all escape routes – a site map with escape routes marked on is recommended • clearly marked escape routes that are as short and direct as possible • enough exits and routes for all people to escape • emergency doors that open easily • emergency lighting where needed • briefing for contractors when on site to know and use the escape routes • a safe meeting point for people on site
15.	10.2	Share the conclusions of the DSEAR assessment with the site staff.
16.	10.3	Ensure all containers of flammable liquids such as diesel carry the Category 3 Flammable label and that gas lines are labelled as Biogas

4 Properties of DSEAR Substances

Biogas is a mixture of approximately 60% to 65% flammable methane (CH₄) and 35 - 40% non-flammable (asphyxiant) carbon dioxide (CO₂).

In addition (toxic) hydrogen sulphide (H₂S) is also present, the H₂S levels are low, typically 200ppm but could be as high as several thousand ppm if chemical dosing systems fail.

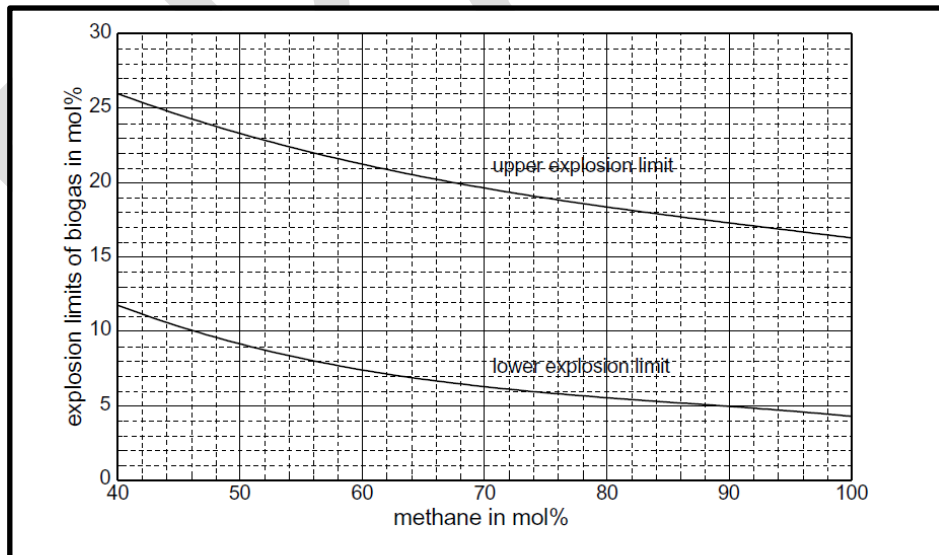
Flammable Properties of Methane and H₂S

Name (alternative names in brackets)	Mol. mass (M)	Lower explosive limit (LEL)	Flash point	Boiling point	Density at ntp (air = 1.2 kg/m ³)	Saturated vapour pressure (svp)	App. grou p	Temp. class (AIT)
Methane (CH ₄)	16	4.4%	Gas	Gas	0.66 kg/m ³	Gas	IIA	T1 (537°C)
Hydrogen sulphide (H ₂ S)	34	4.0%	Gas	Gas	1.406 kg/m ³	Gas	IIB	T3 (260°C)

Physical property data from BS EN 60079-20-1:2010 Explosive atmospheres. Material characteristics for gas and vapour classification. Test methods and data.

Flammability of Biogas

Figure 3: Flammability Biogas Mixtures[†]



[†] Figure 6 from: "2014 ISSST", 2014 International Symposium on Safety Science and Technology. Explosion protection in biogas and hybrid power plants Volkmar SCHROEDER*, Bernd SCHALAUa, Maria MOLNARNEb

The flammability of biogas is different from that of methane alone. Whereas LEL of pure methane is approximately 4.4%, the LEL of a 60% methane Biogas is approximately 7.5%.

5 Regulation 5 Risk Assessment and Regulation 6 Risk Elimination/ Reduction

5.1 Regulation 5 Guidance

DSEAR Regulation 5 requires risk assessments that identify:

- The hazardous properties of the substance.
- Information on safety provided by the supplier, including information contained in any relevant safety data sheet.
- The circumstances of the work, including:
 - The work processes and substances used and their possible interactions;
 - The amount of the substance involved;
 - Where the work will involve more than one dangerous substance, the risk presented by such substances in combination, and;
 - The arrangements for the safe handling, storage and transport of dangerous substances and of waste containing dangerous substances.
- Activities, such as maintenance, where there is the potential for an increased level of risk.
- The effect of measures which have been or will be taken pursuant to these regulations.
- The likelihood that an explosive atmosphere will occur and its persistence.
- The likelihood that ignition sources, including electrostatic discharges, will be present and become active and effective.
- The scale of the anticipated effects of a fire or an explosion.
- Any places, which are or can be connected via openings to places in which explosive atmospheres may occur.
- Such additional safety information as the employer may need to complete the Risk Assessment.

The method involves the following steps:

- Using guidewords to identify credible potential fire and explosion hazards and their consequences;
- Rating the severity and likelihood of the event occurring to arrive at an overall risk ranking (see Paragraph 5.2 below);
- Listing existing mitigation;
- Reviewing and amending the severity and / or likelihood to arrive at a mitigated risk;
- Assigning actions for any further mitigation that might be deemed necessary.

The risk assessment focusses on areas where flammable hazards are present.

Guide words used for the risk assessment were:

External Fire e.g. pool fire/ flash fire/ torch fire / BLEVE/lagging fire/electrical fire	Credible.
Internal Fire e.g. inside equipment, ducts, vent headers, metals fire	Credible
Internal Explosion Contained explosion, relieved explosion, burst containment, detonation	Credible
Confined Explosion (in building / structure) or detonation/vapour cloud explosion	Credible

Unconfined Explosion e.g. VCE / explosion / detonation	Not credible
Maintenance	Credible

Only risks giving rise to meaningful hazards were recorded.

Unmitigated risk is allocated a severity and a likelihood. The risk is then categorised as 1, 2 or 3 as per matrix.

3	Very serious intolerable risk. Terminate activities immediately
2	Tolerable if ALARP: Consider further action to reduce risks As Low as Reasonably Practicable
1	Broadly acceptable: Manage continuously to maintain existing control measures

Following application of mitigating factors, the risk is reassessed, and actions listed if required.

The Principle of ALARP is as low as reasonably practicable. It is a level of risk accepted by the HSE when further measures to reduce the risk would lead to disproportionate cost or effort.

HSE Definition of ALARP:

“ALARP” is short for “as low as reasonably practicable”. “SFAIRP” is short for “so far as is reasonably practicable”. The two terms mean essentially the same thing and at their core is the concept of “reasonably practicable”; this involves weighing a risk against the trouble, time and money needed to control it. Thus, ALARP describes the level to which we expect to see workplace risks controlled.
<http://www.hse.gov.uk/risk/theory/alarpglance.htm>

5.2 Risk Ranking

Figure 4: Risk Matrix

Likelihood	Severity					Conclusion	
	1	2	3	4	5	Mitigated Risk Categories	
5	5	10	15	20	25	3	Very serious intolerable risk. Terminate activities immediately
4	4	8	12	16	20	2	Tolerable if ALARP: Consider further action to reduce risks As Low as Reasonably Practicable
3	3	6	9	12	15		
2	2	4	6	8	10	1	Broadly acceptable: Manage continuously to maintain existing control measures
1	1	2	3	4	5		

Severity of Consequences:

Severity	Factor	Guideword
5 Catastrophic	Safety	Multiple onsite fatalities. Any number of offsite fatalities
	Fires	Whole plant or office significantly affected. Over one month of business interruption. Significant damage to multiple plant items. Significant loss of business information.
4 Major	Safety	Fatality / life threatening injury, amputation of limb (including fingers / toes)
	Fires	Whole plant or office significantly affected. Over one month of business interruption. Significant damage to multiple plant items. Significant loss of business information
3 Severe	Safety	Fractures, other than fingers or toes. Reduction or loss of sight. Crush injury to head or torso. Burns that cover more than 10% of the body or cause significant injury to eyes or respiratory tract. Loss of consciousness due to head injury or asphyxiation. Any accident involving injury in a confined space. Any injury or illness involving resuscitation or hospitalisation for more than 24 hours.
	Fires	Whole plant or office significantly affected. Up to 4 weeks of business interruption. Significant damage to multiple plant items. Significant loss of business information.
2 Serious	Safety	An incident involving medical treatment beyond defined first aid. A lost time accident without Severe consequences.
	Fires	Multiple areas affected. Up to one week of business interruption. Significant heat damage to equipment. Minor loss of business information.
1 Significant	Safety	A first aid incident.
	Fires	One plant area or office significantly affected. Up to two days of business interruption. Some heat damage to equipment. Minor loss of business information.

Likelihood:

Probability of Occurrence							
10-7 (H)	10-6 (G)	10-5 (F)	10-4 (E)	10-3 (D)	10-2 (C)	10-1 (B)	1 (A)
1	2		3		4		5
EXTREMELY UNLIKELY	VERY UNLIKELY		UNLIKELY		POSSIBLE	PROBABLE	REGULAR
Theoretically possible but extremely remote chance of occurrence	Foreseeable event but very remote chance of occurrence during the lifetime of the plant / facility / process. Requires multiple failures.		Incidents known in industry. Unlikely events not expected during the lifetime of the plant / facility / process. Requires 2 systems to fail.		Possible during the lifetime of the plant / facility / process. Root cause likely to have occurred.	Event or near miss that has occurred during the plant / facility / process life time.	Event occurs regularly on the plant / facility / process.

5.3 Ignition Risk Assessment

EN 1127³ Part 1 [13] Section 5 lists thirteen type of ignition source. Control measures for each are tabulated below.

Ignition source (By EN 1127-1 paragraph)	Controls in place ⁴
5.1) Hot surfaces	<p>Action 1 –Haworth Scouring shall operate a hot work permit system (safe system of work) for maintenance of the equipment provided by Fre-energy. Guidance is provided in HS(G) 250 - Section 10.6.</p> <p>Autoignition temperature of methane is 537°C. Exhaust gases on biogas engines are typically at approximately 450°C⁵. Hot surfaces from engine are an unlikely source of ignition.</p>
5.2) Flames and hot gases (including hot particles)	Smoking is prohibited on site
5.3) Mechanically-generated sparks	<p>See Action 1.</p> <p>The Safe System of Work should control sparks and hot surfaces arising from engineering activities.</p>
5.4) Electrical apparatus	<p>Action 2: Haworth Scouring shall ensure that mobile phones and other items of portable equipment not suitable for use in DSEAR zones are prohibited from hazardous areas indicated by EX signage unless controlled by a Safe System of Work / hot work permit.</p> <p>FRE-energy has ensured that appropriately protected electrical and non-electrical equipment is fitted within ATEX zones.</p> <p>Action 3: All equipment in hazardous zones shall be installed, maintained and inspected by competent persons and must comply with the EPS⁶ and BSEN 60079-17⁷ Replace any non – compliant items. A suitable measure of competence is CompEX training⁸.</p> <p>We work with https://www.cenelec.com/ for such services.</p>
5.5) Stray static currents, cathodic corrosion protection	<p>Fre-energy has ensured that all equipment is earthed to prevent static shock to personnel.</p> <p>Compliance with the Electricity at Work Regulations 1989 incorporating requirements for earthing and bonding are the appropriate controls.</p>

³ BS EN 1127- Explosive atmospheres - Explosion prevention and protection Part 1: Basic concepts and methodology

⁴ Additional guidance can be found in the appropriate part section 6.4.X of EN 1127-1

⁵ <https://www.clarke-energy.com/2013/chp-cogen-efficiency-biogas/>

⁶ Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996 (EPS)

⁷ BS EN 60079-17: 2014 Explosive atmospheres. Electrical installations inspection and maintenance.

⁸ CompEx stands for Competency in Explosive atmospheres. CompEx is a globally recognised certificate. The certificate shows that employees and contractors have an understanding and level of competency sufficient for them to work in potentially explosive atmospheres.

Ignition source (By EN 1127-1 paragraph)	Controls in place⁴
	<p>The Electricity at Work Regulations apply to all aspects of the use of electricity within the workplace. They place duties on employers, employees and the self-employed to prevent danger.</p> <p>Duty holders must</p> <ul style="list-style-type: none"> • Have the electrical systems constructed in a way that prevents danger. • Maintain the electrical systems as necessary to prevent danger (including a 5 year fixed installation inspection). • Carry out work on electrical systems carried out in a way that prevents danger. <p>Electrical equipment used in hazardous environments must be constructed or protected to prevent it becoming dangerous. This includes:</p> <ul style="list-style-type: none"> • Extremes of weather. • Extremes of temperature. • Corrosive conditions. <p>Employees should only work on or with electrical equipment if they have suitable:</p> <ul style="list-style-type: none"> • Training. • Knowledge. • Experience. • Supervision. <p>Records of earth checks are maintained on site.</p> <p>No cathodic protection on site.</p> <p>Action 4: Annual fixed wire electrical testing is required to Electrical testing to Codes and Standards - IET Wiring Regulations 18th Edition⁹ Tests should be recorded for auditing.</p> <p>Portable electrical equipment such as mobile phones must be controlled in hazardous areas.</p> <p>Cathodic protection is not required.</p>
5.6) Static electricity	<p>Fre-energy has ensured that all equipment is earthed to prevent incendiary static discharge.</p> <p>Action 5: All earthing should be checked at least annually, and results recorded for inspection.</p> <p>Anti-static clothing is not required.</p> <p>Action 6: Static dissipative safety footwear should be worn when operating and maintaining the site. Outer clothing such as hi vis vests and jackets must not be removed in hazardous areas because of the risk of static.</p>

⁹ IET Wiring Regulations 17th Edition (BS 7671:2008+A3 2015)

Ignition source (By EN 1127-1 paragraph)	Controls in place ⁴
5.7) Lightning	A lightning risk assessment has been carried out. see associated documents: <ul style="list-style-type: none"> • Haworth Scouring New SD Plant LPRA Study. ADH.24.031C.EE4 • Appendix A, LPRA StrikeRisk Results summary for Structure 1. ADH.24.031C.EE4 • Appendix B, LPRA StrikeRisk Results summary for structure 2. ADH.24.031C.EE4
5.8) RF electromagnetic waves from 10 ⁴ Hz to 3 x 10 ¹¹ Hz	None identified.
5.9) Optical electromagnetic waves from 3 x 10 ¹¹ Hz to 3 x 10 ¹⁵ Hz	None identified.
5.10) Ionizing radiation	Unlikely to be present.
5.11) Ultrasonics	Unlikely to be present.
5.12) Adiabatic compression and shock waves	Unlikely to be present.
5.13) Exothermic reactions, including self-ignition of dusts	Exothermic or other potentially violent reactions are unlikely to be carried out. There are no substances capable of self ignition.

5.4 Assumptions

1. For all maintenance work, adequate procedures are in place for the isolation from all energy sources and the removal of stored energy which may present a hazard.
2. Written operating procedures in place in the form of the Fre-energy and CHP OEM Manuals.
3. Trained experienced operators operate the plant.
4. Written emergency procedures for response to fire and explosion are in place with employees trained, contractors informed during induction and visitors accompanied if not inducted.
5. Fire Risk Assessment as required by the Regulatory Reform (Fire Safety) Order 2005 is up to date with respect to call points, extinguishers etc.
6. Personnel trained in fire response and emergency evacuation.
7. Emergency services available locally and familiar with site hazards.
8. Equipment compliance to EPS, IP rating and other standards, as stated in associated documentation, is assumed. The equipment has not been inspected to verify this compliance.
9. Competent personnel shall be engaged for all operations and maintenance tasks.
10. Evidence of staff training and competency assessment shall be recorded for future inspection as required by The Competent Authority.

This section should be read in conjunction with these documents:

- Hazard Identification Study (HAZID) PDA-HAW-HAZ-24001
- Hazard and Operability Study (HAZOP) PDA-FRE-HS-25001
- Fire Risk Assessment Strategy ADH.24.031C.EE4
- CFD Gas Dispersion Study for HS new AD Plant ADH.24.031C.EE4
- Haworth Scouring New SD Plant LPRA Study. ADH.24.031C.EE4
 - Appendix A, LPRA StrikeRisk Results summary for Structure 1. ADH.24.031C.EE4
 - Appendix B, LPRA StrikeRisk Results summary for structure 2. ADH.24.031C.EE4

5.5 Risk Assessment Tables

5.5.1 Digesters

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
Internal Fire Or Explosion	Air in Digester or biogas piping creates a flammable mixture.	Unprotected equipment (not ATEX or UKEX certified) Lightning Static Sparks from equipment	Explosion could lead to operator injury - worst case fatality Likelihood – possible	4	4	16	<ul style="list-style-type: none"> Equipment and biogas piping operates fuel rich when on line. Period of danger is during commissioning when there is supervision by Fre-energy and limited people in the area. Hazard known and understood by Fre-energy. Only competent people who can understand and manage the risks are involved in commissioning. Static unlikely as source of ignition because liquid is conductive as are vessels, high humidity in all vessels and all 	4	1	4	<p>Basis of Safety: Absence of a flammable atmosphere.</p> <p>Residual risk during commissioning is controlled by competent people and procedures.</p>

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
							equipment is earth bonded.				
External fire Or Explosion within bunded area.	Liquid leak from piping or Digester. Methane dissolved in the liquid evolves and forms a flammable atmosphere above the liquid pool	Personal ignition sources e.g. mobile phones Smoking Static electricity Uncertified equipment (not ATEX or UKEX certified) Lightning Vehicles	Fire, as an explosion is unlikely due to lack of confinement. Fire could cause significant equipment damage. Possible serious injury or fatality if someone in the area is unable to escape.	4	3	12	<ul style="list-style-type: none"> Methane evolves slowly from liquid digestate leaks. Work quoted in ESA ICoP 3¹⁰ for leachate concludes that the methane content of air in equilibrium with leachate saturated with methane will only be slightly over LEL of methane. Because of the open aspect, ventilation will be of medium degree with high availability resulting in zones of negligible extent (non – hazardous) and certified equipment not required within the bunded area except near to releases such as compressor seals. Gas system is at low pressure until booster 	4	1	4	Basis of Safety: Control of sources of ignition.

¹⁰ AREA CLASSIFICATION FOR LEACHATE EXTRACTION, TREATMENT & DISPOSAL. INDUSTRY CODE OF PRACTICE. ESA ICoP 03, edition 1: May 2006

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
							just upstream of CHP engine meaning that leak rates are low except for catastrophic failure. <ul style="list-style-type: none"> • Equipment in hazardous zones – e.g. gas mixing compressors suitably certified • No access to banded area for vehicles • Digester has over and under pressure relief. • Gas piping design pressure exceeds the maximum bigas pressure. • Emergency plan • Fire Risk Assessment (FRA) • Escape routes • Trained operators 				
External fire Or Explosion within banded area.	Biogas leak from piping, compressor seal or Digester.	Personal ignition sources e.g. mobile phones Smoking Static electricity Uncertified equipment (not	Fire. Explosion unlikely due to lack of confinement. Fire could cause significant	4	3	12	<ul style="list-style-type: none"> • Natural ventilation limits flammable atmospheres. • Hazardous area classification. • Certified equipment in hazardous areas (e.g. compressors) is 	4	1	4	Basis of Safety: Control of sources of ignition.

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
		ATEX or UKEX certified) Lightning Vehicles	equipment damage. Possible fatality if someone is nearby				installed and inspected by competent persons. <ul style="list-style-type: none"> Gas system is at low pressure until booster just upstream of CHP engine meaning that leak rates are low except for catastrophic failure. There are no combustibles such as vegetation within banded area. No access to banded area for vehicles Digester has over and under pressure relief. Gas piping design pressure exceeds the maximum bigas pressure. Steel piping is unlikely to suffer mechanical damage in its location. Digester is substantial steel construction with over and under pressure protection. 				

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
							<ul style="list-style-type: none"> Periodic inspections of piping and digester. Emergency escape routes Trained operators FRA 				
External fire Or Explosion	Pressure relief valve of Digester fails fully open – nearby railway line could be affected by a substantial release.	Personal ignition sources e.g. mobile phones Smoking Static electricity Uncertified equipment (not ATEX or UKEX certified) Lightning Vehicles Rail traffic	Fire. Explosion unlikely due to lack of confinement. Fire will cause significant equipment damage. Possible fatality if someone is nearby	4	3	12	<ul style="list-style-type: none"> Digester Relief valve located at high level > 6m so releases are likely to disperse upwards on release. CFD modelling defines worst case scenarios and concludes rail line is likely to be unaffected. Naturally vented in an open air situation. Unlikely to release as would need a blockage or valve closure in vent line. Valve in vent line is a maintenance valve not used in normal operation so there is no reason for operator to close it. Biogas molecular weight is close to that 	4	1	4	Basis of Safety: Control of sources of ignition.

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
							<p>of air, but as it is warm in most ambient conditions it will rise and disperse.</p> <ul style="list-style-type: none"> • Hazardous zone for Digester RV calculated as 4.5m with a mushroom like shape from vent cowl. • Emergency escape routes • Trained operators • FRA 				
External fire Or Explosion	<p>Digester roof leak or rupture – could be closed isolation valve causing collapse under vacuum.</p> <p>Major release of liquid evolving methane leading to a flammable atmosphere above liquid pool.</p>	<p>Personal ignition sources e.g. mobile phones</p> <p>Smoking</p> <p>Static electricity</p> <p>Uncertified equipment (not ATEX or UKEX certified)</p> <p>Lightning</p> <p>Vehicles</p>	<p>Fire.</p> <p>Explosion unlikely due to lack of confinement.</p> <p>Fire will cause significant equipment damage.</p> <p>Possible fatality if someone is nearby</p>	4	3	12	<ul style="list-style-type: none"> • Roof is substantial construction designed for +12 / -1.5 mbarg. • Operated at up to approximately 7 mbarg. • Vacuum relief is provided. • Controlled access to vehicles in bunded area. 	4	1	4	

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
External fire Or Explosion	Fire from other combustibles causes failure of biogas store or piping		No other combustibles in area – not credible.				•				
External fire Or Explosion	Pipework joint leak or pipe rupture – e.g. by impact leading to a major release of biogas and a flammable cloud.	Personal ignition sources e.g. mobile phones Smoking Static electricity Uncertified equipment (not ATEX or UKEX certified) Lightning Vehicles	Fire. Explosion unlikely due to lack of confinement. Fire will cause significant equipment damage. Possible fatality if someone is nearby	4	3	12	<ul style="list-style-type: none"> Pipework is designed for 10 barg operated at approximately 7 mbarg. Piping is routed at high level where it is unlikely to be impacted by vehicles etc. Relief protection of Digester at +12 / -1.5 mbarg and relief protection to Gas Bag at +12 / -0.5 mbarg CFD modelling covers major leak scenarios. 	4	1	4	Basis of Safety: Control of sources of ignition.
Confined explosion	No scenarios envisaged										
Unconfined explosion	Biogas will disperse and not accumulate a flammable atmosphere										

5.5.2 Biogas Storage

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
Internal Fire Or Explosion	Air in Biogas Bag	Unprotected equipment (not ATEX or UKEX certified) Lightning Static Sparks from equipment	Fire will cause significant equipment damage. Explosion could lead to operator injury worst case fatality	4	4	16	<ul style="list-style-type: none"> Equipment operates fuel rich when on line. Period of danger is during commissioning when there is supervision by Fre-energy and limited people in the area. Hazard known and understood by Fre-energy. Only competent people who can understand and manage the risks are involved in commissioning. All equipment is earth bonded. 	4	1	4	Residual risk during commissioning is controlled by competent people and procedures.
External fire or explosion	Biogas leak from piping.	Personal ignition sources e.g. mobile phones Smoking Static electricity Uncertified equipment (not ATEX or UKEX certified) Lightning	Fire. Explosion unlikely due to lack of confinement. Fire could cause significant equipment damage.	4	3	12	<ul style="list-style-type: none"> Gas system is at low pressure until booster just upstream of CHP engine meaning that leak rates are low except for catastrophic failure. Equipment in hazardous zones – e.g. gas mixing compressors suitably certified 	4	1	4	

		Vehicles	Possible fatality if someone is nearby				<ul style="list-style-type: none"> No access to banded area for vehicles Biogas bag has over and under pressure relief. Gas piping design pressure exceeds the maximum biogas pressure. Steel piping is unlikely to suffer mechanical damage in its location. Digester is substantial steel construction with over and under pressure protection. Periodic inspections of piping and digester. 			
Confined explosion	Leak from inner biogas bag accumulates a flammable atmosphere in interspace.	Static electricity Uncertified equipment (not ATEX or UKEX certified) Lightning	Fire or more likely than explosion. Possible fatality of a person nearby.	4	3	12	<ul style="list-style-type: none"> Blower will disperse leaks preventing the build up of a flammable atmosphere. Gas system is at low pressure until booster just upstream of CHP engine meaning that leak rates are low except for catastrophic failure. Equipment in hazardous zones – e.g. gas mixing compressors suitably certified 			

							<ul style="list-style-type: none"> • Biogas bag has over and under pressure relief. 				
Unconfined explosion	<p>Catastrophic failure of both layers of biogas bag unlikely except with a lightning strike.</p> <p>See action related to lighting protection.</p>										

5.5.3 CHP – Generic assessment that can be updated if Haworth provides OEM information.

Typical precautions based on Clarke Energy Series 3 CHP Engine:

Ventilation within engine room is suitable for cooling hot surfaces and exceeds that required for dilution to Zone 2 NE¹¹.

- Minimisation of flammable gas leaks by good installation practice to a recognised standard.
- Leak testing on commissioning and following any maintenance involving line breaking.
- Ventilation designed to dilute any foreseeable leak to less than 20% of the LEL
- Gas detectors are set to two levels:
 - At 10% LEL, (pre- alarm)
 - Engine safety shut off valves (internal) is closed
 - Gas safety valve external to container closes
 - Enclosure Ventilation Fan(s) run at full speed
 - Ventilation inlet outlet louvres open fully
 - At 20% LEL, (alarm)
 - Engine safety shut off valves (internal) is close
 - Gas safety valve external to container closes
 - Enclosure Ventilation Fan(s) run at full speed
 - Ventilation inlet outlet louvers open fully
- Note: at 20% LEL the control system reaction is the same as with 10%LEL The difference is that at 10% a soft stop is initiated while at 20% the safety line is acted upon to ensure that the engine is stopped and the gas isolated.

¹¹ NE stands for negligible extent. A Zone of negligible extent is defined when the consequences of ignition are low. ATEX certified equipment is not required.

- When the Engine safety shut off valve system closes, the leak sources are from the pipework, upstream of the engine safety shut off valves and the compressor system and the detectors which remain activated on shut down would detect any unlikely event of gas leakage and initiate an alarm and start the ventilation fans plus preventing a re-start.
- Area not normally occupied

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
External fire or explosion (This is also the confined explosion scenario).	Leak of gas making a flammable atmosphere within shed around the CHP engine	Personal ignition sources e.g. mobile phones Smoking Static electricity Uncertified equipment (not ATEX or UKEX certified) Vehicles	Destruction of CHP Possible operator fatality if in area	4	4	16	<ul style="list-style-type: none"> • Minimisation of flammable gas leaks by good installation practice. • The engine enclosure has forced ventilation to cool the engine which will control releases. • Leak testing on commissioning and following any maintenance involving line breaking. • Fire detection within CHP enclosure to raise an alarm and close a slam shut valve isolating the gas supply to the engine • Area not normally occupied 	4	1	4	

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
Internal fire or explosion	Unburned gas accumulates into flammable atmosphere	Igniter Hot surfaces	Destruction of CHP or boiler plant Possible operator fatality if in area.	4	4	16	• Gas burner controls to BS EN746-2 ¹² or equivalent standard.	4	1	4	Action 7: Gas burners must be inspected at least annually by a competent person.
Unconfined explosion	Biogas will disperse and not accumulate a flammable atmosphere										
Internal fire or explosion – inside piping	As in Table 5.5.1										

5.5.4 Flare

The flare provided by Flare Products is an enclosed flare is classified as a flare which consists of an enclosed combustion chamber, where the flame is invisible from outside. An enclosed flare burns more efficiently with a relatively higher temperature than an open flare, and the burning temperature can be monitored.

Basis of Safety is by the application of Process Control Equipment (PCE) within Flare and by absence of a flammable atmosphere outside of Flare.

The following interlocks are provided in the Flare Products Basic Process Control System (BCPS) and are protective measures in the risk assessment:

- Low Pressure – If a low inlet gas pressure is detected at any time, the flare stack will shut down and lockout. A manual reset will be required to clear the low pressure interlock. A timer delay in this interlock allows system start up.

¹² BS EN746-2 Industrial thermoprocessing equipment. Safety requirements for combustion and fuel handling systems

- Flashbacks – If a flashback is detected in the Flare the flare stack will shut down and lockout. A manual reset will be required to clear the flashback interlock. (Note that a site investigation is advised if a flashback is experienced during normal operation).
- A flame arrestor shall also be installed to prevent flashback.
- Ignition Failed– If the flare stack fails to light (i.e., the pilot thermocouple does not detect any heat) after the set period (5 minutes as set on Timer ALT within the control panel), the flare stack will shut down and lockout. A manual reset will be required to clear the Ignition Failed Interlock.
- High Temperature– If a flare stack burn high temperature is detected in Flare, the flare stack will shut down and lockout. A manual reset will be required to clear the Flare High Temperature Interlock.
- Pilot flame failure interlocks the burner to stop.

On power failure all equipment on the flare stack system will stop/shutdown in a safe manner having been designed failsafe. On recovery from a power failure, the system Auto Resets. Once the run and burn rate signals are received from the BCPS, the flare should run as in normal operation.

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
Internal fire or explosion within Flare	Unburned fuel gas in Flare casing / burner can lead to internal explosion	<ul style="list-style-type: none"> • Hot surfaces • Flames • Igniter 	<p>Explosion causing severe damage to equipment and extended plant shutdown.</p> <p>People not normally in area – fatality or at least serious injury if they are.</p>	4	4	16	<ul style="list-style-type: none"> • Burner management system and gas train conforms to standards – E.g. ISO 52280¹³ • Interlocks as defined above table • Regular inspections and maintenance by 'Gas Safe' registered technician 	4	1	4	Requires ongoing vigilance with respect to maintenance of burner management system and gas train.

¹³ ISO 52280: Flares for combustion of biogas

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
						16	<ul style="list-style-type: none"> 5m exclusion zone around flare in conformance with ISO: 52280 Clause 6.18. 			4	
Internal fire or explosion – inside piping	As in Table 5.5.1										
Internal fire or explosion (within piping or equipment)	Flashback of flame from Flare	<ul style="list-style-type: none"> Flashback 	Major fire / explosion leading to extended shutdown, major asset loss and injury / fatality if people are in the area.	4	4	16	<ul style="list-style-type: none"> Flashback arrestor in line Piping will contain 8.5 barg explosion due to design, fabrication and testing Above UEL in piping and equipment. No air in piping or equipment except open flare. Planned preventive maintenance Static earthing and bonding. 	4	1	4	<p>Action 8: Safe operation of the flare requires ongoing vigilance with respect to maintenance of the system in general, controls and interlock, and the flashback arrestor.</p> <p>Action 7 also applies to the flare.</p>

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
External fire or explosion	Leak of flammable biogas mixes with air to form a flammable mixture and finds a source of ignition	<ul style="list-style-type: none"> Uncertified equipment Static Lightning Hot work Personal sources of ignition e.g. mobile phones, tablet devices Vehicles 	<p>Fire causing significant asset damage</p> <p>People not normally in area –fatality or serious injury if they are</p>	4	4	16	<ul style="list-style-type: none"> Static earthing and bonding Natural ventilation in area enough to reduce hazardous zones to negligible extent 6m exclusion zone around flare in conformance with standards and codes of practice. Vehicles excluded from area unless controlled by permit to work 	4	1	4	
Confined explosion	No scenarios envisaged										
Unconfined explosion	Biogas will disperse and not accumulate a flammable atmosphere										

Section 6 from ISO52280 – Biogas Flares:**6 Design and construction of flares for combustion of biogas**

The minimum requirements for the design and construction of safe and minimized methane emission flares for combustion of biogas are described in this Clause. Safety regulations on construction sites during construction are not part of this document.

6.1 Efficiency of the flare

The combustion yield of the flare shall be at least:

99% for enclosed flares, and 99.99% or less than 10mg CH₄/Nm³ in flue gas at a reference of 15 vol % oxygen for enclosed high efficiency flares.

These yields need to be measured on a continuous or regular performance basis by an independent party, using standardised or scientifically proven measurement methodologies which prove that the measured values are representative for the operation of the flare. National standards might impose additional requirements on combustion yields and/or additional protocols for measurement.

Measurement methods have to be scientifically supported (which often is the case for methods included in National or International Standards), to prevent measurements which are not representative for the operation of the flare. Scientifically proven combustion yields shall be proven by measurements.

The flare shall be able to combust the minimum and maximum flow and composition of biogas (or biomethane) expected at the particular installation.

6.2 Pressure

The flare can use the biogas pressure system of the biogas plant to realise sufficient pressure of the biogas if possible and prevent the use of an additional compressor or blower. When the gas pressure is very low (less than 1,0 kPa or 2,0 kPa) or not stable an additional compressor or blower may be needed. Generally, the minimum pressure is 1,0 kPa and the maximum pressure depends on the manufacturer.

The biogas main inlet pipe can be equipped with one or more pressure switches to realise pressure sensing automatic ignition. The pressure shall be adjustable over a range reflecting the actual operation of the system. When the pressure achieves the high limit, the flare turns on, when the pressure reaches the low pressure limit the flare shuts down. The supplier of the flare shall determine a safe operating shut-down point to prevent a vacuum drawing the flame into the digester. Systems with constant pressure gas holders, such as dual membranes, shall use the gas holder level signal and/or biogas pressure signal to determine the start and stop points of the flares.

Pressure detectors for safety shall comply with IEC 60730-2-6 and the function shall meet the requirement of the protective system according to ISO 13577-4.

6.3 Air supply and gas flow

For the air supply natural draft may be used in order to avoid an additional combustion air blower leading to additional operational requirements. High efficiency flares may utilise air injection for pre-mixing. The flare should be designed in a way to realise sufficient air supply in relation to the gas supplied via the gas burner (for example louvers can be used). The burner design shall enable pre-mixed combustion. The air and the biogas are mixed in order to increase the combustion temperature and reduce the flame length. Alternative technologies to supply air can be used, if the applicable combustion yields are achieved. When the flare stops working the gas supply shall be stopped before the air supply is stopped.

6.4 Pilot Burner

An ignition burner or pilot burner (next to the main burner) shall be used for auxiliary ignition to prevent the potential explosion danger. The ignition device source can be biogas or bio methane itself or other fuel gas. For safety reasons it is important the gas is combustible.

In some countries it is forbidden to use biogas as fuel for the pilot burner, for example because biogas can be less reliable for a pilot burner, especially in the case of a cold climate or variable feedstocks. In other countries other fuel gases might not be available, so biogas or biomethane is the only option. National legislation shall be reviewed before choosing the type of fuel for the pilot burner.

6.5 Treatment of the gas

The biogas may be treated before combustion in the flare. This depends on the specification of the biogas (composition of the biogas) and the materials used.

The following treatments can be performed

- *Desulfurisation*
- *Dewatering*
- *Removal of siloxanes*
- *Removal of carbon dioxide (as part of possible biogas upgrading);*
- *Pressurising.*

Flares designed specifically for biogas normally do not require treatment, although it may be required by national emissions regulations, especially regarding sulphur.

6.6 Materials

Materials of construction should be designed to resist heat and corrosion that the portion of the flare will see.

Materials in contact with the biogas, such as piping materials, shall be stainless steel AISI 304 or AISI 316 at least AISI 304 when the H₂S concentration is lower than 300 ppmv and stainless steel AISI 316 in case the H₂S concentration is 300 ppmv or more. AISI 304 is allowed for materials in contact with biogas with a H₂S concentration between 300 ppmv and 600ppmv in case an independent expert can prove the material is resistant for such concentrations in the specific circumstances.

For valves, drip traps, and flame arresters in the line up to the flare, low copper aluminium (AA-356) is an acceptable material.

Supporting structures should be made of hot dip galvanised steel or stainless steel AISI 304 or AISI 316. The materials of the internally insulated combustion chamber can be AISI 304 or AISI 316.

The main body of the flame burner (directly in contact with the flames) should be high temperature resistant stainless steel (anti-corrosion materials). AISI 309 or 310. An alternative for materials in contact with combustion heat is AISI 347.

The main gas control valve material of flame burner should be made of corrosion resistant materials or should have sufficient corrosion allowance (e.g. applicable for cast iron steel). For the seal fluorine rubber or nitrile-base rubber are suitable for use. Except AISI 304 or AISI 316 also AA 356 is suitable as corrosion resistant material.

For enclosed flares when a lining or refractory ceramic fibre module is used, a top rain cover shall be used to prevent erosion or corrosion of the material. When a stainless-steel body is used there is no need to apply a rain cover. If the flare has a refractory lining, protection of rain ingress shall be applied to protect the refractory.

The materials of the structure, the burner, the combustion chamber and the pipes shall be designed with a lifetime of at least ten years based upon the composition of the gas for the specific location.

6.7 Flame arresters

The flare shall have a flame arrester placed between the main gas valve and the burner to prevent propagation of the flames to the gas source and/or the gas storage. Flame arresters shall be in accordance with ISO 16852.

The distance between the flame arrester and the gas burner shall not exceed the value specified by the supplier of the flame arrester.

In order to prevent detrimental effects to the gas source and/or gas storage caused by possible sparks from equipment such as compressors or blowers, it is recommended to place an additional flame arrester upstream of this equipment.

One or more additional flame arresters are needed in cases where sparks from equipment can cause risks to the gas source and/or gas storage. For example, this can be the case if the equipment is upstream from the maximum distance between flame arrester and gas burner, as mentioned before.

Many types of flame arresters can only stop a flame for a prescribed period. The flame arresters shall either be equipped with some means of thermal shut-off that is activated by a continuous burn on the flame arrester or alternatively the burner nozzle pressure shall be monitored and switch off when the flare burner pressure falls below a specified value to prevent back burning.

Flame arresters shall be maintained on a regular basis and for this reason shall be equipped with manual valves.

6.8 Burner control unit, ignition transformer, flame monitoring device

The flare shall be equipped with an automatic burner control unit in order to start and monitor the combustion process. The automatic burner control unit shall comply with IEC 60730-2-5.

The burner control unit shall consist of a shut-off valve for the main gas line, a shut-off valve for the ignition gas line and a flame detector. Furthermore, it consists of an ignition transformer, ignition electrodes, flame monitoring device, ignition or pilot solenoid valve and other safety equipment needed to ignite the flame and to monitor the presence of the flame continuously.

The ignition transformer transmits a high voltage to a spark rod, spark plug or ignition electrodes. Cables that have been properly sized and insulated for the output voltage of the ignition transformer shall be used. An ultraviolet sensor or similar device is used to monitor the status of the flame (flame monitoring device). When no flame is detected the safety shut-off valve shall be closed immediately.

6.9 Safety valves and other valves

Safety shut off valves shall be installed in the line going to the flare. The shut off valve shall be actuated pneumatically, hydraulically, electrically, or should be a diaphragm valve actuated by the biogas pressure, with means for electrically closing the valve.

The safety shut down valve shall be activated to prevent unsafe conditions at the flare. At a minimum it shall shut based on detecting a flame or high or low pressure.

If a by-pass flare is used to facilitate maintenance, this by-pass flare line shall have the same safety devices as the primary biogas supply line.

Automatic valves shall be quick-shut-off type pneumatic valve, slow or hydraulic slow opening-quick closing valve, to prevent the danger of flame back flash. For larger enclosed flares (>DN40), hydraulic slow opening and quick shut off valve both are recommended, for quick close purposes, proper valves shall be selected. Safety valves shall also prevent also an uncontrolled influx or air into the gas system.

Manual or automatic valves shall be placed at strategic locations to insulate (block-in) parts of the process for maintenance.

A manual valve shall be installed to stop the gas flow in case of emergencies or to enable maintenance. The valve shall be quarter turn to minimise the time required to operate in case of emergency.

To avoid creating an explosive atmosphere inside the flare pipework in accordance with IEC 60079-10-1 there shall be at least two automatic (safety) valves (refer to ISO 23551-1) in series in the paperwork leading to the flame. The automatic (safety) valves shall fulfil the requirements of ISO 13577-2:2014, 4.2.2.6.

Furthermore, an automatic valve shall be present to open or stop the main gas flow. This valve shall be closed when gas detection or leak detection alarm signals are created.

6.10 Control system

The control system of the flare shall include the automatic burner control system, ignition or pilot control system, shut-off valves and flame detector. The safety system shall be an independent system. An independent manual control system shall guarantee the safety. The manual control system can open or close the pipes to the flare manually in case of emergencies.

The control system shall be connected to the pipeline pressure signals and gas holder pressure signals. The flame burner reduction is accounted for the proportion of maximum burning flow and minimum burning flow (flame is invisible at outside).

The automatic control system shall be able to achieve functions as follows: the flare can be controlled manually remotely according to the following signals: gas holder level signal, and/or biogas pressure signal. The operation status signal i.e. combustion OK, valve open, fault etc., can be displayed and transferred to the control unit, including a maximum of four automatic restarts after which a qualified maintenance provider shall investigate the failure.

The design of the control cabinet depends on customer's demand. The control cabinet shall be equipped with heating devices, automatically start when the temperature is below 5°C and should be located outside the explosion zone. The cabinet shall be equipped with sufficient ventilation provisions.

For control cabinets installed outdoors, its protection grade should not be less than IP55 plus a rain cover or roof. Also, electrical equipment and cables shall be suitable for outdoor application. The location of control cabinets shall be selected considering national standards specifically regarding classification of hazardous areas.

The longitude of the signal cable which transfers the flare transmitter signal should not be over 50 meters and electromagnetic interference shall be avoided.

6.11 Flow measuring and gas analysis

For flares with a capacity of more than 100Nm³ biogas per hour a flow meter shall be present to register the quantity of gas in the burner. This flow meter is not necessary placed directly next to the flare, it is also allowed to deduct the flow by calculations from a flow meter elsewhere in the biogas system. This flow meter shall be calibrated at a frequency specified by the supplier, a common frequency is every two years. The requirement for a flow meter is not applicable for emergency flares (less than 10% of the hours per year) with a capacity of less than 500Nm³ biogas per hour.

The efficient combustion of methane shall be monitored, for example by measuring the methane content of the biogas to ensure the right ratio of methane and oxygen or the temperature of the flue gas.

6.12 Condensate removal

Accumulation of water in the flare system and pipes shall be prevented. At the bottom of the flare device, a drainage device shall be installed to collect and discharge the condensate water. The device for discharging condensate water shall be designed in a way that no biogas will escape. Equipment and instructions for condensate removal shall focus on preventing the escape of biogas as much as possible.

6.13 Insulation and heating

On locations where frost can occur, equipment, pipes, valves and other equipment and instruments which can contain humid gas, or condensate shall be insulated and/or heated (for example by tracing sufficiently).

6.14 Heat protection

At the bottom of the flare a protection shield shall be used if needed to prevent safety risks because of heat materials. The flare height should be calculated based on ground level radiant heat to ensure that personnel are properly protected when working around the flare.

6.15 Buildings and cabinets

In case (a part of) the equipment is installed in rooms, appropriate ventilation measures shall be taken to prevent gases are accumulating considering the different densities of the constituents in biogas (methane, carbon dioxide, hydrogen sulphide, etcetera).

National authorities can impose requirements for the rate of ventilation per hour to determine the room as non-hazardous regarding explosions. In contexts where such requirements are not fulfilled or not present, all electrical equipment shall be explosion proof.

Floors of these buildings and cabinets shall be tight and sealed to prevent leakages of fluids such as compressor oil and to prevent soil pollution.

Heating measures shall be taken in order to prevent damage in geographical areas with the low ambient temperatures (e.g. frost).

6.16 Lightning protection and earthing

The flare shall be protected against lightning and properly earthed in accordance with IEC 62305-2 and good industrial practices. The foundations and structures shall comply with the outcome of the before mentioned calculations.

6.17 Strength and stability calculations

Before installation of the flare and the civil foundation strength and stability calculations shall be executed by a suitable and certified company or authority, taking into consideration amongst others, weights, soil conditions, wind loads and earthquakes. For projects with big wind load, additional support can be used. National legislation shall be considered for the strength and stability calculations and for the way of executing the calculations.

6.18 Distances to other objects

The minimum distances between flares on the one hand and digesters, gas storage, buildings etcetera on the other hand in combination with the height of flares and other objects are mentioned below. There can be deviation from the minimum distances specified if thermal radiation calculations show that smaller distances are safe.

For the open flare, consideration should be given to the fire protection distance, the flare installation height and the influence of thermal radiation calculation shall prove that the applied distances are safe for human beings. For the enclosed flare, the main body of the flare height is mainly considered concealing and insulating the flame.

The flame or the flue gas outlet height should be at least 4m.

The radius of 5m around the flare shall be kept free of combustible materials (such as bushes, trees). The distance to buildings and traffic routes shall be at least 5m for enclosed types. Exceptions can be made after completion of thermal radiation calculations by an independent expert. For open gas flares and high throughput flares greater distances are usually necessary.

The required safety distances between gas flares and e.g. gas holders and hazardous areas shall be observed. The gas flare should be positioned in a way that the flame is blown away from the gas holder, buildings and traffic routes taking the prevailing wind direction into account.

A biogas flare shall not be placed on the lowest point of the direct surroundings.

7. Operations and maintenance requirements

7.1 Operations and maintenance manual

The manufacturer of the flare shall develop and provide the user a manual for operations and maintenance in English and in the local national language where the flare will be installed.

This manual shall describe at least the following:

- *Safety instructions*
- *Emergency procedures*

- *Risk of operation*
- *Operations instructions (a.o. procedures for start and stop)*
- *Monitoring and logbooks*
- *Maintenance schedules*
- *Regular inspections*
- *Efficiency evaluations*

7.2 Testing of the flare

Before site acceptance tests described below all vessels, piping and valves shall be tested at no less than 1.5 times the maximum operating pressure with an allowed deviation of +/-10% for at least one hour.

Before initially starting up the flare (and also before starting up after shut down, modifications and maintenance) the automatic leak detections (and if applicable gas detection) shall be tested as well as the function of the automatic safety shut-off valve of the flare and the generation of alarms. This can be tested in the software before starting up with gas. The automatic valve shall be opened and closed automatically based upon the specified pressures.

The purging of the flare met with inert gas shall be tested before starting operations with gas or biogas.

Often the flare is part of another gas installation and the flare shall start automatically in case of emergencies. These automatic starts shall be tested to ensure they are operating properly.

The automatic burner control system shall be tested by executing the following steps:

- *Start conditions before validation*
- *Air supply starts (if applicable)*
- *Ignition line solenoid valve opens → electrode produces spark*
- *Pilot burner starts*
- *Pilot flame is detected by flame monitoring device → electrode stops sparking →*
- *Open main gas valve*
- *Establish the main burning flame*
- *Normal combustion (automatic or manual adjustment of the burning load)*

- *The main fire flame extinction (including the main fire flame failure)*
- *Close gas supply*
- *Close gas supply (if applicable)*
- *Purge the pipes and combustion chamber (if applicable) downtime*

7.3 Operation of the flare

Operators are not allowed to manually operate the flare, unless all proper safety provisions are enabled during manual operation.

To avoid burns and other accidents operators and other personnel shall be prevented from touching devices or materials having high temperatures. Operators and maintenance staff shall be properly trained and instructed. Specific attention during the training shall be paid to safety aspects of toxic substances in biogas especially for the hazards associated with hydrogen sulphide H₂S and ammonia (NH₃) which differ from natural gas.

The flare shall be permanently ready for operation and be able to combust the maximum biogas production.

After unsuccessful start up or failure, a maximum four (4) restarts are allowed, after which a qualified maintenance provider shall investigate the failure.

When the flare stops on purpose or due to a breakdown (or electrical power supply failure), the gas supply valve shall always be closed.

Venting via emergency vent is an ultimate remedy in case of an emergency and the biogas cannot be applied in a different way and cannot be combusted by a flare. The emergency vents shall have different controls to ensure equipment can be protected, vents shall be designed to ensure safe release of biogas. This would include evaluation of adequate height and location.

7.4 Maintenance and inspection of the flare

The flare system shall be inspected by a qualified service provider on a regular basis to determine deterioration of materials, valves, gaskets, instruments, etcetera. The frequency of these inspections shall be described in the operations manual by the supplier before the start of the operation. A yearly inspection by a qualified service provider is recommended.

Before the start of maintenance an operator or maintenance technician shall make sure that the valves of gas supply are closed and properly locked and tagged (lock out tag out procedures), the temperatures of materials are safe, the absence of gases and the percentage of oxygen are detected and it has to be made sure that the electrical power is switched off by a professional electrician (and locked and tagged in accordance with lock out tag out procedures.).

5.5.5 Maintenance

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
External fire	Equipment not properly purged leading to a leak when containment broken	Grinding Welding Burning Cutting Portable electrical equipment not ATEX certified Personal ignition sources e.g. mobile phones Static Smoking	Fire will cause significant equipment damage and could lead to operator injury worst case fatality	4	4	16	• See comments	4	2	8	Previous actions to control ignition sources, use competent technicians and implement a permit system and training will reduce risk to ALARP
Internal fire Or Explosion	Equipment not properly purged leading to a flammable mixture within the equipment	Welding Burning Cutting Static	Fire will cause significant equipment damage. Explosion could lead to operator	4	4	16	• See comments	4	2	8	Previous actions to control ignition sources, use competent technicians and implement a permit system and training

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures	S	L	MR	Comments
			injury worst case fatality								will reduce risk to ALARP

5.5.6 Other Fire Hazards

Guide Word	Identified Risk	Potential Ignition Source	Consequence	S	L	RR	Prevention & Protection Measures Assumed	S	L	MR	Comments
Other Potential Fire Hazard / Scenario – e.g. electrical equipment fire	A fire Incident may present potential for harm to site occupants Unlikely and severe threat	Misuse of equipment, faulty equipment, arson, portable appliances, combustible waste, heating appliances, lightning strike, personal items and accidental fire	Fatality. Extensive asset damage.	4	4	16	<ul style="list-style-type: none"> All equipment is fully maintained and ongoing fire risk assessment regime in place on-site. Formal procedures apply to operations and relevant staff authorised / trained. Waste and combustible materials appear to be well controlled – at time of survey. Fixed wire testing in accordance with codes and standards. 	4	1	4	

6 Regulation 6 Guidance

DSEAR Regulation 6 requires employers to

- 1 eliminate or reduce risk as far as is reasonably practicable
- 2 flammable materials should be replaced with non-flammables where possible
- 3 control risks and, if there remains a possible explosion risk, mitigate the effect of the explosion
- 4 Consider the following control measures in order of priority:
 - a) reduce quantities to a minimum
 - b) avoid releases
 - c) if releases occur, control at source
 - d) prevent the formation of an explosive atmosphere, including provision of ventilation
 - e) collect, contain and render safe any flammable releases
 - f) avoid ignition sources, adverse conditions;
 - g) segregate incompatible substances
- 5 Mitigation measures to include (as appropriate):
 - h) reduce number of employees exposed
 - i) avoid propagation of fires/explosions
 - j) provision of explosion pressure relief
 - k) provision of explosion suppression equipment
 - l) provision of plant able to withstand explosion pressure
 - m) provision of PPE
- 6 safely handling, storage and transport of flammable materials
- 7 ensure risk-reduction measures are maintained
- 8 any other practical safety measures

6.1 Hierarchy of Controls

Hierarchy of Controls and Organisational Measures for Explosion Protection are addressed in this section.

The Hierarchy of Controls is HSE good practice for risk mitigation and control.

HSE hierarchy of controls:

Most effective	Hierarchy	Example
	Elimination	Physically remove the hazard by not using the flammable substance
	Substitution	Replace the hazard with a substance that is not flammable or of a higher flashpoint
	Engineering Controls	Prevent flammable hazards by inerting or ventilation to dilute the releases below explosive limits. Or Isolate people from the hazard with fireproof walls and doors.

Most effective	Hierarchy	Example
	Administrative controls	Change the way people work by placing them away from the range of hazard
	PPE	Protect the worker with personal protective equipment to mitigate the effects of an incident

The hierarchy is addressed top down with PPE as a last resort.

Hierarchy of Controls	Discussion
<p>Elimination:</p> <p>Can the need for the flammable materials be eliminated?</p>	<p>Biogas is produced by the process to be burned to generate power and cannot be eliminated.</p>
<p>Substitution:</p> <p>Can the flammable material be substituted by a less flammable one?</p>	<p>Biogas is produced by the process to be burned to generate power and cannot be substituted.</p>
<p>Engineering Controls:</p> <p>Can engineering controls be applied such as:</p> <ul style="list-style-type: none"> A. Ventilation / extraction B. Equipment protected suitably for the zone C. Maintenance by competent tradesmen 	<ul style="list-style-type: none"> A. Natural ventilation for fugitive releases of biogas from piping and equipment connections and relief devices. B. Certified equipment provided for Hazardous Areas. C. Action 3 (repeated): Equipment in hazardous areas should be inspected to ensure that it is fit for purpose in line with BS EN 60079-17:2014 Explosive atmospheres. Electrical installations design, selection and erection. Competent persons must be used for this – these could be staff or contractors.
<p>Administrative Controls:</p> <ul style="list-style-type: none"> A. Control of portable and fixed ignition sources B. Safe System of Work (SSoW with Hot Work Permit) C. Written operating instructions D. Spill procedures E. Housekeeping 	<ul style="list-style-type: none"> A. Action 2 (repeated): The control of portable ignition sources is critical to safety. People should also recognise the meaning of the EX signs. B. A simple permit system is needed for control of contractors on site – see action 2. C. FRE-energy provided an operating and maintenance manual for the main plant and Schmitt for the CHP. D. There are only two employees who both understand how to clean up the area. Written procedures not required. Action9: H₂S is highly toxic and can be fatal if inhaled at high concentration. Any spills below ground level should be considered toxic and the area not entered without a test to ensure a breathable atmosphere. E. Action 10: Housekeeping is an important control measure for DSEAR safety. Ensure that combustible materials are not stored in hazardous areas.

Hierarchy of Controls	Discussion
F. Maintenance procedures	F. FRE-energy provided an operating and maintenance manual. The CHP OEM will provide a maintenance manual for the CHP engine.
Personal Protective Equipment:	PPE is provided as appropriate for the hazards experienced, although this is not specifically for response to fires and explosions.

6.2 Risk Reduction

Risk Reduction Measure	Description
Elimination / Minimisation of Inventory	Flammable substances cannot be eliminated
Avoiding or Minimising Release of a Dangerous Substance.	Managed by piping design, minimising number of connections, especially indoors.
Prevention of the Formation of an Explosive Atmosphere	Natural ventilation specified where possible. Reliable artificial ventilation must be provided in engine test cells.
Collection / Containment / Removal of the Release	Natural ventilation for most equipment. CHP has forced ventilation within enclosure for engine cooling. Artificial ventilation inflates the interspace area between biogas bag layers.
Avoidance of Ignition Sources Including Electrostatic	See assessment in 5.3.
Avoidance of Adverse Conditions	There are no adverse conditions anticipated apart from the obvious issue of vibration with compressors, but this is not seen as excessive. Adequate access, lighting and ventilation are available. There are no contamination or vibration issues noted.
Segregation of Incompatible Dangerous Substances	None identified.

6.3 Risk Mitigation

Risk Mitigation Measure	Description
Minimisation of the Number of Employees Exposed	There are only two permanent employees.
Avoidance of Propagation of Fires or Explosions	The risk of propagation of fire and explosion is minimised by separation distances between equipment and operating areas
Provision of Explosion Pressure Relief Arrangements	Not applicable to this installation

Risk Mitigation Measure	Description
Provision of Explosion Suppression Equipment	Not applicable to this installation
Plant Constructed to Withstand Explosion Pressure	Not applicable to this installation
Provision of Personal Protective Equipment.	<p>Suitable PPE is provided for all personnel as appropriate for the job in hand.</p> <p>Action 11: Ensure that people who enter hazardous areas wear anti-static footwear and do not use portable uncertified equipment like mobile phones in hazardous areas.</p> <p>It should be noted that the PPE provided is not specifically designed to protect personnel against fire or explosion.</p>

6.4 Administrative Measures.

Administrative Measure	Assessment
Operating instructions	FRE energy and Schmitt have provided operating and maintenance manuals.
Competence of the persons employed	Experienced and trained people are employed on site.
Content and frequency of training (and the participants)	Operators trained in the use of equipment.
Suitable protective clothing	Suitable PPE is provided for all personnel as appropriate for the job in hand.
Permit-to-work system	A simple permit to work system is required – see action2.
Maintenance, inspection and checking	Plant preventive maintenance system is well established and adhered to.
Management of Engineering Change	Action 12: Any change in feeds, wastes, equipment or processes requires review of this DSEAR assessment.

7 Hazardous Area Classification

This section should be read in conjunction with these documents:

- Hazard Identification Study (HAZID) PDA-HAW-HAZ-24001
- Hazard and Operability Study (HAZOP) PDA-FRE-HS-25001
- Fire Risk Assessment Strategy ADH.24.031C.EE4
- CFD Gas Dispersion Study for HS new AD Plant ADH.24.031C.EE4
- Haworth Scouring New SD Plant LPRAs Study. ADH.24.031C.EE4
- Appendix A, LPRAs StrikeRisk Results summary for Structure 1. ADH.24.031C.EE4
- Appendix B, LPRAs StrikeRisk Results summary for structure 2. ADH.24.031C.EE4

7.1 Guidance

DSEAR Regulation 7 requires:

- 1 Area classification of the site
- 2 Zoned areas to contain suitably-protected equipment
- 3 Where necessary, hazardous areas marked with signs at points of entry
- 4 Verification of overall explosion safety by competent person before first use
- 5 Provision of anti-static clothing in zoned areas where the risk assessment indicates that a static charge could cause ignition

7.2 Feed Systems

Process Description

The digester feed is effluent from the wool scouring process which is an aqueous stream rich in organics which is non – hazardous with respect to DSEAR.

Conclusion: There are no DSEAR substances handled in the feed system, and it is classified as a non – hazardous area for DSEAR purposes

Warning: Any enclosed area or below ground area such as a sump should be suspected as having toxic H₂S concentrations at dangerous levels. A confined space permit should always be used to assess the risk and control access to such areas.

7.3 Digester and Recirculation System

Process Description

The AD plant consists of nine buffer / digester / holding tanks.

The six digesters are piped up as two sets of three Loading / feeding sequence starts when the client Input Buffer Tank has sufficient level to require processing.

FRE Energy SCADA sets up a route through three primary and three secondary digesters.

A digester must have sufficient space before it can be filled.

A digester must have sufficient level allow it to be partially unloaded (to approx. 80% level).

Each primary tank is filled in turn with one third of its volume.

Digesters have level and temperature indication at the PLC with high alarm fitted to both level and temperature.

Mixing in the Digesters is achieved using recirculated biogas via gas compressors operating at approximately 1 barg discharge pressure. These are located at the digester platform level.

Gas mixing piping is stainless steel.

The digesters operate between 38°C and 42°C (target 40°C) and approximately 7mbarg.

Design conditions are +12.5 / -1.5 mbarg.

Pressure relief for over pressure is provided by a combined vent and overflow. A patented feature of the overflow is a foam alleviation device which prevents foam from accumulating leading to potential over pressure and adverse process operation.

The overflow also prevents liquid overflowing of the digester from causing over pressure damage to the vessel or its roof. Overflow is in an open, unobstructed location with good ventilation.

Under pressure relief is provided by a luted condensate trap fitted to the outlet gas line. There is also a pressure relief valve on the biogas line.

Gas is harvested from the six digester vessels and her Output Buffer Tank by a common gas manifold connected to the inlet of the biogas storage bag assessed in 7.4.

Biogas output is a maximum of 180m³/hour of biogas with approximately 65% methane.

Stainless steel biogas piping between the Digesters and Gas Bag has minimal flanges with a design pressure of 10 barg.

The gas piping is mainly routed above ground in an open air, unobstructed location with good ventilation.

Digester liquor can contain up to 50 milligrams per litre of dissolved methane. In open situations, this evolved methane will not give rise to a hazardous zone. However, if enclosed in a building, sump or pit then flammable concentrations of methane could lead to hazardous zones.

There is a patented grit removal system fitted to each Digester preventing accumulation of solids that would reduce Digester volume and need manual removal periodically.

Sources of Release

Continuous	<ul style="list-style-type: none"> There are no continuous sources of release.
Primary	<ul style="list-style-type: none"> Leaks from digester pressure / vacuum relief valve (PVRV).
Secondary	<ul style="list-style-type: none"> Ullage space of the Digester. Flanged and screwed piping and instrument connections and valve stems in the gas piping and connected equipment. PVRV if it lifts due to excess pressure. Lute if it relieves due to excess pressure Seals on gas mixing indexing shaft at digester Seals on gas mixing compressors

Ventilation

Within the Digester there is no ventilation, as gas is drawn to the CHP engine through the Gas Bag. Outside the Digester any leaks will rapidly disperse in the open, unobstructed location.

Zoning

Plant: Haworth Scouring			Drawing: N/A			Flammable material: Biogas						
Vent:- Type: Natural (N) Artificial (A) Degree: High (H), Medium (M), Low (L), Availability: Good (G), Fair (F) Poor (P)												
No	Release			Operating temp. & press.		Ventilation			Hazardous area		Note	
	Plant item	Location	Grade	°C	mbar	Type	Degree	Availability	Zone	Zone radius (m) Vert. Horiz		
1	Digester	Ullage space	S	Amb	7	N/A. Digesters are air free and are connected to biogas storage and CHP			2	Ullage space of Digester		1
2	Digester overflow	Overflow outlet	S	38	7	N	M	G	2	7.0m radius		4
3	Gas piping	Flanged connections, valve stems and overflow outlet	S	38	7	N	M	G	2 NE	Negligible extent		2
4	Gas mixing recirculation piping	Flanged connection and valve stems and overflow outlet	S	38	1000	N	M	G	2 NE	Negligible extent		2

Plant: Haworth Scouring			Drawing: N/A			Flammable material: Biogas						
Vent:- Type: Natural (N) Artificial (A) Degree: High (H), Medium (M), Low (L), Availability: Good (G), Fair (F) Poor (P)												
No	Release			Operating temp. & press.		Ventilation			Hazardous area		Note	
	Plant item	Location	Grade	°C	mbar	Type	Degree	Availability	Zone	Zone radius (m)		
										Vert.	Horiz	
5	Gas mixing compressor seals	Near to compressors	S	38	1000	N	M	G	2	0.5m radius of compressor seals		3
6	Seals on Digester Mixing Shaft	Near to seals on Digester Mixing Shaft	S	38	1000	N	M	G	2	0.5m radius		3
7	Digester Relief Valve	Near to relief valve	S	38	7	N	M	G	2	7.0 m radius		4

Notes:

1. The ullage space of the digester gives rise to a secondary source of release. This is because a flammable mixture will only exist briefly during commissioning or in the very rare event of air being pulled into the roof space. Declared Zone 2.
2. Zone 2 negligible extent (NE) because of low pressure operation and good natural ventilation means that the consequences of ignition of a leak is not damaging to people or equipment. This is explained in detail in Appendix One.
3. Leaks from compressor seals and the seals on the indexing shaft on Digester roof give rise to a secondary source of release leading to a Zone 2 of 0.5m from SR25 Table 2 if the seals are not of a special high integrity type.
4. Calculation in Section 12.2 from ESA ICoP 2 gives Zone 2 extent 7m.

7.4 Gas Storage

Process Description:

The Gas Storage Bag receives biogas from the digesters. It is a double skinned roof floor mounted bag with interspace air inflation. Pressure relief is provided in the form of two pressure relief valves.

Gas is drawn from the Gas Bag by the CHP engine gas booster.

Sources of Release:

Continuous	<ul style="list-style-type: none"> There are no continuous sources of release
Primary:	<ul style="list-style-type: none"> There are no primary sources of release.
Secondary:	<ul style="list-style-type: none"> From the pressure / vacuum relief lute Within the Gas Bag double skinned membrane cover in the event of a pinhole leak and at the outlet from the blower air

Ventilation

There is no ventilation in the Biogas Storage as gas is drawn to the CHP engine.

Ventilation within interspace is artificial and medium from the air inflation compressor.

Ventilation around the Gas Bag is in an open air, unobstructed location with good ventilation.

Zoning

Plant: Haworth Scouring			Drawing: N/A			Flammable material: Biogas						
Vent:- Type: Natural (N) Artificial (A) Degree: High (H), Medium (M), Low (L), Availability: Good (G), Fair (F) Poor (P)												
No	Plant item	Release Location	Grade	Operating temp. & press.		Ventilation			Zone no.	Hazardous area		Note
				°C	mbar	Type	Degree	Availability		Zone radius (m)	Vert.	
8	Gas Bag	Ullage space	S	38	7	N/A. Digesters are air free and are connected to biogas storage and CHP.			1	Ullage space of Gas Bag		1
9	Gas Bag	Interspace between double skinned Gas Bag	S	38	7	A	M	G	2	Within interspace and 1m of outlet		2
10	Pressure / Vacuum lute	Outlet	S	Amb	Atmos	Nat	High	Good	2	7.0m radius		3
11	Gas piping	Flanged connections, valve stems and overflow outlet	S	38	7	N	M	G	2 NE	Negligible extent		4

Notes:

- The ullage space of the Gas Bag gives rise to a secondary source of release. This is because a flammable mixture will only exist briefly during commissioning or in the rare event of air being pulled in via digesters. Declared Zone 1 because of poor ventilation.

2. A leak in the interspace could lead to a flammable atmosphere there and for 1m of inlet and outlet in all directions. Calculation 12.1 confirms this.
3. Calculation 12.2 from ESA ICoP gives Zone 2 extent 7.0m.
4. Low pressure biogas piping gives rise to zones of negligible extent.

7.5 Combined Heat and Power (CHP) Engine – Generic assessment that can be updated if Haworth provides OEM information.

Process Description

CHP engines located in an adequately ventilated container are not normally subjected to HAC because of the constant presence of sources of ignition. Usually the engine is in an artificially ventilated acoustic enclosure that gives weather protection and noise abatement.

Risk assessment is applied in lieu of HAC – see Section 5.5.3.

Generically the main control measures are:

- Minimisation of flammable gas leaks by good installation practice to a recognised standard.
- Leak testing on commissioning and following any maintenance involving line breaking.
- Periodic inspection inside shed to check for smell of gas. Any leaks are identified and fixed before they get serious.

To give further confidence in these figures the following should be noted:-

1. Recent work carried out by the Health and Safety Executive ⁽⁴⁾ acknowledges that current approaches (IGE/SR/25 and BS EN 60079-10) for calculating V_z ‘...significantly over estimates the hazard and therefore leads to areas requiring a higher classification than necessary’.
2. Whilst admittedly referring to fuel burning equipment for domestic and non-commercial environments the ATEX guide makes a statement that ‘...as a general rule such types of equipment are excluded. As they are not intended for use in a potentially explosive atmosphere’ ⁽⁵⁾.
3. When discussing the application of DSEAR to gas boilers and burners the HSE commented as follows ‘.....Burner control packages, mounted on the face of a boiler are often very close to hot surfaces, or air intakes that are directly connected to the internal flames. In these circumstances it makes little sense to assign a hazardous area around the gas fittings or use ATEX compliant electrical parts so close to other permanent sources of ignition.’ ⁽⁶⁾
4. Leading industry figures have discussed the application of ATEX to fuel burning equipment and gave some guidance as to good practice but also stated that ‘...logically it would seem that fuel burning equipment need not be ATEX certified or suitable for use in a potentially explosive atmosphere of its own creation, as sources of ignition such as hot surfaces and flames are unavoidable’ ⁽⁷⁾.

Sources of Release

Continuous	<ul style="list-style-type: none"> There are no continuous sources of release
Primary:	<ul style="list-style-type: none"> There are no primary sources of release.
Secondary:	<ul style="list-style-type: none"> Gas Booster seals. Flanged connections on biogas piping and equipment

Ventilation

It is normal to design engine and boiler rooms with sufficient ventilation to enable a classification of zones of negligible extent – the requirements are set out in IGEM UP/16¹⁴.

Ventilation outdoors is adequate.

Zoning

Plant: Haworth Scouring.			Drawing: N/A			Flammable material: Biogas						
Vent:- Type: Natural (N) Artificial (A) Degree: High (H), Medium (M), Low (L), Availability: Good (G), Fair (F) Poor (P)												
No	Release			Operating temp. & press.		Ventilation			Zone	Hazardous area		Note
	Plant item	Location	Grade	°C	mbar	Type	Degree	Availability		Vert.	Horiz	
12	Gas booster	Near to gas booster seal	S	38	500	N	M	G	2	0.5m around gas booster		1
13	Leaks from piping and equipment	Inside CHP acoustic enclosure	S	Amb	500	A	H	G	2 NE	Negligible extent inside acoustic enclosure.		None
14	Leaks from piping and equipment	outdoors	S	Amb	500	N	M	G	2 NE	Negligible extent.		2

Notes:

- Biogas booster Zone 2 for 0.5m around it in all directions. This is from SR25 Table 2 and assumes no adverse conditions.
- Biogas piping and equipment connections outdoors are Zone 2 negligible extent.

¹⁴ IGEM/UP/16 Design for Natural Gas Installations on Industrial and Commercial Premises with Respect to DSEAR.

7.6 Flare

Process Description

The flare is a standard enclosed Flare Products ground flare installation. An enclosed flare is specified to reduce the visibility of the flare especially in night time conditions and is appropriate for the application.

Sources of Release

Continuous:	<ul style="list-style-type: none"> There are no continuous sources of release.
Primary:	<ul style="list-style-type: none"> There are no primary sources of release.
Secondary:	<ul style="list-style-type: none"> Flanged and screwed connections on piping and instruments. Gas booster seals

Ventilation

Flare is in a well ventilated outdoor area.

Zoning

Plant: Haworth Scourings.			Drawing: N/A			Flammable material: Biogas						
Vent:- Type: Natural (N) Artificial (A) Degree: High (H), Medium (M), Low (L), Availability: Good (G), Fair (F) Poor (P)												
No	Release			Operating temp. & press.		Ventilation			Hazardous area		Note	
	Plant item	Location	Grade	°C	mbar	Type	Degree	Availability	Zone no.	Zone radius		
										Vert.	Horiz	
15	Leaks from piping and equipment	Outdoors	S	Amb	Up to 30	N	M	G	2 NE	Negligible extent		1
16	Gas booster	Gas booster seals	S	38	200	N	M	G	2	0.5		2

Notes

1. Leaks from piping give rise to zones of negligible extent.
2. Zone 2 radius 0.5m from gas booster seal for prudence.

7.7 Digested Effluent

Process Description

Depleted effluent is pumped from the final buffer tank into the site effluent plant where it is pH adjusted and sent to sewer.

Sources of Release

Continuous:	Slow release of biogas from digestate.
Primary:	There are no primary sources of release.
Secondary:	There are no secondary sources of release.

Ventilation

Ventilation within separator is open and any methane produced will easily disperse.

Ventilation within Tank 1 is open, however at low levels biogas and importantly hydrogen sulphide will accumulate.

Ventilation within Tank 2 is restricted by the roof, biogas and importantly hydrogen sulphide will accumulate

Zoning

Plant: Haworth Scourings.			Drawing: N/A			Flammable material: Biogas						
Vent:- Type: Natural (N) Artificial (A) Degree: High (H), Medium (M), Low (L), Availability: Good (G), Fair (F) Poor (P)												
No	Release			Operating temp. & press.		Ventilation			Hazardous area		Note	
	Plant item	Location	Grade	°C	mbar	Type	Degree	Availability	Zone no.	Zone radius		
										Vert.	Horiz	
17	Liquid surface	Within separator	C	Amb	Atm	N	L	G	NH	Non – hazardous.		1
18	Liquid surface	Within Tank 1	C	Amb	Atm	N	L	G	NH	Zone 0 to lip of tank		2
19	Liquid surface	Within Tank 2	C	Amb	Atm	N	L	G	NH	Zone 0 within tank.		3

Notes

1. Biogas will be slowly generated within the separator, but the containment is shallow and will not encourage the build up of flammable mixtures. Classified as non – hazardous.
2. Biogas will be slowly generated within Tank 1 and the containment to the tank lip will discourage good dispersion. Classified Zone 0 for prudence within tank. There will be no external zone as any gases will readily disperse.

3. Biogas will be slowly generated within Tank 2 and the containment to the tank lip will discourage good dispersion. Classified Zone 0 for prudence within tank. There will be no external zone as any gases will readily disperse from the tank vent.

The accumulation of H₂S within any tank or below ground sump is a known life threatening hazard on biogas plants.

Any space below ground or any confined space must be assumed to be contaminated with H₂S and entered with caution.

Attention is drawn to HSE L101 Safe work in Confined Spaces.

Regulation 4 is of particular importance:

Regulation 4 Work in confined spaces

(2) Without prejudice to paragraph (1) above, so far as is reasonably practicable, no person at work shall enter or carry out any work in or (other than as a result of an emergency) leave a confined space otherwise than in accordance with a system of work which, in relation to any relevant specified risks, renders that work safe and without risks to health.

79 Where it is not reasonably practicable to avoid entering a confined space to undertake work, the dutyholder is responsible for ensuring that a safe system of work is used. In designing a safe system of work, they should give priority to eliminating the source of any danger before deciding what precautions are needed for entry.

80 To be effective, a safe system of work should be in writing and set out the work to be done and the precautions to be taken. When written down it is a formal record that all foreseeable hazards and risks have been considered in advance, and the necessary precautions have been taken and are in place before the work is allowed to begin. The safe procedure consists of all appropriate precautions taken in the correct sequence. In practice, a safe system of work will only ever be as good as its implementation. Precautions to be included in the safe system of work

81 The precautions required in a safe system of work will depend on the nature of the confined space and the results of the risk assessment. For example, the risks involved and precautions needed for cleaning car interiors with solvents will be relatively straightforward by comparison with those involved when undertaking welding work inside a chemical reactor vessel, or work in a sewer.

82 The main elements to consider when designing a safe system of work, and which may form the basis of a 'permit-to-work', are:

- (a) supervision;
- (b) competence for confined spaces working;
- (c) communications;
- (d) testing/monitoring the atmosphere;
- (e) gas purging;
- (f) ventilation;
- (g) removal of residues;
- (h) isolation from gases, liquids and other flowing materials;
- (i) isolation from mechanical and electrical equipment;
- (j) selection and use of suitable equipment; (
- k) PPE and RPE;

- (l) portable gas cylinders and internal combustion engines;
- (m) gas supplied by pipes and hoses;
- (n) access and egress;
- (o) fire prevention;
- (p) lighting;
- (q) static electricity;
- (r) smoking;
- (s) emergencies and rescue;
- (t) limited working time.

Supervision

83 The degree of supervision should be based on the findings of the risk assessment. In some cases an employer might simply instruct an employee how to do the work and then periodically check that all is well, for example if the work is routine, the precautions straightforward, and all the arrangements for safety can be properly controlled by the person carrying out the work. It is more likely that the risk assessment will identify a level of risk that requires the appointment of a competent person (see paragraph 49) to supervise the work and who may need to remain present while the work is being undertaken.

84 It will be the supervisor's role to ensure that the permit-to-work system, where applicable, operates properly, the necessary safety precautions are taken, and that anyone in the vicinity of the confined space is informed of the work being done. Competence for confined spaces working

85 Workers must have adequate training and experience in the particular work involved to be competent to work safely in a confined space. Training standards must be appropriate to the task, and to the individual's roles and responsibilities, so that work can be carried out safely. Where the risk assessment indicates that properly trained individuals can work for periods without supervision, you should check that they are competent to follow the established safe system of work and have been provided with adequate information and instruction about the work to be done. Communications

86 An adequate communication system must be in place and should enable communication:

- (a) between those inside the confined space;
 - (b) between those inside the confined space and those outside;
- and (c) to summon help in case of emergency.

87 Whatever system is used, and it can be based on speech, tugs on a rope, the telephone, radio etc, all messages should be able to be communicated easily, rapidly and unambiguously between relevant people. Consider whether the communication methods are appropriate for any workers wearing breathing apparatus. The communication system should also cover the need for those outside the space to raise the alarm and set in motion emergency rescue procedures.

88 Equipment such as telephones and radios should be specially protected so that it does not present a source of ignition where there is a risk of flammable or potentially explosive atmospheres.

Testing/monitoring the atmosphere

89 Prior to entry, the atmosphere within a confined space should be tested to check the oxygen concentration or for the presence of hazardous gas, fume or vapour. Testing should be carried out where knowledge of the confined space (eg from information about its previous contents or

chemicals used in a previous activity in the space) indicates that the atmosphere might be contaminated or to any extent unsafe to breathe, or where any doubt exists as to the condition of the atmosphere. Testing should also be carried out if the atmosphere was known to be contaminated previously, was ventilated as a consequence, and needed to be tested to check the result.

Retesting

90 Where the atmosphere in the space may not be safe to breathe and requires testing, the findings of the risk assessment should indicate whether testing should be carried out on each occasion that the confined space is re-entered, even where the atmosphere initially was found to be safe to breathe. Regular monitoring may be necessary to ensure that there is no change in the atmosphere while the work is being carried out, particularly where there is a known potential for adverse changes during the work.

91 The conditions should be continuously monitored when, for example, forced ventilation is being used, and where the work activity could give rise to changes in the atmosphere. The exact testing, retesting and monitoring requirements should be defined by a competent person within the safe system of work. This regular monitoring of the atmosphere in a confined space may be through the use of fixed monitors used within an area to protect a number of workers or through the use of personal/portable monitors worn by individual workers.

The remainder of L101 provides useful guidance that we recommend is used to develop a robust confined space procedure.

7.8 Signage in Hazardous Zones (DSEAR Schedule 4)

Figure 5: Approved ATEX sign

The ATEX regulations and DSEAR Schedule 4 prescribe a sign as pictured right which shall be used at the points of entry to hazardous zones where it adds value.



In addition to the EX signage specified above a sign like this:

Figure 6: No Sources of Ignition Sign

Should be provided near to all AD equipment.

Action 13: EX signs required at the following locations:

- **Top of Digester Stairways**
- **Near to gas mixing compressors**
- **Near to Biogas Storage Bag**
- **Near to Gas Booster at flare**



8 Specification of Equipment in Hazardous Areas

DSEAR Regulation 7(2), Schedule 3(1) states: -

“Equipment and protective systems for all places in which explosive atmospheres may occur must be selected on the basis of the requirements set out in the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (EPS) unless the risk assessment finds otherwise.”

With very few exceptions, newly-installed equipment must be marked as certified for use in hazardous areas.

Where hazardous areas are declared, any electrical and mechanical equipment that can give rise to a source of ignition must be suitably protected to prevent the ignition source from becoming effective.

The specification for such equipment in hazardous area in the EU must conform to the DTI’s Equipment and Protective Systems for Use in Potentially Explosive Atmospheres Regulations 2016 (EPS). Equipment can be ATEX or UKEX certified.

Equipment categories are defined, depending upon the zone in which the equipment will be installed as follows:

Zone	Cat 1	Cat 2	Cat 3	Comments
0	Y	N	N	2 levels of protection or 2 independent faults
1	Y	Y	N	1 level of protection based on frequent disturbances or equipment faults
2	Y	Y	Y	1 level of protection based on normal operation

In addition, gases and vapours are assigned gas groups according to their ease of ignition as follows:

Gas Group	Representative Gas
IIA	Propane
IIB	Ethylene
IIC	Acetylene

Finally, the surface temperature of a piece of equipment must be less than the autoignition temperature. For convenience gases and vapours are grouped as follows:

T Rating	Maximum Surface Temperature °C
T1	450
T2	300
T3	200
T4	135
T5	100

T Rating	Maximum Surface Temperature °C
T6	85

Any mechanical equipment that pre-dates the ATEX regulations can continue to be used providing that a risk assessment confirms that it is safe. The approved methodology for such a risk assessment is set out in BS EN ISO 80079-36:2016 Explosive atmospheres. Non-electrical equipment for explosive atmospheres. Basic method and requirements.

Classification Criteria	Description	Symbols		
		Ex	Description	Zone
Ex Protection Type	Methods of explosion protection that may be applied to electrical apparatus. The type used will depend on the type of zone in which it is installed.	Ex p	Pressurisation	1,2
		Ex o	Oil-filling	1, 2
		Ex q	Quartz/Sand	1, 2
		Ex m	Encapsulation	1,2
		Ex n	Non-incendive	2
		Ex e	Increased safety	1,2
		Ex d	Flameproof	1,2
		Ex ia	Intrinsic safety	0,1,2
		Ex ib	Intrinsic safety	1,2
		Ex s	Special	0,1,2
		Apparatus Group	Defines in which gases the apparatus may be used and is based on the energy required to cause ignition. Group II applies to surface Industries	Group
Group IIA				includes Methane and Propane
Group IIB				includes Ethylene
Group IIC				includes Hydrogen
Temperature Rating	Defines the maximum surface temperature of the apparatus. Selected Rating must be below the ignition temperature of the gas.	T Rating	Max Temp. (°C)	Gas (examples)
		T1	450	Methane (595°C), Hydrogen (560°C), Propane (470°C)
		T2	300	
		T3	200	Acetylene

Classification Criteria	Description	Symbols		
		T4	135	
		T5	100	
		T6	85	
Explosive Atmosphere	Defines the type of explosive atmosphere for which the apparatus is certified	Symbol		Description
		G		Gas
		D		Dust

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.

BS EN IEC 60079-17 Explosive atmospheres. Electrical installations inspection and maintenance [15], provides guidance on inspection regimes and competence.

The Energy Institute Guidelines for managing inspection of Ex electrical equipment ignition risk in support of IEC 60079-17 [16] provides a system for the maintenance of equipment in hazardous zones. The guide promotes a risk based inspection regime where high ignition risk areas and more onerous zones are prioritised over areas where less risk exists.

Ongoing inspections are the responsibility of the Operator, Haworth Scouring.

9 References

1. HSE DSEAR Code of Practice L138
2. BS60079-10-1: 2021 Classification of areas Explosive gas atmospheres
3. BS60079-10-2: 2015 Classification of areas Explosive dust atmospheres
4. ESA ICoP 1: DSEAR Implementation for The Waste Management Industry
5. ESA ICoP 2: Area Classification for Landfill Gas Extraction, Utilisation and Combustion
6. ESA ICoP 3: Area Classification for Leachate Extraction, Treatment and Disposal
7. HSG103 Safe handling of combustible dusts: Precautions against explosions
8. CLC-TR-60079-32-1:2018 Explosive atmospheres – Part 32-1: Electrostatic hazards – Guidance
9. BS EN 60079-14:2024 Explosive atmospheres. Electrical installations inspection and maintenance
10. BS EN 60079-17:2025 Explosive atmospheres. Electrical installations inspection and maintenance
11. Institute of Gas Engineers and Managers (IGEM) SR25 edition 2. Hazardous area classification of Natural Gas Installations. (IGEM)
12. HSE Research Report RR630 Area Classification for Secondary Releases from Low Pressure Gas systems
13. The Equipment and Protective Systems for Use in Potentially Explosive Atmospheres Regulations 2016 (EPS) as amended by the EU Withdrawal Act 2018
14. BS EN 1127-1 Explosive atmospheres. Explosion prevention and protection. Basic concepts and methodology. 2019

10 Responsibilities of “The Operator¹⁵” under DSEAR

10.1 DSEAR Regulation 8

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

- A. procedures, information, warning systems, remedial actions, escape facilities are in place in case of accidents, incidents and emergencies
- B. liaison with the emergency services
- C. 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

Assessment:

The site emergency plan must be updated for the new equipment.

Action 14: A simple emergency plan is needed which should be on display and communicated to emergency response crews and contractors working on the site.

The plan should have the following elements:

- schematic layout of the site showing location of flammable substances
- a clear passageway to all escape routes – a site map with escape routes marked on is recommended
- clearly marked escape routes that are as short and direct as possible
- enough exits and routes for all people to escape
- emergency doors that open easily
- emergency lighting where needed
- briefing for contractors when on site to know and use the escape routes
- a safe meeting point for people on site

10.2 DSEAR Regulation 9

Regulation 9 requires suitable and sufficient information, instruction and training on the appropriate precautions and actions to be taken by the employee 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.

¹⁵ The operator is also known as ‘The Employer’ in DSEAR.

Assessment:

Action 15: Share the conclusions of the DSEAR assessment and the meaning of the DSEAR EX sign with the site staff.

10.3 DSEAR Regulation 10

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.

Regulation 10 requires that all containers and pipes carrying flammable liquids and gases should be marked accordingly.

Action 16: Ensure all containers of flammable liquids such as diesel carry the Category 3 Flammable label and that biogas lines are labelled as Biogas.

10.4 DSEAR Regulation 11

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 regulation is usually managed as follows:

- Staff training
- Contractors inducted and controlled by permit to work
- Visitors being accompanied

Guidance:

Organisational measures must include:

- what operating instructions have been produced for a workplace or activity;
- what steps are taken to ensure competence of the persons employed;
- the content and frequency of training (and the participants);
- any rules for the use of mobile work equipment in hazardous places;
- what steps are taken to ensure that workers wear only suitable protective clothing;
- whether a permit-to-work system is in place and, if so, how it is organised;
- how maintenance, inspection and checking are organised;
- how the hazardous places are marked.

10.6 Permit to Work / Safe System of Work (SSoW)

10.6.1 Safe System of Work / Permit to Work.

The SSoW should address the following issues:

- The work permit should clearly define the equipment item to be worked on and the type of work required (Equipment removal, excavation, hot/cold work, repairing seals, vessel entry, waste disposal, isolation).
- The work permit system should include sufficient safety information including precautions to be taken, maintenance instructions, correct PPE and equipment for use etc. For example, precautions taken prior to initiating a work permit (physical and energy isolations / lockout, draining, flushing, environmental monitoring, risk assessments, communication, time allotted for the work) etc.
- In addition, the environment that the work is to take place in should be identified e.g. flammable, corrosive, explosive, zones 0/20, 1/21 & 2/22, electricity supplies etc.
- Specifically for ATEX/DSEAR any precautions should be specified, such as cleaning flammable dust residues from the area prior to hot work.
- In any risk assessment human factors (stress, fatigue, shift work, attitude) should be considered and precautions listed.
- The person(s) operating the plant should be aware that the work is taking place and be aware of the nature of the work.
- The permit should identify the persons carrying out the work and be properly authorised by a competent person and be time limited.
- A formal handover procedure should be in place to ensure that the plant is returned to the operator(s) in a known condition Handover across shift changeover is particularly important. It is recommended that permits are renewed each time a shift changes over.
- The work permit system should be managed, regularly inspected and reviewed with all permits kept on file.

This is not an exhaustive list but is indicative of the type of precautions necessary. If in any doubt seek expert guidance.

Further guidance can be found in HS(G)250 Guidance on permit-to-work systems in the petroleum industry from HSE Website.

Figure 7: Essential elements of a permit to work system

1 Permit title	2 Permit reference number Reference to other relevant permits or isolation certificates
3 Job location	
4 Plant identification	
5 Description of work to be done and its limitations	
6 Hazard identification – including residual hazards and hazards associated with the work	
7 Precautions necessary and actions in the event of an emergency – people who carried out precautions, eg isolating authority, should sign that precautions have been taken	
8 Protective equipment (including PPE)	
9 Issue – signature (issuing authority) confirming that isolations have been made and precautions taken, except where these can only be taken during the work. Date and time duration of permit. In the case of high hazard work (paragraph 26) a further signature from the permit authoriser will be needed	
10 Acceptance – signature confirming understanding of work to be done, hazards involved and precautions required. Also confirming permit information has been explained to all permit users	
11 Extension/shift handover procedures – signatures confirming checks made that plant remains safe to be worked upon, and new performing authorities and permit users made fully aware of hazards/precautions. New expiry time given	
12 Hand-back – signed by performing authority certifying work completed. Signed by issuing authority certifying work completed and plant ready for testing and recommissioning	
13 Cancellation – certifying work tested and plant satisfactorily recommissioned	

10.6.2 Hot Work:

From HSG250 page 30: Hot work permit

- 2 Hot work is usually taken to apply to an operation that could include the application of heat or ignition sources to tanks, vessels, pipelines etc which may contain or have contained flammable vapour, or in areas where flammable atmospheres may be present. Hot work permits, typically coloured red or red-edged, are more generally applied to any type of work which involves actual or potential sources of ignition and which is done in an area where there may be a risk of fire or explosion, or which involves the emission of toxic fumes from the application of heat. They are normally used for any welding or flame cutting, for the use of any tools which may produce sparks and for the use of any electrical equipment which is not intrinsically safe or of a suitably protected type. Some sites or installations distinguish between high energy sources of ignition like naked flames, welding and spark-producing grinding wheels, which are almost certain to ignite flammable atmospheres, and low energy sources like hand tools and non-sparking portable electrical equipment, which are likely to cause ignition only if there is a fault. In some cases, to differentiate between these tasks, fire and naked flame certificates or electrical

certificates have been used, to minimise the risk of electric shock to people carrying out any work on electrical equipment.

HSE Code of practice for DSEAR L 138, ACOP regulation 6(8) and Schedule 1:

Hot work

- 328 Hot work and maintenance processes that involve the application of heat or generation of sparks should be eliminated wherever reasonably practicable. Where it is not possible to do so, before work commences employers should:
- (a) risk assess and implement appropriate safety procedures for all activities;
 - (b) make plant and equipment safe to eliminate residual dangerous substances by isolation and by adequate cleaning and gas-freeing;
 - (c) ensure that where inerting with nitrogen, carbon dioxide or combustion gas is used, risks from inerting gas are considered under COSHH; and
 - (i) inerting material is maintained at adequate levels for the duration of the work to ensure the atmosphere in the plant or equipment cannot support combustion or that any free volume is sufficiently small that any explosion within this will not pose a danger;
 - (ii) a calibrated oxygen detection meter is used to ensure the oxygen concentration is adequately low and does not rise above the determined safe level;
 - (d) ensure a competent person inspects and monitors the atmosphere inside plant and equipment.
- 329 In exceptional circumstances hot work can be carried out on operationally active or inactive plant or equipment that has previously contained a dangerous substance without cleaning or inerting. Such techniques are only applicable to plant or equipment containing liquids or gases and are not suitable for plant containing dangerous substances which are solids, dusts or explosives or that contain liquid or gaseous oxygen.
- 330 Where it is intended to carry out hot work on plant or equipment that still contains a dangerous substance the employer must ensure that:
- (a) there is sufficient liquid or gas within the plant to prevent air or oxygen from entering and forming an explosive atmosphere;
 - (b) flames or heat will only be applied to the outside surface of the plant;
 - (c) the plant cannot fail or leak as a result of the hot work activity and allow liquid or gas to escape and ignite;
 - (d) the gas or liquid composition cannot change to become an explosive atmosphere during the hot work;
 - (e) sufficient control can be exercised over the movement of materials into or out of that plant and any associated plant or equipment;
 - (f) substances or residues present in the plant cannot undergo any reaction or decomposition leading to a dangerous increase in pressure or attack on the metal;
 - (g) these techniques are only carried out under a strict permit-to-work system;
 - (h) all personnel involved in planning and carrying out the work and supervising it are competent and trained in appropriate procedures and fire and explosion hazards; and
 - (i) there are no explosive atmospheres around the work area arising from that plant or other work activities.

-
- 331 The specified conditions above should prevent a fire or explosion by ensuring that the contents of the plant are kept above their higher explosion limit and that the hot work is only carried out on the outside of the plant.
- 332 Eliminating dangerous substances before performing maintenance will include removing stocks of dangerous substances, cleaning and making plant safe, sealing drums and containers, isolating pipework or material handling systems and clearing up any spills or deposits of dangerous substances.

Preparation and procedures for hot work

- 333 Wherever reasonably practicable, employers should eliminate the need for hot work by the use of other processes that do not involve the application of heat or the generation of heat or sparks.
- 334 The use of cold-cutting equipment (including low-speed drills, saws and chisels) may not be considered to be 'hot work' but they may still create sparks or hot surfaces with the potential to ignite explosive atmospheres. Their use, therefore, should be assessed and controlled as for any other potential ignition source.
- 335 Where it is not reasonably practicable to avoid hot work on plant or equipment that has contained a dangerous substance, regulation 6(3) requires the employer to apply appropriate measures, so far as reasonably practicable, to control the fire and explosion risks.

Cleaning and gas-freeing plant for hot work

- 336 Before starting work, plant and equipment which has contained a dangerous substance should be isolated, cleaned and – in the case of volatile liquid and solid dangerous substances – gas-freed and ventilated to remove dangerous substances. These are hazardous operations requiring their own assessments and appropriate safety procedures.
- 337 Thorough removal of all residues must be ensured. However, this may not be reasonably practicable for very large tanks, for example on ships, nor may complete inerting of the enclosed spaces prior to work. In these cases, the areas surrounding the proposed repair site should be cleaned back to an extent assessed as adequate by a competent person. All involved will need to be experienced and trained in this type of work. The competent person will need to ensure that:
- (a) surfaces have been cleaned of all residues of dangerous substances;
 - (b) there are no significant amounts trapped or held in any voids, crevices or absorbent components of the plant;
 - (c) by monitoring the atmosphere within the plant or equipment, it is free from all flammable gases and vapours;
 - (d) the concentration of any dangerous substance is less than 1% of its LEL;
 - (e) flammable gases or vapours do not reoccur during the hot work activity. The need for further continuous or periodic monitoring of the atmosphere throughout the work activity should be considered.
- 338 Where it is not reasonably practicable to eliminate dangerous substances by adequate cleaning techniques, the employer must implement measures to control and if necessary mitigate against the fire and explosion risks arising from the hot work.

Inerting

- 339 Gas-freeing and inerting should only be performed by those competent to do so, with appropriate measuring equipment, systems for work and safety equipment.
- 340 In some cases, cleaned and emptied plant and equipment may still contain residues of dangerous substance which are difficult or impracticable to remove. Inerting may be appropriate where there is a risk that these residues could ignite or form an explosive atmosphere during hot work.
- 341 Inerting is only applicable to flammable, highly flammable or extremely flammable dangerous substances or to substances that can create an explosive atmosphere on heating. It is not applicable to dangerous substances which are oxidisers or chemically unstable and are able to react without the presence of atmospheric oxygen to give rise to hazardous heat or pressure effects.
- 342 Inerting techniques may use water, nitrogen foam, nitrogen gas, combustion gas or carbon dioxide to reduce the oxygen content in the plant to below the levels that combustion can occur. Inerting may be hazardous if insufficient inert material is added to plant and equipment to achieve and maintain a non-combustible atmosphere or if people are exposed to dangerous quantities of toxic or asphyxiating gases and vapours.
- 343 Further information can be found in *Safe work in confined spaces* L101.52. Additionally, the resultant displaced dangerous substances may accumulate outside the plant and equipment giving rise to unforeseen health and safety hazards so should either be vented to a safe place or to atmosphere as appropriate.

Using gas welding and cutting equipment

- 344 Employers must implement measures to control the risk of fires and explosions arising from gaseous welding mixtures and cutting equipment. These measures will include:
- (a) providing appropriate equipment designed and constructed to recognised standards, which has been inspected and maintained in accordance with the manufacturer's instructions;
 - (b) protecting welding/cutting equipment, pipework and any associated fuel gas or oxygen compressed gas cylinder by the use of a suitable device which will arrest the progression of a flame flashback or acetylene decomposition;
 - (c) where appropriate, monitoring or detecting leaks or the possible buildup of oxygen or fuel gases in confined spaces;
 - (d) ensuring work takes place away from heat sources and there is adequate ventilation. If the use of gas cylinders in confined spaces cannot be avoided, supply valves should always be securely closed if cylinders are left unattended and special precautions, such as local exhaust ventilation, need to be taken;
 - (e) routing hoses or pipes through areas where they are not easily damaged and not near to heat sources;
 - (f) where moveable gas hoses or pipes are used or routed through confined spaces, they should be removed to a well-ventilated area at the end of each operation. Where this is not possible, they should be disconnected from source at a point outside the confined space and their contents safely vented; and

- (g) appropriate training, instruction and supervision to ensure correct operating procedures are followed.

345 Industry guidance on storage and use of gases can be found from suppliers and from the British Compressed Gas Association.10, 53–56 Guidance on acetylene and on the fire and explosion risks associated with hot work is available on the HSE website at www.hse.gov.uk/fireandexplosion/acetylene.htm, and in UKLPG Code of Practice 7 *Storage of Full and Empty LPG Cylinders and Cartridges*.

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11 Inspections in Hazardous Zones

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 IEC 60079-17 Published: October 2008 REF/ISBN: 9780852935132.

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 EN60079 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 to maintain the explosion protection features of the installation in satisfactory condition. EN 60079 – 17 provides descriptions of competency required by people working in hazardous zones.

If Haworth Scouring does not have a competent inspections contractor, PDA partner company Cenelec Standards Inspections is competent to carry out ATEX inspections.

Please contact Steven Turner, Technical Director for more information.

21-22 Apex Business Village | Northumberland Business Park | Newcastle Upon Tyne | NE23 7BF

Direct: (+44)191 250 2005 (*Extension 222*) | **Fax:** (+44) 191 250 2006 | **Mob:** (+44) 07872 038829

Steven.Turner@cenelec.com | <http://www.cenelec.com/>

12 Supporting Calculations

12.1 Calculation of Leak Rate from Biogas Bag (ESA ICoP 2)

Step 1: Calculate the mass release rate, g

$$g = 1500 C_d A (MP/T)^{0.5}$$

where g = mass flow rate of landfill gas in kg/s through a leak

C_d = constant = 0.8 for most releases

A = cross-sectional area of the orifice in m². Assume a 1mm diameter leak ≈ 0.8mm²

M = molecular mass = 27 kg/kmol for Biogas

P = gas pressure in bar gauge (barg) = 0.007 barg (7 mbarg)

T = absolute temperature of gas upstream of orifice in K = 283 K

$$\begin{aligned} \text{Thus } g &= 1500 \times 0.8 \times (0.8 \times 10^{-6}) \times (27 \times 0.007/283)^{0.5} \\ &= 3.1 \times 10^{-5} \text{ kg/s} = 0.11 \text{ kg/hour} \end{aligned}$$

Step 2: use equation 2 to convert g to a volume release rate, Q

$$Q_{CH_4} = 0.0493gT/M$$

where Q_{CH₄} = volume flow rate of methane in m³/s

g = mass flow rate in kg/s = 3.1x 10⁻⁵ kg/s as calculated in step 1

T = absolute temperature of gas in K = 283 K

M = molecular mass for landfill gas = 27.2 kg/kmol

$$\text{Thus } Q_{CH_4} = 0.0493 \times 3.1 \times 10^{-5} \times 283/27 = 1.6 \times 10^{-5} \text{ m}^3/\text{s}$$

Step 3: use equation 3 to find the zone radius, x

$$x = (1840Q_{CH_4}/kE\%)^{0.55}$$

where x = zone radius in m

Q_{CH₄} = volume flow rate of methane calculated in step 2 = 1.6 x 10⁻⁵ m³/s

k = safety factor applied to the LEL = 0.5 (for a secondary grade release)

E% = lower explosive limit in % v/v = 4.4

$$\text{Thus } x = (1840 \times 1.6 \times 10^{-5} / [0.5 \times 4.4])^{0.55} = 0.09 \text{ m. A 90mm sphere has a volume of less than 2 litres which can be classified as a zone 2 of Negligible Extent.}$$

12.2 Calculation of Extent of Zone from Digester and Gas Bag PVRV and Overflow Lute Pot

For simplicity we used the same calculation for the digester and biogas bag PVRV and the digester lute pot.

It is likely that the zone calculations are conservative as we have taken the full gas flow rate of 180m³/hour through each route.

Method 1: ESA ICoP 2.

4.5.3 Zone radius equation for outdoor releases

The zone radius can be calculated directly from the following empirical equation:

$$x = (1840Q_{CH_4}/kE_{\%})^{0.55} \quad \text{Equation 3}^s$$

where x = zone radius (assumed a sphere) in m
 1840 = constant of proportionality derived from the empirical formula
 – this constant is not dimensionless
 Q_{CH₄} = volume flow rate of methane in m³/s calculated from equation 2
 k = safety factor applied to the LEL
 0.5 for secondary grade releases *or*
 0.25 for primary grade releases
 E_% = lower explosive limit in % v/v

This equation takes account of obstructions caused by proximity to the ground, walls or other objects. It is only applicable to freely-ventilated outdoor locations and assumes a wind-speed sufficient for turbulent diffusion. EN 60079-10 section 4.4.5(a) states that 2 m/s is a minimum for this mechanism, whereas the minimum wind-speed that can be relied upon virtually continuously is only 0.5 m/s. Thus, the wind speed is not always sufficient for equation 3 to be fully applicable, so some 'layering' will occur at low wind-speeds. However, in view of the low pressure assumed (350 mbarg) and with the safety factor (k) included, this equation gives an acceptably conservative result for area classification purposes.

The zone radius is measured from the point of release in all directions, and is thus independent of the density of the release.

Using the following values:

Q_{CH₄} = 180m³/hour of biogas which is 65% methane = 117m³/hour = 0.0325m³/s.

K = 0.5

E_% = approximately 4.4%

X = 6.1m rounded to 6.5.

Method 2: SR25 Table 17:

180m³/hour at 65% methane is approximately 117m³/hour of methane at a density of approximately 0.66kg/m³ = 0.02kg/s.

Using SR25 Table 17 gives 7m for a 150mm to 900mmdiameter PVRV.

VENT PIPE FLOW RATE (G) (kg s ⁻¹)		VENT PIPE TERMINATION DIAMETER (d) (mm)													
		10	15	25	40	50	80	100	150	200	250	300	450	600	900
		DISPERSION RADIUS (X)(m)													
		Distances shaded brown are 20% higher than those in IGE/SR/25 Edition 1 Distances shaded green are 20% lower than those in IGE/SR/25 Edition 1													
>	≤	See Table 18													
0.002	0.005	4.5	5.5	4.5	4	4	4	4	4	4	4	4	4	4	4
0.005	0.01	5	6.5	7	6	6	6	5.5	5.5	5.5	5.5	5.5	5.5	6	6
0.01	0.02	5	7	9.5	8.5	8.5	7.5	7.5	7	7	7	7	7	7	7.5
0.02	0.05	5.5	7.5	12	14	13	12	11	11	10	9.5	9.5	9.5	9.5	10
0.05	0.1	7.5	8	13	18	18	16	15	14	14	14	14	14	14	14
0.1	0.2	10	11	13	20	23	23	21	20	20	20	20	19	19	19
0.2	0.5	16	16	17	21	30	35	35	35	35	30	30	30	30	30
0.5	1	23	23	23	25	30	45	50	50	45	45	40	40	40	40
1	2	35	35	35	35	35	45	60	70	70	60	60	60	60	60
2	5		60	60	60	60	60	60	80	90	100	100	90	80	80
5	10			80	80	80	80	80	90	110	120	120	120	120	110
10	15			100	90	90	100	100	100	110	130	140	150	150	130
15	20				110	110	110	110	120	130	140	150	170	170	150
20	30				140	130	130	130	140	150	150	170	200	200	190
30	50					180	170	170	170	180	190	190	230	250	240
50	75						210	210	210	210	220	230	250	280	290
75	100						250	250	250	250	250	250	280	300	330
100	150						310	300	300	300	300	300	320	340	380
150	200							350	350	350	350	350	360	380	420
200	300								430	420	420	420	430	450	480
300	500								550	550	540	540	540	550	580

Note 1: Shaded areas in grey will not occur as the maximum flow at 100 bar has been reached.

Note 2: Shaded areas in blue should be avoided as explosive mixtures could occur in the vent stack.

TABLE 17 - NON-IDEAL, IMPEDED VENT PIPE TERMINATIONS. DISPERSION RADIUS (see Figure 14)

Conclusion:

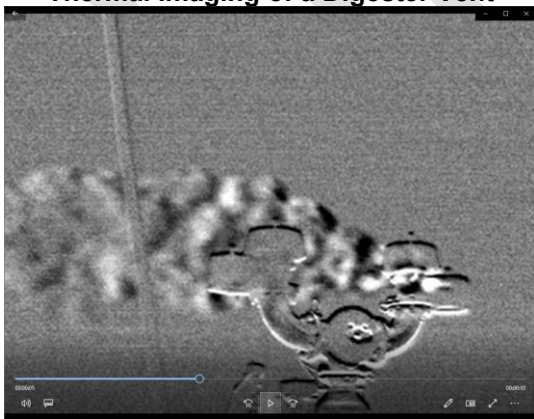
As the two methods give similar results a Zone 2 of 7m radius will be applied.

Shape of the Zone:

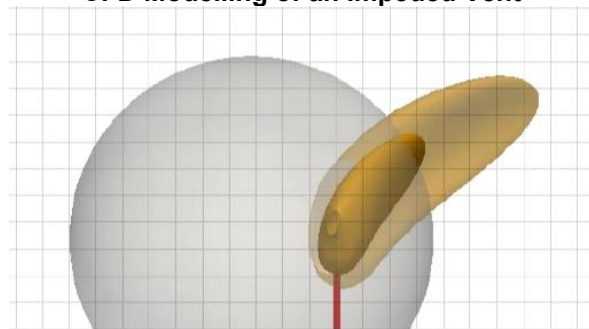
Previous CFD modelling and thermal images taken of PVRV releases confirm that the shape of the release is a mushroom like one as illustrated below:

Figure 8: Shape of a Biogas Release.

Thermal Imaging of a Digester Vent



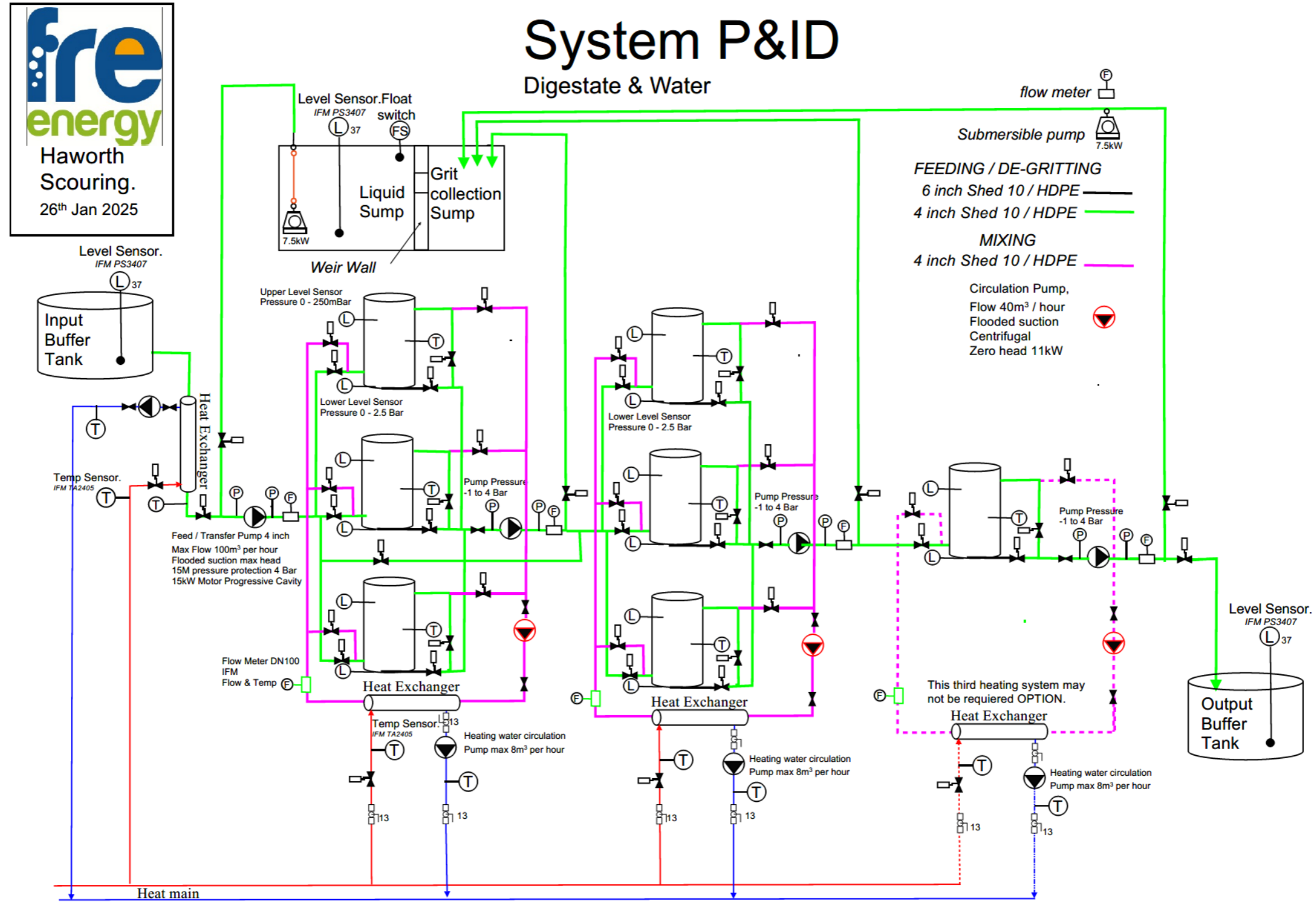
CFD Modelling of an Impeded Vent



Imagine the shape rotated through 360° and that is the shape of the release for HAC purposes.

13 Flowsheet and Hazardous Zones Drawing (by Fre-energy)

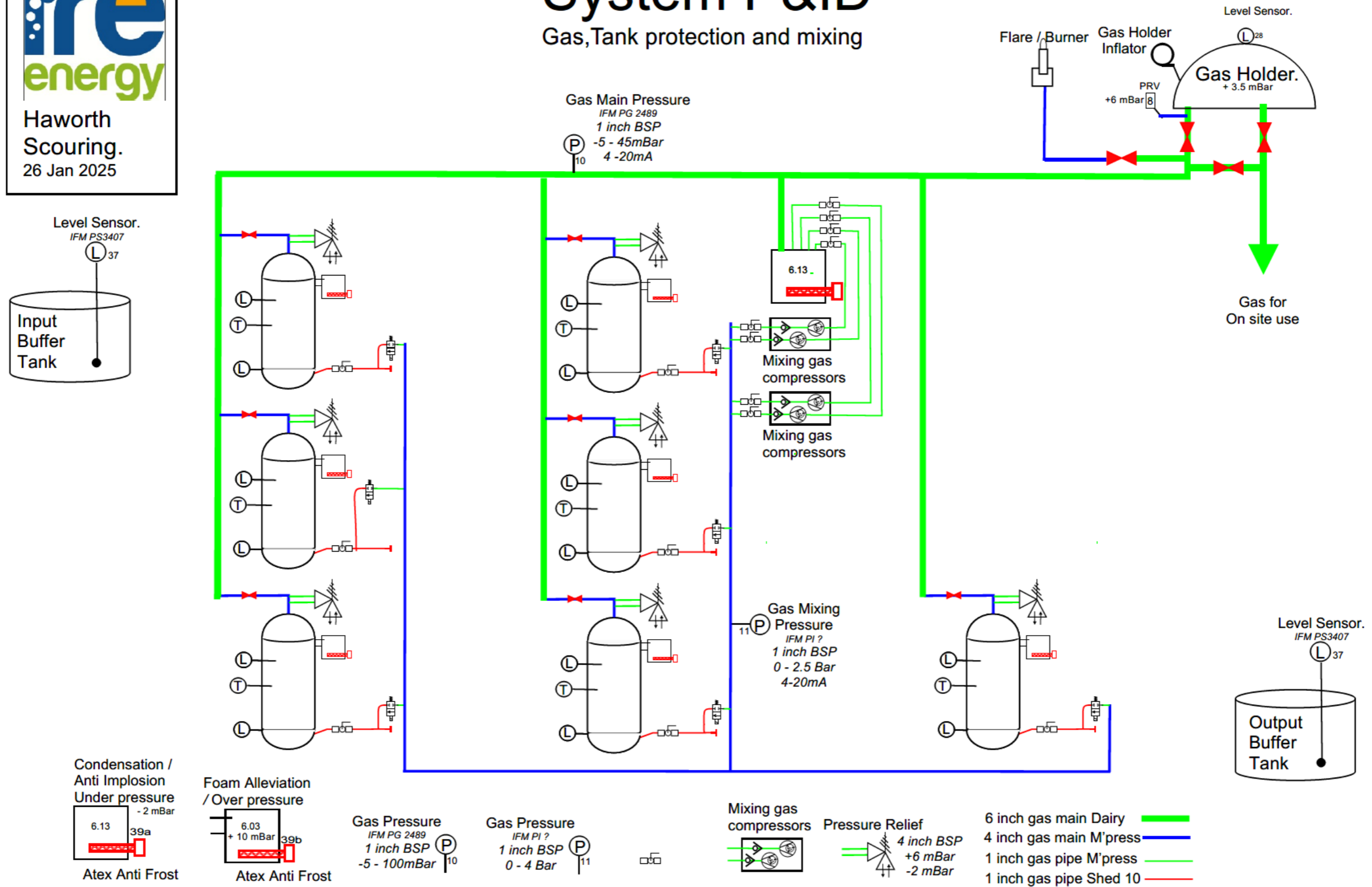
13.1 Process Flowsheet

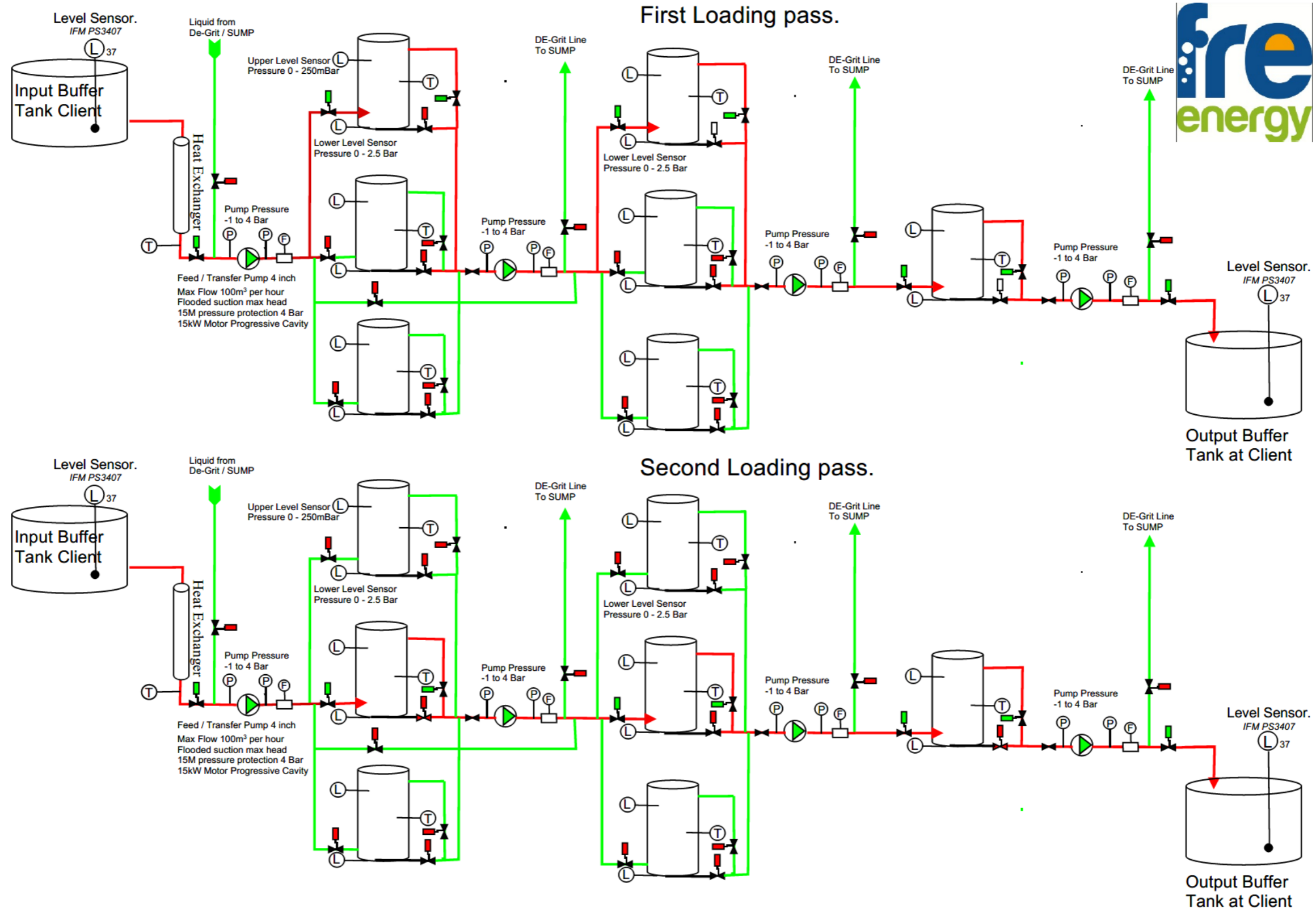


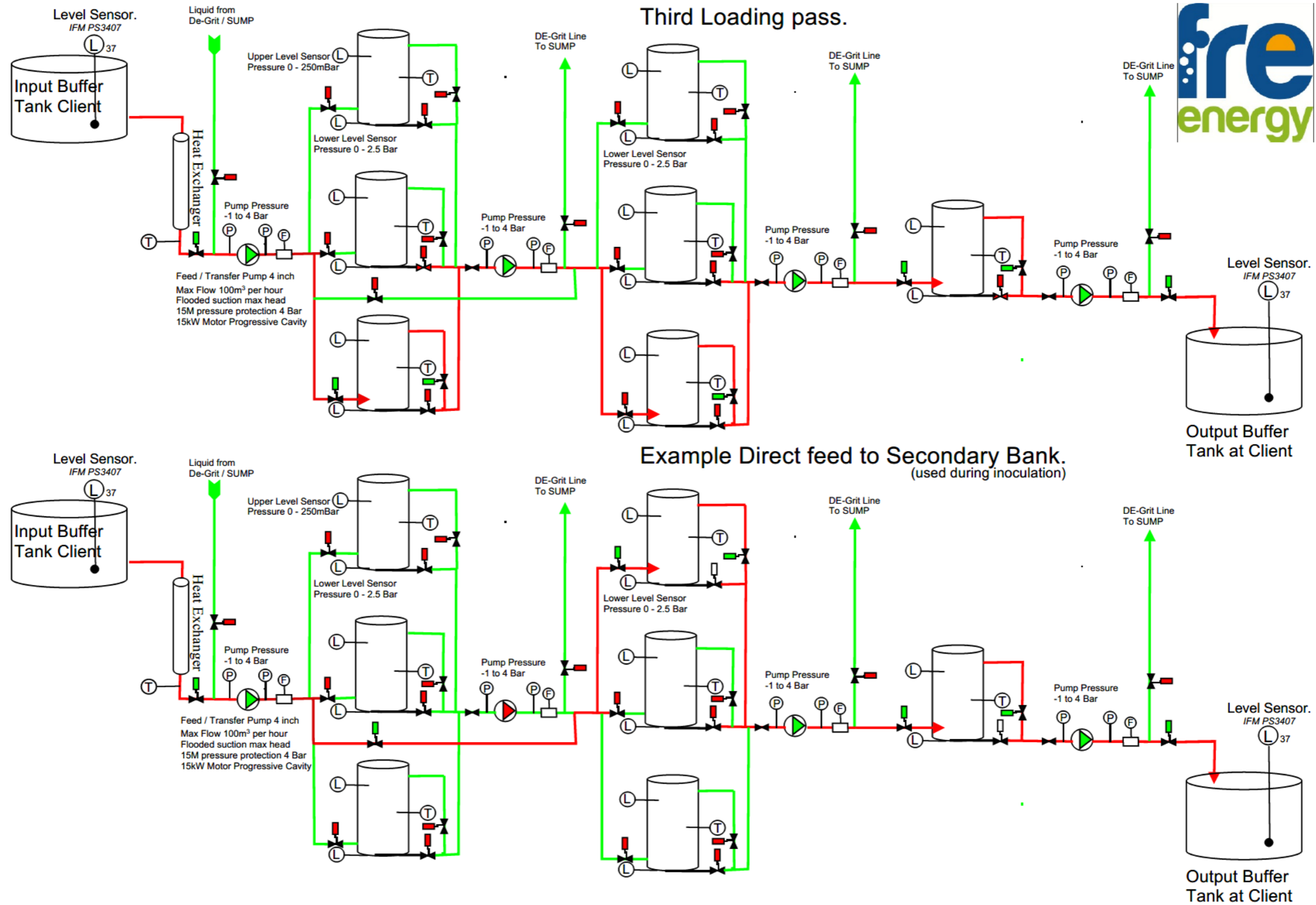


System P&ID

Gas, Tank protection and mixing

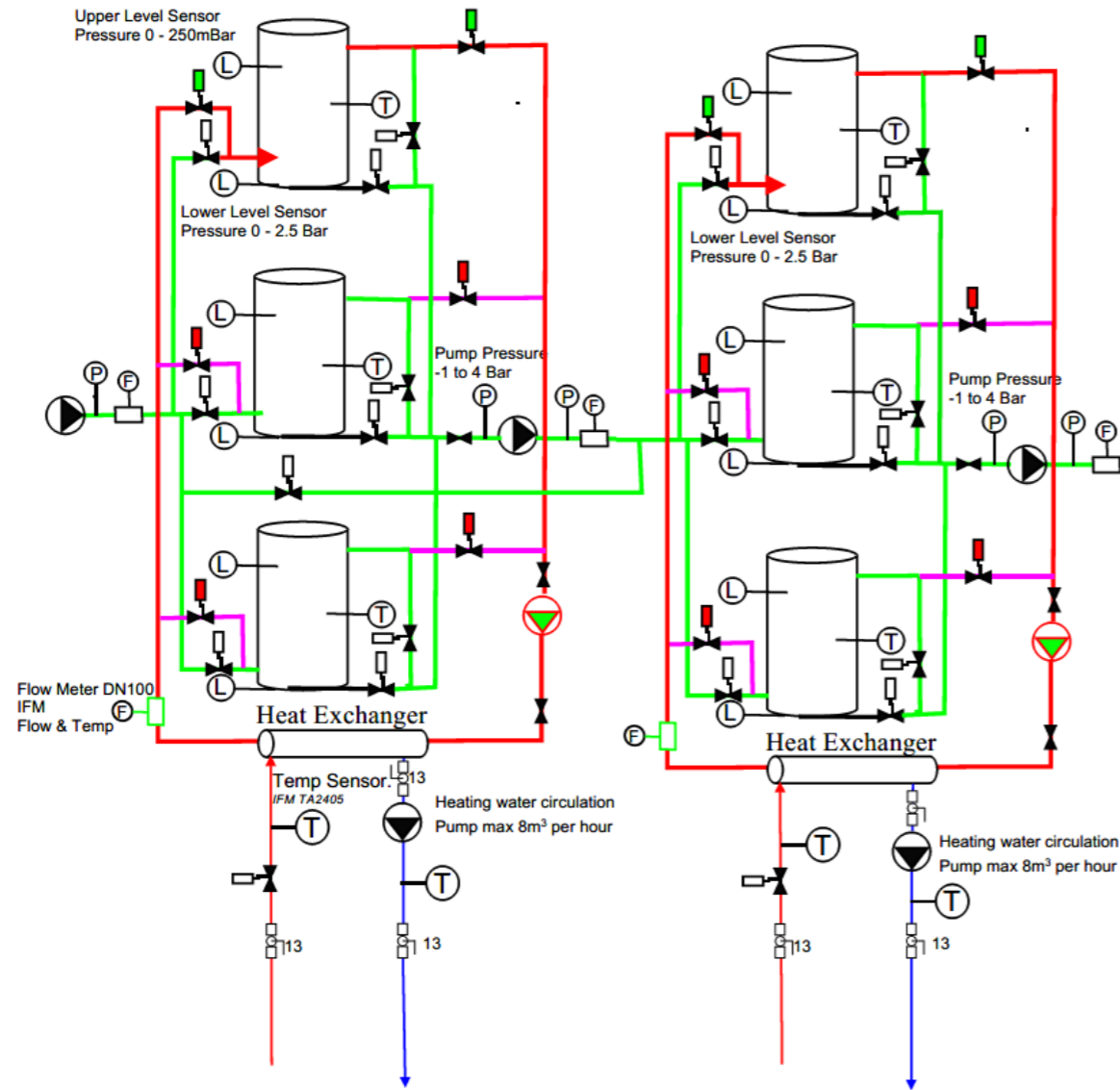




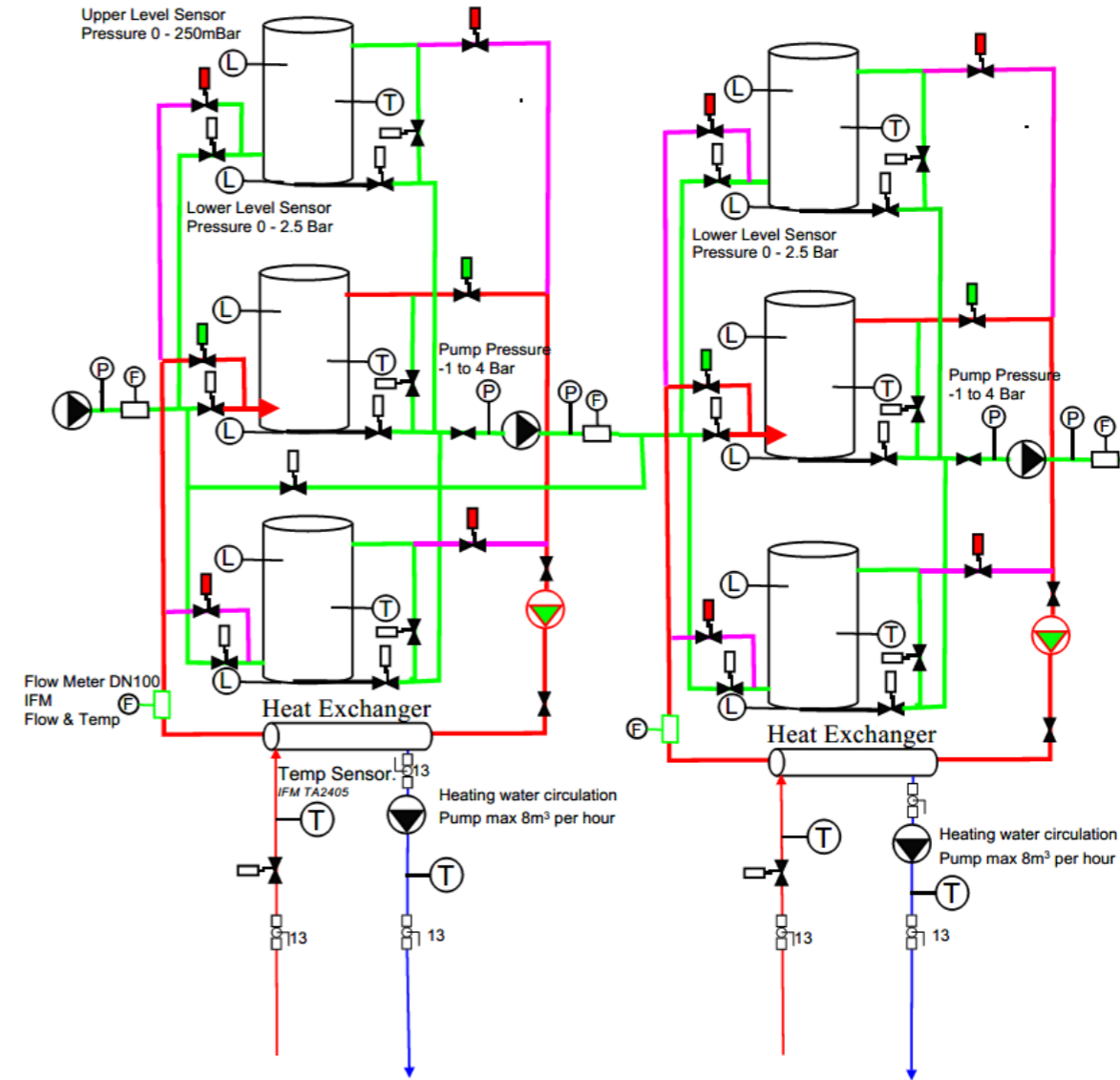




First Circulation & Heating pass.

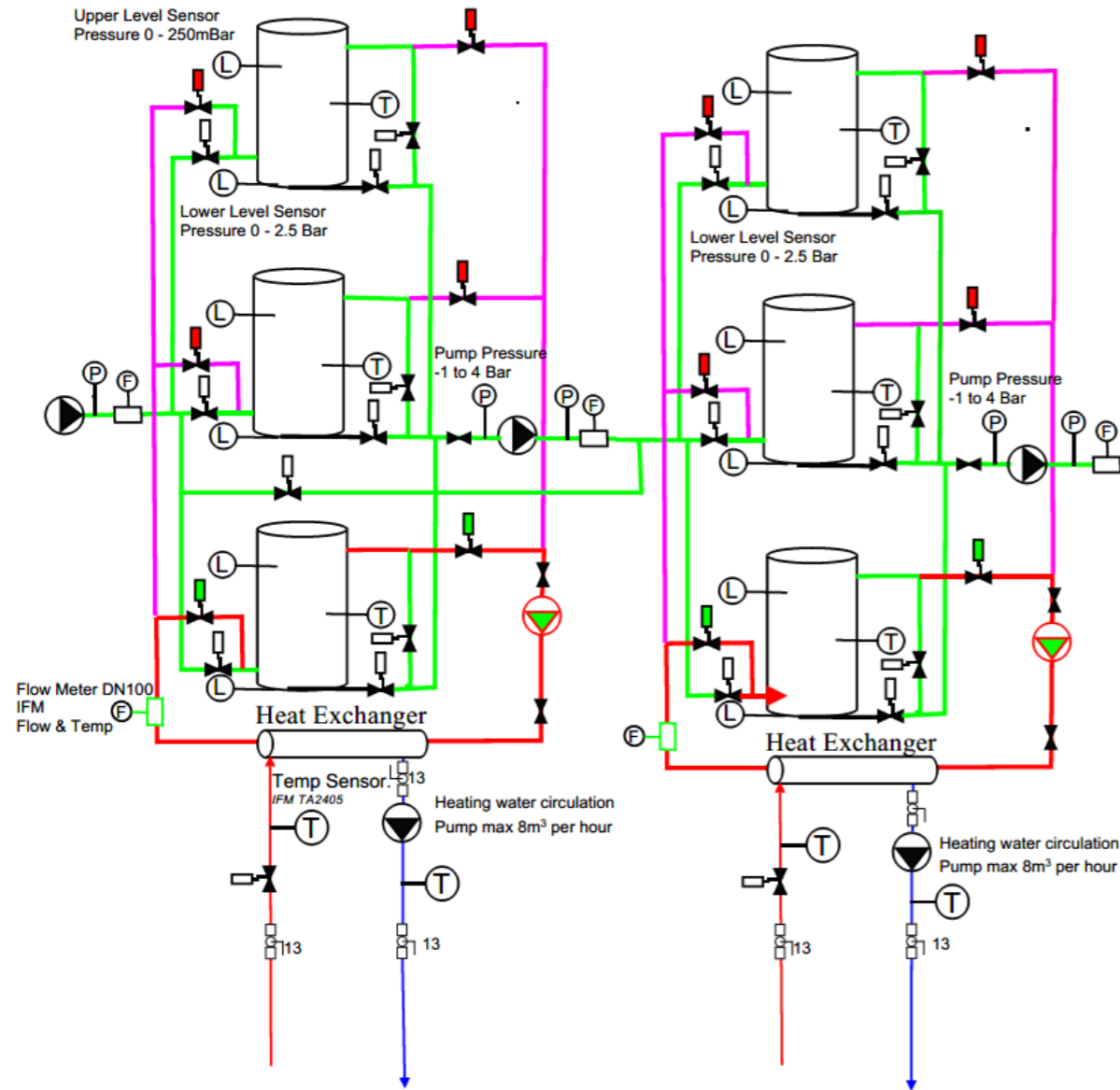


Second Circulation & Heating pass.





Third Circulation & Heating pass.

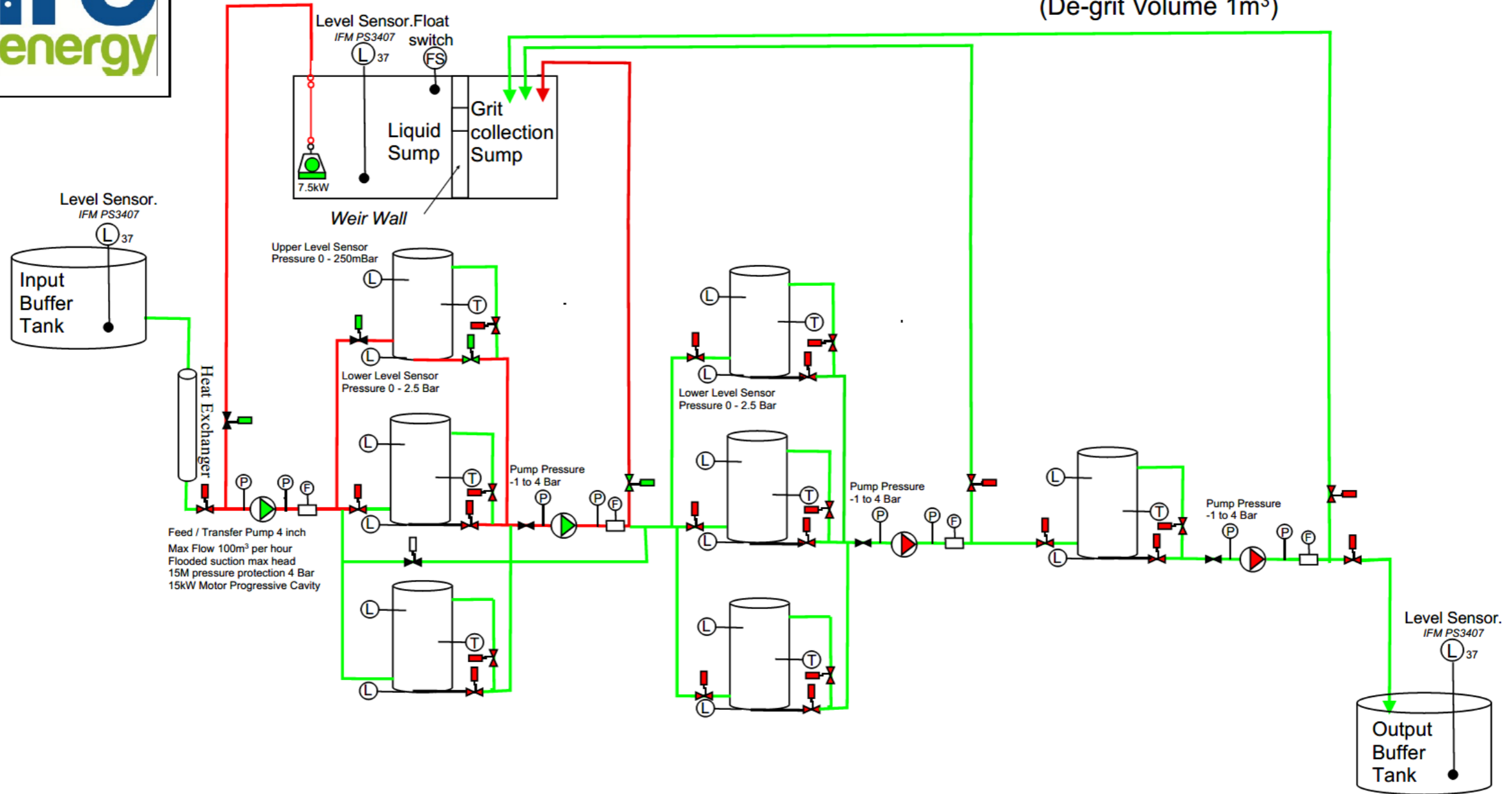


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De-gritting Tank in phase 1

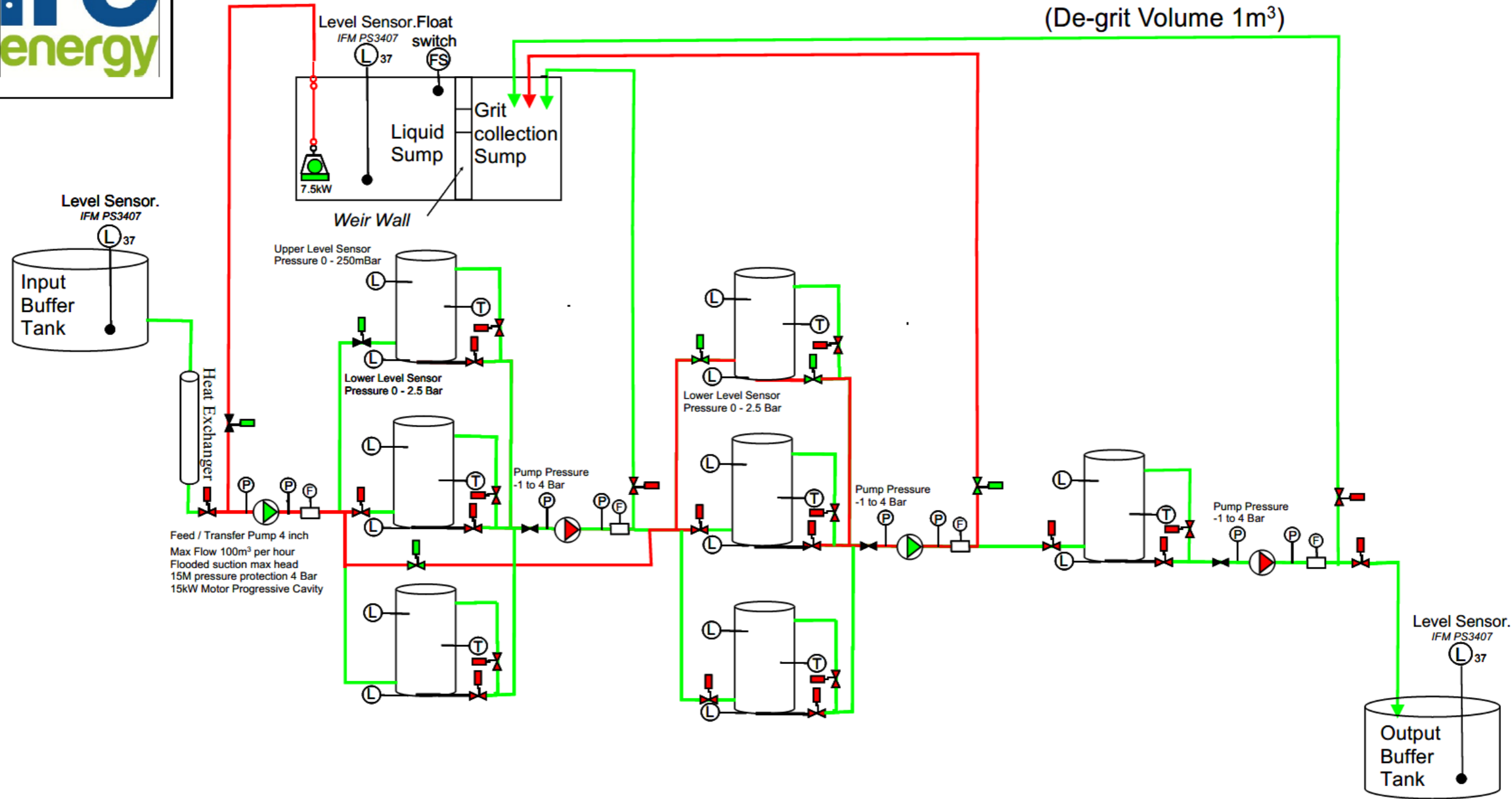
(De-grit Volume 1m³)





De-gritting Tank in phase 2

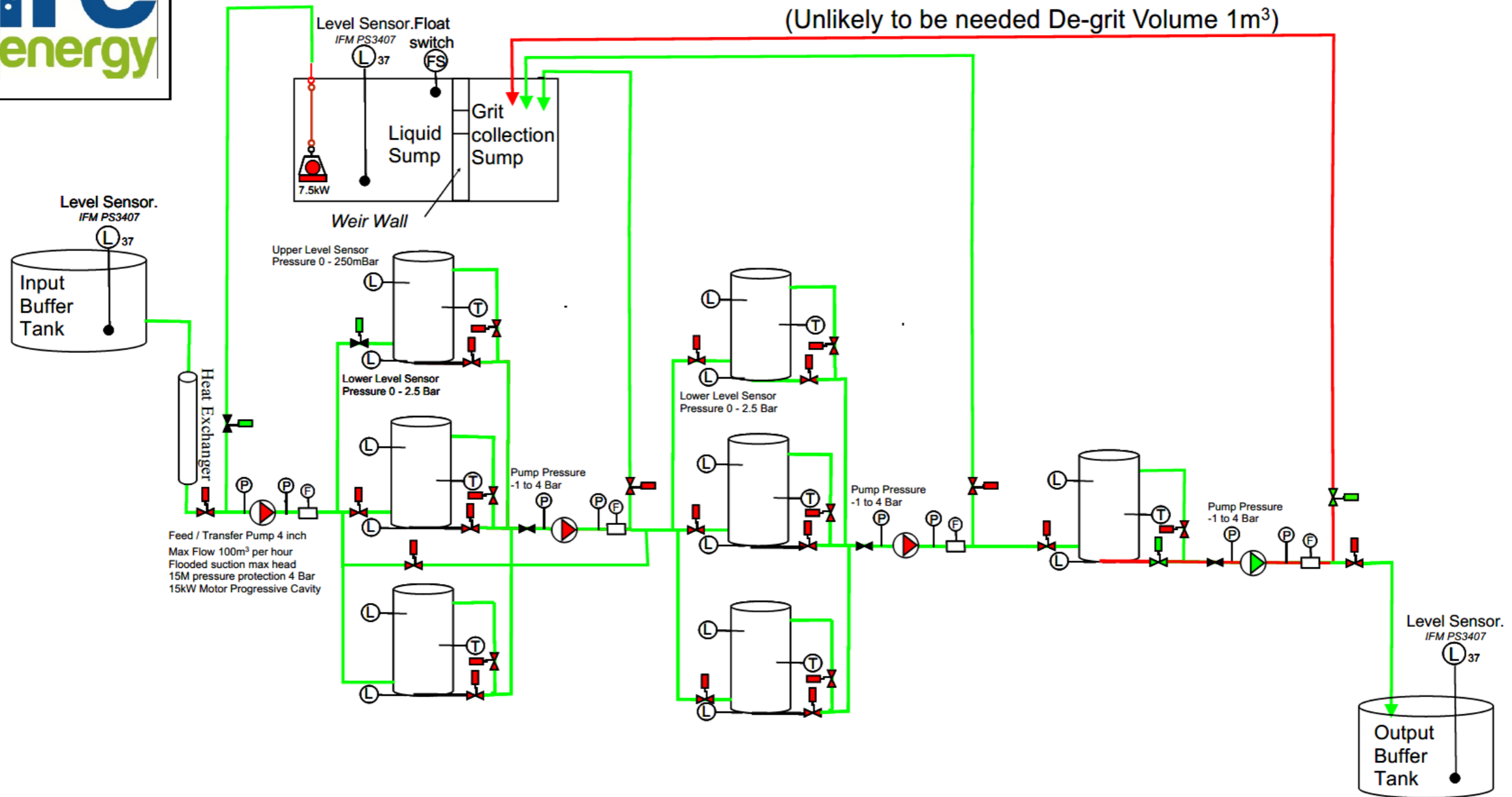
(De-grit Volume 1m³)



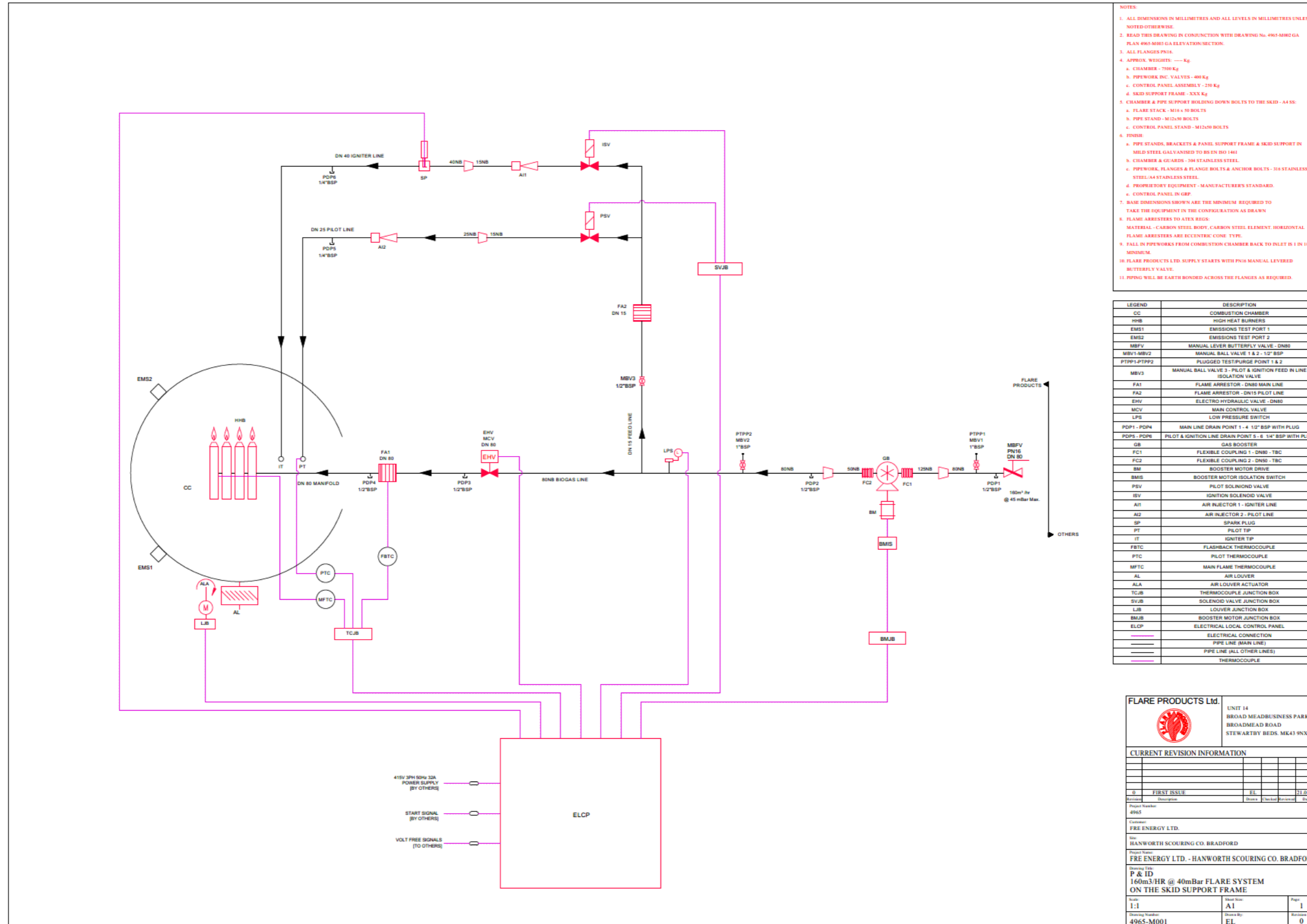


De-gritting Tank in phase 3

(Unlikely to be needed De-grit Volume 1m³)



13.2 Flare P&ID (by Uniflare)



- NOTES:**
1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN MILLIMETRES UNLESS NOTED OTHERWISE.
 2. READ THIS DRAWING IN CONJUNCTION WITH DRAWING No. 4965-M002 GA PLAN 4965-M003 GA ELEVATION SECTION.
 3. ALL FLANGES PN16.
 4. APPROX. WEIGHTS: --- Kg
 - a. CHAMBER - 7000 Kg
 - b. PIPEWORK, INC. VALVES - 400 Kg
 - c. CONTROL PANEL ASSEMBLY - 250 Kg
 - d. SKID SUPPORT FRAME - 300 Kg
 5. CHAMBER & PIPE SUPPORT HOLDING DOWN BOLTS TO THE SKID - A4 SS:
 - a. FLARE STACK - M16 x 50 BOLTS
 - b. PIPE STAND - M12x50 BOLTS
 - c. CONTROL PANEL STAND - M12x50 BOLTS
 6. FINISH:
 - a. PIPE STANDS, BRACKETS & PANEL SUPPORT FRAME & SKID SUPPORT IN MILD STEEL GALVANIZED TO BS EN ISO 1461
 - b. CHAMBER & GUARDS - 304 STAINLESS STEEL
 - c. PIPEWORK, FLANGES & FLANGE BOLTS & ANCHOR BOLTS - 316 STAINLESS STEEL/A4 STAINLESS STEEL
 - d. PROPRIETARY EQUIPMENT - MANUFACTURER'S STANDARD
 7. BASE DIMENSIONS SHOWN ARE THE MINIMUM REQUIRED TO TAKE THE EQUIPMENT IN THE CONFIGURATION AS DRAWN
 8. FLAME ARRESTERS TO ATEX REGS:
 - MATERIAL - CARBON STEEL BODY, CARBON STEEL ELEMENT. HORIZONTAL FLAME ARRESTERS ARE ECCENTRIC CONE TYPE.
 - FALL IN PIPEWORKS FROM COMBUSTION CHAMBER BACK TO INLET IS 1 IN 100 MINIMUM.
 9. FLARE PRODUCTS LTD. SUPPLY STARTS WITH PN16 MANUAL LEVERED BUTTERFLY VALVE.
 11. PIPING WILL BE EARTH BONDED ACROSS THE FLANGES AS REQUIRED.

LEGEND	DESCRIPTION
CC	COMBUSTION CHAMBER
HNB	HIGH HEAT BURNERS
EMS1	EMISSIONS TEST PORT 1
EMS2	EMISSIONS TEST PORT 2
MBV	MANUAL LEVER BUTTERFLY VALVE - DN80
MBV1-MBV2	MANUAL BALL VALVE 1 & 2 - 1/2" BSP
PTYP1-PTYP2	PLUGGED TEST/PURGE POINT 1 & 2
MBV3	MANUAL BALL VALVE 3 - PILOT & IGNITION FEED IN LINE ISOLATION VALVE
FA1	FLAME ARRESTOR - DN80 MAIN LINE
FA2	FLAME ARRESTOR - DN15 PILOT LINE
EHV	ELECTRO HYDRAULIC VALVE - DN80
MCV	MAN CONTROL VALVE
LPS	LOW PRESSURE SWITCH
PDP1 - PDP4	MAIN LINE DRAIN POINT 1 - 4 1/2" BSP WITH PLUG
PDP5 - PDP6	PILOT & IGNITION LINE DRAIN POINT 5 - 6 1/4" BSP WITH PLUG
GB	GAS BOOSTER
FC1	FLEXIBLE COUPLING 1 - DN80 - TBC
FC2	FLEXIBLE COUPLING 2 - DN80 - TBC
BM	BOOSTER MOTOR DRIVE
BMS	BOOSTER MOTOR ISOLATION SWITCH
PSV	PILOT SOLENOID VALVE
ISV	IGNITION SOLENOID VALVE
AI1	AIR INJECTOR 1 - IGNITER LINE
AI2	AIR INJECTOR 2 - PILOT LINE
SP	SPARK PLUG
IT	IGNITER TIP
FTC	FLASHBACK THERMOCOUPLE
PTC	PILOT THERMOCOUPLE
MFTC	MAIN FLAME THERMOCOUPLE
AL	AIR LOUVER
ALA	AIR LOUVER ACTUATOR
TCJB	THERMOCOUPLE JUNCTION BOX
SVJB	SOLENOID VALVE JUNCTION BOX
LJB	LOUVER JUNCTION BOX
BMJB	BOOSTER MOTOR JUNCTION BOX
ELCP	ELECTRICAL LOCAL CONTROL PANEL
---	ELECTRICAL CONNECTION
---	PIPE LINE (GAS LINE)
---	PIPE LINE (ALL OTHER LINES)
---	THERMOCOUPLE

FLARE PRODUCTS Ltd.
 UNIT 14
 BROAD MEAD BUSINESS PARK
 BROADMEAD ROAD
 STEWARTBY BEDS. MK43 9NX

CURRENT REVISION INFORMATION				
Rev	Description	Drawn	Checked	Date
0	FIRST ISSUE	EL		21.03.25

Project Number: 4965
 Customer: FRE ENERGY LTD.
 Site: HANWORTH SCOURING CO. BRADFORD
 Project Name: FRE ENERGY LTD. - HANWORTH SCOURING CO. BRADFORD
 Drawing Title: P & ID 160m³/HR @ 40mBar FLARE SYSTEM ON THE SKID SUPPORT FRAME
 Scale: 1:1 Sheet Size: A1 Page: 1
 Drawing Number: 4965-M001 Drawn By: EL Revision: 0

Notes from Flare P&ID

NOTES:

1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN MILLIMETRES UNLESS NOTED OTHERWISE.
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 - b. PIPEWORK INC. VALVES - 400 Kg
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 - c. PIPEWORK, FLANGES & FLANGE BOLTS & ANCHOR BOLTS - 316 STAINLESS STEEL/A4 STAINLESS STEEL.
 - d. PROPRIETARY EQUIPMENT - MANUFACTURER'S STANDARD.
 - e. CONTROL PANEL IN GRP.
7. BASE DIMENSIONS SHOWN ARE THE MINIMUM REQUIRED TO TAKE THE EQUIPMENT IN THE CONFIGURATION AS DRAWN
8. FLAME ARRESTERS TO ATEX REGS:

MATERIAL - CARBON STEEL BODY, CARBON STEEL ELEMENT. HORIZONTAL FLAME ARRESTERS ARE ECCENTRIC CONE TYPE.
9. FALL IN PIPEWORKS FROM COMBUSTION CHAMBER BACK TO INLET IS 1 IN 100 MINIMUM.
10. FLARE PRODUCTS LTD. SUPPLY STARTS WITH PN16 MANUAL LEVERED BUTTERFLY VALVE.
11. PIPING WILL BE EARTH BONDED ACROSS THE FLANGES AS REQUIRED.

LEGEND	DESCRIPTION
CC	COMBUSTION CHAMBER
HHB	HIGH HEAT BURNERS
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FA1	FLAME ARRESTOR - DN80 MAIN LINE
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MCV	MAIN CONTROL VALVE
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ISV	IGNITION SOLENOID VALVE
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IT	IGNITER TIP
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LJB	LOUVER JUNCTION BOX
BMJB	BOOSTER MOTOR JUNCTION BOX
ELCP	ELECTRICAL LOCAL CONTROL PANEL
—	ELECTRICAL CONNECTION
—	PIPE LINE (MAIN LINE)
—	PIPE LINE (ALL OTHER LINES)
—	THERMOCOUPLE

13.3 Hazardous Zones Diagram

To be provided.

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Appendix One: Hazardous Zoning Definitions

Grades of Release

Potential releases of flammable materials are assigned 'grades of release', which are defined in BS 60079-10-1:2015.

Grade of release	Definition
Continuous:	A release which is continuous or is expected to occur frequently or for long periods (typically >1000 hours/year)
Primary:	A release which can be expected to occur periodically or occasionally during normal operation (typically between 10 and 1000 hours/year)
Secondary:	A release which is not expected to occur during normal operation and, if it does occur, is likely to do so only infrequently and for short periods (typically between 1 and 10 hours/year)

Ventilation

Ventilation is the movement of air within and through a volume to achieve the introduction of fresh air into, and removal of contaminated air from, the volume and the mixing of air and contaminants within the volume.

The openness of a region is important in determining the effectiveness of ventilation and the extent and severity of a hazardous area. Two boundary cases (open area, enclosed area) and an intermediate case (sheltered or obstructed area) are considered relating to two main types of ventilation, natural in the case of an open area and artificial in the case of an enclosed area, also defined below.

The degree of ventilation (unrestricted, restricted, adequate or inadequate) is a key factor in determining the zone classification of an area.

In enclosed areas, different artificial ventilation options (general or local exhaust, dilution and over-pressure) may be used to provide adequate ventilation.

Type:	Natural (N) Artificial (A)
Degree:	High ventilation (H) Medium (M) Low (L)
Availability:	Good (G) Fair (F) Poor (P)

For naturally ventilated buildings the below guide can be used to estimate a minimum level of ventilation. The table is from CIBSE Guide A – Environmental Design and neglects any purpose designed ventilation such as louvres, open doorways, and thermal effects from inside heat sources. In this way it is a conservative estimate of adventitious ventilation.

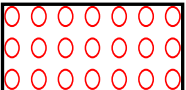
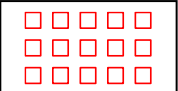



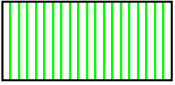
Figure 9: CIBSE Guide A. Table 4.11

Construction	Air infiltration rate (h^{-1})	Air infiltration heat loss factor ($\text{W} \cdot \text{K}^{-1} \cdot \text{m}^{-3}$)
Table 4.11 Empirical values for air infiltration and heat loss due to air infiltration for factories		
Multi-storey; brick or concrete construction:		
— lower and intermediate floors	1	0.33
— top floor with flat roof	1	0.33
— top floor with sheeted roof, lined	1.25	0.42
— top floor with sheeted roof, unlined	1.25	0.42
Single storey, non-partitioned; brick or concrete construction:		
— up to 300 m^3 volume	1.5	0.5
— 300 m^3 to 3000 m^3	0.75	0.25
— 3000 m^3 to 10 000 m^3	0.5	0.17
— over 10,000 m^3	0.25	0.08
Curtain wall or sheet construction, lined:		
— up to 300 m^3 volume	1.75	0.58
— 300 m^3 to 3000 m^3	1	0.33
— 3000 m^3 to 10 000 m^3	0.75	0.25
— over 10 000 m^3	0.5	0.17
Curtain wall or sheet construction, unlined:		
— up to 300 m^3 volume	2.5	0.75
— 300 m^3 to 3000 m^3	1.5	0.5
— 3000 m^3 to 10 000 m^3	1	0.33
— over 10 000 m^3	0.75	0.25

Operating Conditions

Temperature:	Ambient	(Amb)
Pressure:	Atmospheric	(Atm)

Zone Definitions

High probability		
Zone 0	An area in which an explosive gas atmosphere is present continuously or for long periods or frequently	
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.	
Medium probability		
Zone 1	An area in which an explosive gas atmosphere is likely to occur in normal operation occasionally.	
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 occasionally.	
Low probability		
Zone 2	An area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.	
Zone 22	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.	
Zone 2 NE	<p>NE represents negligible extent and applies to gas and vapour.</p> <p>Zone 2 NE implies that the area is non-hazardous and is based upon the premise that a flammable volume of less than 0.1 m³ if ignited will result in an explosion of insignificant consequences [3].</p> <p>Whilst this is true for outdoor unobstructed situations and indoors when the enclosure volume is large and ventilation is defined as adequate under BS60079-10-1, a smaller enclosure can mean that the overpressure resulting</p>	No symbol required as taken as non – hazardous with special equipment not required.

	<p>from the ignition of a flammable volume of 0.1m³ can result in a damaging overpressure. Hence BS60079-10-1 adopts the following rationale:</p> <p style="text-align: center;">When $V_0 > 10 \text{ m}^3 : V_z < 0.1 \text{ m}^3$</p> <p style="text-align: center;">When $1 \text{ m}^3 < V_0 < 10 \text{ m}^3 : V_z < 0.01 V_0$</p> <p style="text-align: center;">When $V_0 < 1 \text{ m}^3 : V_z < 0.001 V_0$</p> <p style="text-align: center;">Where V_0 = volume of enclosure</p> <p>V_z = hypothetical volume of a mixture bounded at 50% of the lower explosive limit (LEL).</p>	
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Other Zone Definitions

Extents:	Negligible Extent (NE)
Hazard:	Non-Hazardous (NH)

Rare events and Catastrophic Failure

An important point to note is that HAC only applies to normal and foreseeable abnormal events.

Rare events and catastrophic failures are deemed outside the scope of HAC yet may cause an explosive atmosphere to be present in an area defined by area classification as ‘non-hazardous’. These events come under risk assessment required by other legislation such as the Health and Safer at Work Act 1974.

BS EN 60079-10-1 describes rare events and catastrophic failures as below:

“Rare Events and Catastrophic Failures

It is important to note that area classification only deals with normal operation and reasonably foreseeable abnormal events and does not consider rare or highly improbable (‘catastrophic’) events.

In Section 1 Scope, IEC 60079-10-1 1c) defines ‘catastrophic’ failures as “beyond the concept of normality dealt with in this standard” and lists “Catastrophic failures in the context of this standard include, for example, major accidents such as the rupture of a process vessel, or large-scale failures of equipment or piping such as total breakdown of a flange or seal.” as examples. See Clauses 3.7.3 and 4.5 in the standard.

3.7.3

rare malfunction

type of malfunction which may happen only in rare instances

Note 1 to entry: Rare malfunctions in the context of this standard include failure of separate and independent process controls, that may be either automated or manual, that could trigger a chain of events that would lead to major release of flammable substance.

Note 2 to entry: Rare malfunctions could also include unanticipated conditions that are not covered by the plant design such as unexpected corrosion that results in a release. Where releases due to corrosion or similar conditions may or could reasonably be expected as part of the plant operations then this is not considered as a rare malfunction.

4.5 Catastrophic failures

As far as possible, such failures should be prevented.

Reasonably unexpected catastrophic failures need not be accounted for in the hazardous area classification. For example, major accidents such as the rupture of a process vessel, or large scale failures of equipment or piping such as total breakdown of a flange or seal.

The likelihood of such failures should be reduced by appropriate inspection, design, operation and maintenance of a plant.

In 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 local exhaust ventilation (LEV) at the same time as failure of a flange.

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