



**BCGA GUIDANCE NOTE GN13**

**DSEAR Risk Assessment**

**2008**

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**British Compressed Gases Association**

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## **DSEAR Risk Assessment**

**2008**

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## PREFACE

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The Association endeavours to compile these documents using the best sources of information known at the date of issue. The information is used in good faith and belief in its accuracy. The publications are intended for use by technically competent persons and their application does not, therefore, remove the need for technical and managerial judgement in practical situations and with due regard to local circumstances, nor do they confer any immunity or exemption from relevant legal requirements, including by-laws.

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\* Numbers in brackets refer to references in Section 5. Documents referenced are the edition current at the time of publication of this Guidance Note.

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## DSEAR Risk Assessment

2008

### 1 Introduction

The Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR) (4) are concerned with protection against risks from fire, explosion and similar events arising from dangerous substances and potentially explosive atmospheres. The regulations apply to most workplaces in Great Britain where a dangerous substance is present or could be present.

These regulations in the UK implement the safety aspects of the Chemical Agents Directive (1) and the Explosive Atmospheres Directive (2). These can be split into several distinct regulations which are listed below.

**1 Risk assessment.** - A suitable and sufficient risk assessment shall be completed where a dangerous substance is present in the workplace. More detail on this is given in section 4.

**2 Elimination or reduction of risks from substance** – Dangerous substances shall be eliminated or reduced where possible. If not, then measures shall be put into place to minimise, control and/or segregate persons from the hazard.

**3 Classify areas where an explosive atmosphere may occur, and ensure compliant equipment.** – Where necessary, the area where the hazardous substance is present needs to be classified into ‘zones’. The type of zone will be dependent on the frequency and duration of an explosive atmosphere. Note: This is not applicable to oxidising substances as they do not form an explosive atmosphere with air.

**4 Arrangements to deal with accidents, incidents and emergencies.** - Procedures covering emergency arrangements, safety drills with effective warning and communication systems need to be in place.

**5 Information, instruction & training.** - Suitable information and instruction shall be provided to ensure all those personnel that may be affected by the dangerous substances are trained in the precautions associated with those substances.

**6 Identification of hazardous contents of containers and pipes.** - All containers and pipes shall be suitably marked to identify the contents and nature of the dangerous substance.

**7 Duty of co-ordination.** - Where a workplace is shared, each employer has a duty to co-ordinate measures to implement the above regulations.

Regulations 1-4 and 12+ are concerned with general application of and exemptions from the regulations and are not covered here.

It is strongly recommended that reference is made to the Approved Code of Practice on DSEAR L138 (3) published by the HSE.

An important document which is associated with DSEAR is The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations (ATEX 1 or the Product Directive) (9). These regulations are concerned with the installation of equipment into hazardous areas. This document traditionally only considered electrical equipment, but now must consider any other potential source of ignition energy e.g. mechanical.

## 2 Scope

This document acts as a guide for the generation of DSEAR risk assessments for customer installations, and covers the following parts of DSEAR.

**Regulation 5** – Risk Assessment

**Regulation 6** - Elimination or reduction of risks from substance

**Regulation 7 – Part 1** - Classify areas where an explosive atmosphere may occur. The section concerned with ensuring compliant equipment is outside the scope of this document.

The other regulations are outside of the scope of this document. However, these do need to be considered when complying with DSEAR as a whole.

Risk assessment examples have been included in the appendices to assist in the generation process. However, these are generic and should be reviewed for individual installations and adjusted as necessary. Customers shall perform their own risk assessments if required for any process or application beyond the gas company owned equipment.

## 3 Definitions

The following definitions are applicable throughout this guidance note.

**Dangerous Substance.** A dangerous substance is:

(a) a substance or preparation which meets the criteria in the approved classification and labelling guide (5) for classification as a substance or preparation which is explosive, oxidising, extremely flammable, highly flammable or flammable, whether or not that substance or preparation is classified under the CHIP Regulations(6);

(b) a substance or preparation which, because of its physico-chemical or chemical properties and the way it is used or is present at the workplace creates a risk, not being a substance or preparation falling within subparagraph (a) above; or

(c) any dust, whether in the form of solid particles or fibrous materials or otherwise, which can form an explosive mixture with air or an explosive atmosphere, not being a substance or preparation falling within subparagraphs (a) or (b) above;

**Explosive Atmosphere.** An explosive atmosphere means a mixture, under atmospheric conditions, of air and one or more dangerous substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture;

#### **4 Risk Assessment & Methodology**

The risk assessment generated as a result of this guidance note shall comply with the following general requirements:

- Suitable & sufficient – This is generally defined as a rigorous assessment that considers all foreseeable hazards and risks.
- Regularly reviewed – The timescale of this review is not fixed. However if changes are made to the installation, or it is thought that the assessment is no longer valid, then a review shall take place.
- Recorded – if the employer has 5 or more employees.
- Commencement – The work activity shall not commence until the risk assessment is done and the control measures implemented.

The approach taken to generate the DSEAR risk assessment is split into distinct parts for ease of application. Each of these covers separate requirements under the regulations.

##### **4.1 Part 1: Dangerous Substance and Hazardous Area Classification**

This part consists of 2 sections.

###### **4.1.1 Dangerous Substance Characteristics**

When considering a particular installation the relevant dangerous substances shall be listed in this section. Where these consist of mixtures, the composition needs to reflect the percentage of the dangerous substance present. Where there is more than one dangerous substance, the potential interaction of these substances, where possible, needs to be considered.

The properties of the dangerous substances need to be listed. This information can be found from material safety datasheets (MSDS) as provided by the gas supplier or from gas data books.

This information needs to be completed in its entirety, as it is used to assist in the subsequent sections of the risk assessment.

#### 4.1.2 Hazardous Area Classification

Once the dangerous substances have been listed, the potential sources of release shall be identified. These shall be listed in the table, together with the following information:

**Location** – Is the leak External or Internal. This will have an impact on the ventilation available, and the possible accumulation of the dangerous substance.

**Likelihood of Release** – This is a figure between 0 to 3, dependent upon the frequency and duration of the leak. These are defined as follows:

3 - Continuous (permanent or long periods of release to atmosphere during normal operation)

2 - Primary (release expected during normal operation)

1 - Secondary (release NOT expected during normal operation)

0 - Probability considered negligible, DSEAR risk assessment not required.

This number is used in a calculation later on in the risk assessment matrix.

#### Operating Conditions

The operating conditions of the dangerous substance are required to determine the leak rates and then the zone extent.

**Pressure (bar)** – This is the maximum pressure at which the dangerous substance is stored under normal operating conditions. This is used to calculate release rates.

**Temperature (°C)** – The maximum temperature at which the dangerous substance is stored under normal operating conditions.

#### Ventilation

Consideration is given to the ventilation of the installation. This is used to work out the likely accumulation of the dangerous substance or the ease with which the substance will disperse. Two factors are considered.

**Type** – This can be one of two types:

**Natural** – In the open air or an open building with vents in walls/roof designed with regard to relative density of gas/vapour equivalent to open-air.

**Artificial** - General or local means of air movement/ air replacement within a building or open air to aid/control product dispersal.

**Degree/Availability** – This is split into 3 categories:



**VH - High ventilation** - can reduce concentration virtually instantly to below LEL, resulting in negligible zone extent, but subject to ventilation availability/reliability

**VM - Medium ventilation** - can control concentration whilst release in progress to give stable zone, and explosive atmosphere does not exist after release stopped

**VL - Low ventilation** - CANNOT control concentration whilst release in progress, and/or cannot prevent persistence of explosive atmosphere after release stopped

### **Hazardous Area**

This section determines the figures required for the generation of the zone map in accordance with regulation 7. Once the zone map is produced, only equipment approved for that zone shall be used within it. For guidance on the classification of hazardous areas, reference should be made to appropriate standards e.g. BS EN 60079. (7)

**Zone Type** – This definition is taken from DSEAR Schedule 2. This is dependent upon the grade of release and ventilation (according to BS EN60079 part 10) the following definitions apply:

- 0- Where an explosive atmosphere is present continuously / for long periods / frequently (normally 'continuous' grade of release)
- 1- Where an explosive atmosphere is likely to occur in normal operation occasionally (normally 'primary' grade of release)
- 2- Where an explosive atmosphere is NOT likely to occur in normal operation, but if it does, will persist for a short period only (normally 'secondary' grade of release)

**Zone Extent – Vertical/Horizontal.** These figures are dependent upon the dangerous substance characteristics, operating conditions, ventilation and size of leak. The procedure for calculation is as follows:

Firstly the leak rate needs to be determined. This is normally calculated using an orifice plate equation, where the size of the hole is determined, and together with the properties and operating conditions, the leak rate can be calculated.

Once the leak rate is known, then the hazardous area extent can be calculated. This is calculated using dispersion model equations. These are generally quite complicated, and care must be taken in choosing the appropriate equation. However, computer software exists that can calculate this relatively easily. An example of this is the DNV PHAST program (8), which has been used in the generic risk assessment calculations.

The calculation will result in 2 figures. One of which will show the maximum vertical extent, at its flammability limit. The other will show the horizontal extent.

## **4.2 Part 2: Ignition sources and Personnel Exposure**

Part 2 considers the possible ignition sources, and the personnel exposed to these dependent upon the activity taking place.

### **4.2.1 Ignition Source & Category**

The types of ignition source are split into 4 categories:

- Heat Energy
- Mechanical Energy
- Chemical Energy
- Electrical Energy

These are further split into sub headings covering the different types of ignition source. Although the list is extensive, consideration shall be given to other possible ignition sources which may not be included.

### **4.2.2 Likelihood of Ignition Source Occurring**

An assessment of the likelihood of the ignition source occurring shall be made. Please note that this does not consider whether a flammable atmosphere is present, it is purely concerned with the ignition source occurring. This shall be assessed into one of four figures.

- 3 = Present continuously or for long periods (>1000 hours/year)
- 2 = Likely to occur (>10 < 1000 hours/year)
- 1 = Not likely to occur or infrequent and for short periods (<10 hours/year)
- 0 = Not present

These shall be considered for normal operations, filling operations and maintenance operations. This matrix shall be completed in its entirety. Where ignition sources are not applicable, the figure 0 shall be used.

Where a figure of 1, 2 or 3 is used, these shall carry over to the relevant risk assessment in parts 3, 4 or 5.

## **4.3 Parts 3/4/5: Risk Assessment**

This section assesses risks in terms of probability, consequence and existing control measures utilising a ranking matrix.

It shall be noted that this DSEAR risk assessment is only concerned with the explosion and fire risks associated with dangerous substances. All other risks are covered under separate legislation e.g. – Toxicity – COSHH.

The approach to the risk assessment is common through parts 3, 4 and 5. The difference is that each of the parts considers a particular operation.

- Part 3: Risk Assessment – Normal Operations
- Part 4: Risk Assessment – Filling Operations
- Part 5: Risk Assessment – Maintenance Operations

The basis of the risk assessment is taken from those ignition sources that were highlighted as likely to be present in Part 2. i.e. all those with numbers 1 to 3. These shall be copied into the first column of the risk assessment table.

#### **4.3.1 Likelihood of Explosion/Fire**

For an explosion to take place, there needs to be both a flammable atmosphere, and an ignition source occurring.

The next 3 columns calculate an overall likelihood of explosion by multiplying the following figures together:

- The likelihood of a flammable atmosphere (taken from part 1). This shall be the highest figure listed in the spreadsheet that is applicable to this particular ignition source.
- The likelihood of having an ignition source occurring (taken from part 2).

This will give a figure, with a value up to a maximum of 9.

#### **4.3.2 Consequence & Severity of Explosion/Fire**

A description of the consequence of such a fire or explosion shall be detailed in this column.

This shall be supported with a figure for the severity, based on the following descriptions:

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

### 4.3.3 Assessed Level of Risk

Once the likelihood of an explosion/fire and the severity are know, the following matrix shall be used to assess the level of risk.

	L	M	H	
L I K E L I H O O D	P 3	P 2	P 1	6 - 9
	P 4	P 3	P 2	3 - 5
	P 5	P 4	P 3	1 - 2

With the following risk definitions, and actions required.

P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level

P2 = Substantial risk which must be improved through risk reduction methods

P3 = Moderate risk - efforts should be made to reduce the risk within a defined time period

P4 = Risk is considered tolerable no additional controls required. Monitoring is required to ensure controls are maintained

P5 = No action required

### 4.3.4 Part 3: Risk Assessment – Normal Operations

This details the risk associate with normal operations of the installation. This covers all the non-exception activities associated with the installation.

### 4.3.5 Part 4: Risk Assessment – Filling Operations

Filling operations have specific hazards above and beyond the normal operations. This primarily considers product tank or storage filling, where this is an infrequent activity. Consideration needs to be given to vehicle movement, connection/disconnection and the product transfer.

#### **4.3.6 Part 5: Risk Assessment – Maintenance Operations**

In most cases, this is an infrequent activity which has a high potential risk associated with it. Special consideration needs to be given to the hazards associated with:

- Release of substance when disconnecting pipework for maintenance
- Working in a potentially flammable atmosphere
- Additional ignition sources created when performing maintenance

## 5 REFERENCES

	<u>Document Number</u>	<u>Title</u>
1	98/24/EC	Chemical Agents Directive  <a href="http://eur-lex.europa.eu/pri/en/oj/dat/1998/l_131/l_13119980505en00110023.pdf">http://eur-lex.europa.eu/pri/en/oj/dat/1998/l_131/l_13119980505en00110023.pdf</a>
2	99/92/EC	Explosive Atmospheres Directive  <a href="http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999L0092:EN:HTML">http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999L0092:EN:HTML</a>
3	L138	Approved Code of Practice and Guidance: Design of Plant, Equipment and Work Spaces. HSE Books 2003 ISBN 0 7176 2203 7  <a href="http://www.hsebooks.co.uk/">http://www.hsebooks.co.uk/</a>
4	S.I. 2002 No.2776	The Dangerous Substances and Explosive Atmospheres Regulations  <a href="http://www.opsi.gov.uk/si/si2002/20022776.htm">http://www.opsi.gov.uk/si/si2002/20022776.htm</a>
5	L131	The Approved Classification and Labelling Guide (Fifth edition) HSE Books 2002 ISBN 0 7176 2369 6.  <a href="http://www.hsebooks.co.uk/">http://www.hsebooks.co.uk/</a>
6	S.I. 2002 No. 1689 : ( ( : :	The Chemicals (Hazard Information and Packaging for Supply) Regulations 2002. (CHIP3)  <a href="http://www.opsi.gov.uk/si/si2002/20021689.htm">http://www.opsi.gov.uk/si/si2002/20021689.htm</a>
7	BS EN 60079	Electrical apparatus for explosive gas atmospheres  <a href="http://www.bsi-global.com/index.xalter">http://www.bsi-global.com/index.xalter</a>
8	DNV Phast 6.0	Process Hazard Analysis Software Tool  <a href="http://www.dnv.com/software/all/phast/">http://www.dnv.com/software/all/phast/</a>
9	S.I. 1996 No. 192	Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations  <a href="http://www.opsi.gov.uk/si/si1996/Uksi_19960192_en_1.htm">http://www.opsi.gov.uk/si/si1996/Uksi_19960192_en_1.htm</a>

Further information can be obtained from:

**Health and Safety Executive**

<http://www.hse.gov.uk/>

**HSE Books**

<http://www.hsebooks.co.uk/>

**EIGA**

<http://www.eiga.eu/>

## APPENDIX 1 - Release Rate Calculations

For level 1 scenarios, IP 15 2<sup>nd</sup> edition selects a realistic release source of 0.1 mm equivalent diameter for valves. This diameter is used as the leak diameter for leaks from cylinder valve outlets (cylinder valve seat not closed leak tight – a horizontal release) and for leaks from the valve gland and valve to cylinder neck joint (both likely to be vertical releases).

Leaks from the cylinder body due to corrosion, etc., are very rare and are not considered in this risk assessment.

Leaks caused by the penetration of the cylinder body by FLT forks or other ancillary equipment is not pertinent to DSEAR classification

The Air Products orifice program APORIF has been used to calculate the following release rates for the 0.1 mm leak:

Hydrogen:	200 bar cylinder	8.34.e-5 kg/sec
Acetylene:	15 bar D/A cylinder	2.27.e-5 kg/sec
LPG:	7.5 bar liquefied gas cylinder	1.65.e-5 kg/sec

For the LPG cylinder relief valve the flow rate is 4m<sup>3</sup>/min or 0.13 kg/s



## APPENDIX 2 - Dispersion Modelling

The DNV PHAST 6.1\* (8) program was used to model dispersion of leaks to the lower flammable limit for 3 representative stability/wind speed combinations.

See appendix 1.

The dispersion model is a steady state model and does not account for situations such as gusting of wind and impingement of jets on other cylinders or structures or downwash effects. Hence a degree of safety factor is added to the exclusion zone distances in the conclusions below

\*Due to the properties of acetylene Air Products in house software APJet was used. Flammable zones from dispersion analysis

### 1. Hydrogen discharges

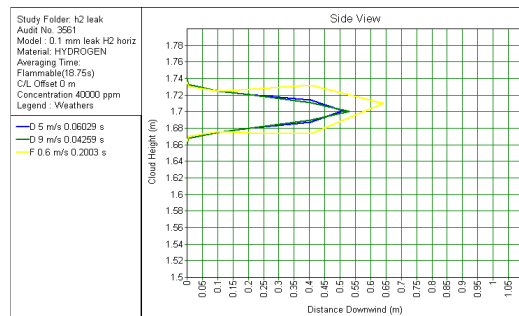
These dispersion plots show the maximum horizontal flammable zone to be 640 mm for a horizontal hydrogen release, with a maximum width of flammable jet of 50-60 mm - relating to the F stability and low wind speeds, i.e. dusk / dawn conditions.

The horizontal flammable jet does not rise due to its high momentum and speed of dispersion to below the 4% flammable boundary.

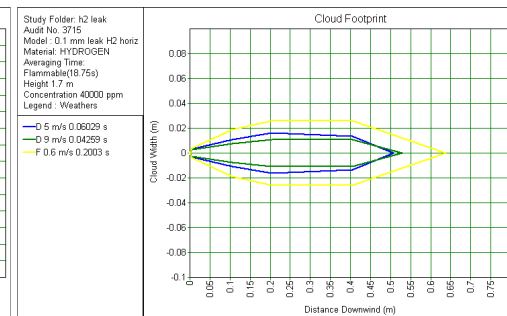
For the vertical release the maximum distance is 260mm, again for F and 0.6m/s. The diameter of the jet is very narrow, about 10-15 mm wide, with a maximum horizontal flammable zone of 130 mm.

Hydrogen horizontal discharge:

Side view

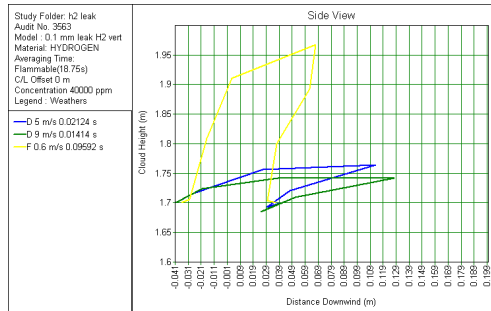


Plan view

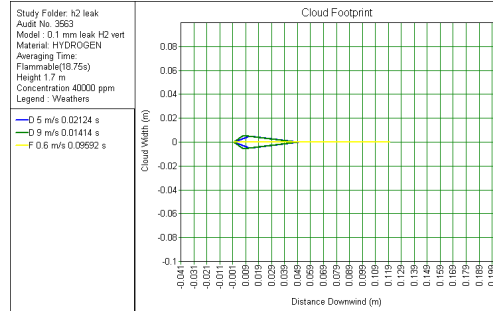


## Hydrogen vertical discharge:

Side view



Plan view



## 2. Acetylene discharges

Direction	Length of flammable zone	Width	Rise
Vertical	62mm	4mm	
Horizontal	65mm	4mm	Nil

### 3 LPG discharges

#### 3.1 Small diameter (0.1mm) release

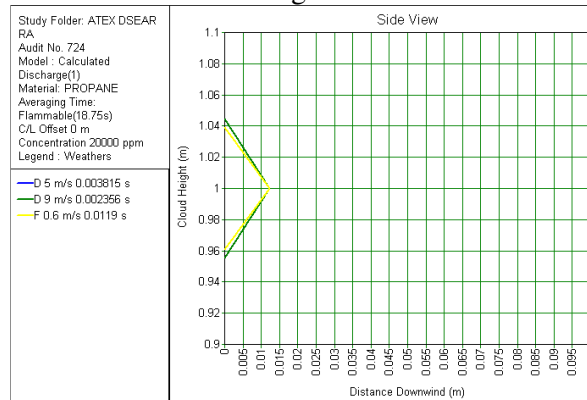
These dispersion plots show the maximum horizontal flammable zone to be 15 mm for a horizontal LPG release. The cross sectional / footprint views do not register at any height so the width of the cloud is small.

The horizontal flammable jet does not rise due to its high momentum and speed of dispersion to below the 2% flammable boundary.

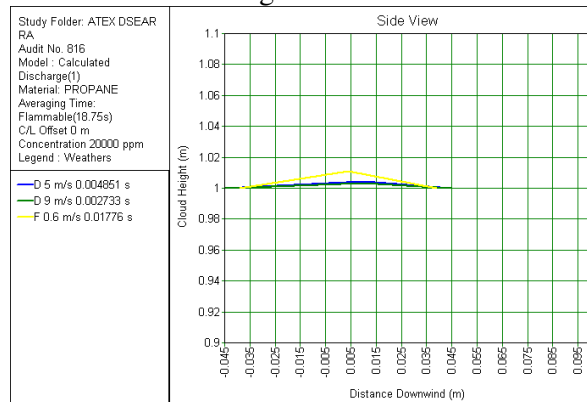
For the vertical release the maximum distance is 45mm.

Again the cross sectional / footprint views do not register at any height so the width of the cloud is small.

#### LPG horizontal discharge:

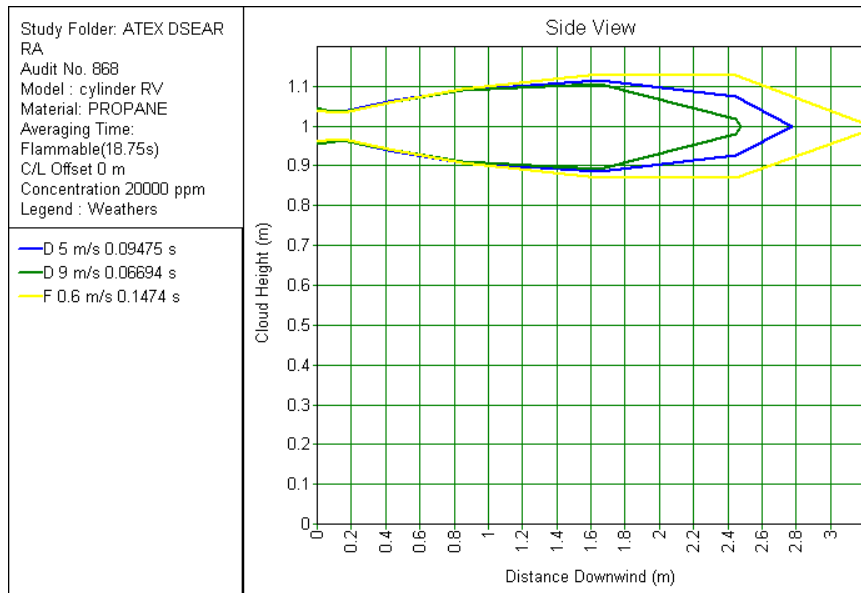


#### LPG vertical discharge:



### 3.2 “Large” release

The dispersion plot shows the distance to ½ LEL ~ 2.5m to 3m.



## APPENDIX 3 – Example Risk Assessments

Customer: **Generic**

Pressure System: **Dissolved Acetylene Cylinder**

Location: **Outdoors**

System Description: **Dissolved Acetylene Cylinder Storage**

Part 1: **Dangerous Substance & Hazardous Area Classification**

DANGEROUS SUBSTANCE CHARACTERISTICS										
Substance Name	Composition	Phase (gas /liquid)	Flammable Limits (in air)		Flash Point (deg C)	Density (Water = 1)	Gas relative density (Air = 1)	Ignition Temperature (deg C)	Group & Temperature Class	CHIP Regulations Classification
			LEL (%)	UEL (%)						
Acetylene	100%	Dissolved Gas	2.2	85		NA	0.9	325	IIC T2	
Potential Release Source	Location	Likelihood of release	Dangerous Substance Operating Conditions		Ventilation		Hazardous Area			Remarks
			Pressure (bar)	Temperature (deg C)	Type	Degree / Availability	Zone Type (0-1-2)	Zone extent vert. (M)	Zone extent horiz. (M)	
Leaking Valve Outlet (damaged valve seat, not closed properly)	External	1	17 bar	Ambient	Natural	VL	2	< 60mm	< 60mm	Bubble leaks, see table below. These leaks are minor and rapidly disperse.
Valve Neck Leak	External	1	17 bar	Ambient	Natural	VL	2	< 60mm	< 60mm	Bubble leaks, see table below. These leaks are minor and rapidly disperse.
Fusible plug leak	External	1	17 bar	Ambient	Natural	VL	2	< 60mm	< 60mm	Bubble leaks, see table below. These leaks are minor and rapidly disperse.
Cylinder Shell Corrosion	External	0	17 bar	Ambient	Natural	VL	N/A	N/A	N/A	Cylinder are inspected externally on every fill.
Puncture (FLT)	External	0	17 bar	Ambient	Natural	VL	NA	NA	NA	Fork Lift Operators trained. Cylinders Handled in Pallets.
Cylinder Failure	External	0	17 bar	Ambient	Natural	VL	NA	NA	NA	Cylinders manufactured to recognised code and inspected periodically .
Cylinder Fall - Valve damage	External	0	17 bar	Ambient	Natural	VL	NA	NA	NA	Valves are suitably protected. Cylinders stable by design & handled in pallets. Operators trained.
Inadvertent Valve Opening	External	0	17 bar	Ambient	Natural	VL	NA	NA	NA	Cylinder Valve Guard Fitted. Operator training. Valve closed quickly. Cylinders normally kept in pallets
Malicious Valve Opening	External	0	17 bar	Ambient	Natural	VL	N/A	NA	NA	Site Security.

### DEFINITIONS

#### LIKELIHOOD OF RELEASE

- 3 = Continuous (permanent or long periods of release to atmosphere during normal operation)
- 2 = Primary (release expected during normal operation)
- 1 = Secondary (release NOT expected during normal operation)
- 0 = Probability considered negligible, DSEAR risk assessment not required.

#### VENTILATION - TYPE

Natural = Open air  
or, Open building with vents in walls/roof designed with regard to relative density of gas/vapour equivalent to open-air  
or, Building that is not open but with permanent natural ventilation openings

Artificial = General or local means of air movement/ air replacement within a building or open air to aid/control product dispersal

#### VENTILATION - DEGREE

Degree and availability influences the effectiveness of controlling dispersion and persistence of the explosive atmosphere classified as follows:  
VH = High ventilation (can reduce concentration virtually instantly to below LEL, resulting in negligible zone extent, but subject to ventilation availability/reliability)  
VM = Medium ventilation (can control concentration whilst release in progress to give stable zone, and explosive atmosphere does not exist after release stopped)  
VL = Low ventilation (CANNOT control concentration whilst release in progress, and/or cannot prevent persistence of explosive atmosphere after release stopped)

#### ZONE TYPE

- Based upon the likelihood of presence of explosive atmosphere dependent upon the grade of release and ventilation (according to EN60079-10)
- 0 = Where an explosive atmosphere is present continuously / for long periods / frequently (normally 'continuous' grade of release)
- 1 = Where an explosive atmosphere is likely to occur in normal operation occasionally (normally 'primary' grade of release)
- 2 = Where an explosive atmosphere is NOT likely to occur in normal operation, but if it does, will persist for a short period only (normally 'secondary' grade of release)

#### LEAK RATES

	Kq/s	Explanation
Bubbles	Less than small	
Small	9 x 10 <sup>-5</sup>	0.1mm hole as defined in IP15 2nd ED, Table C6 page 118

Customer: **Generic**

Pressure System: **Dissolved Acetylene Cylinder**

Location: **Outdoor**

System Description: **Dissolved Acetylene Cylinder Storage**

**Part 2: Ignition Sources & Personnel Exposure**

Ignition Source Category	Ignition Source	Likelihood of Ignition Source occurring			Remarks
		Normal Operation	Filling Operations	Maintenance Operations	
<b>Heat Energy</b>					
	Heating Installations	0	0	0	
	Internal Combustion Engines	1	0	0	Exhaust temperature may reach ignition temperature
	Smoking / Naked Flames	1	0	0	Hot surface, sparks, flame
	Hot Work (eg welding / brazing)	0	0	1	Hot surface, sparks, flame
	Hot surfaces	0	0	1	Hot surface, sparks, flame
	Laser / intense radiation sources	0	0	1	NDE / Testing
<b>Mechanical Energy</b>					
	Friction / overheating	0	0	0	
	Ultrasonic	0	0	0	
	Impact	1	0	1	Hot surface due to friction
	Grinding	0	0	1	Hot surface / sparks
	Compression	0	0	0	
	Internal Combustion Engine	1	0	1	Mechanical failure of engine due to engine overspeed from ingress of acetylene
<b>Chemical Energy</b>					
	Self-heating	0	0	0	
	Impact / heat sensitive materials	0	0	0	
	Runaway exothermic reaction	0	0	0	
<b>Electrical Energy</b>					
	Electrical Lighting	1	0	1	Electrical sparks or heat only occur under fault conditions
	Electromagnetic radiation	0	0	0	
	Short circuit	1	0	1	Electrical sparks or heat
	Electrical arc	1	0	1	Electrical sparks or heat
	Earth fault	1	0	1	Electrical sparks or heat
	Conductor fault	1	0	1	Electrical sparks or heat
	Lightning strike	1	0	1	Electrical sparks or heat
	Static electrical discharge	1	0	1	Spark
	Sparking - Loose contactors on vehicles	1	0	1	Electrical sparks or heat
	Excessive temperature rise due to overload of equipment	0	0	1	Heat
	Induction heating	0	0	0	
	Resistive heating	0	0	0	
	Connection to inappropriate electrical supply	0	0	0	

**DEFINITIONS**

**LIKELIHOOD OF IGNITION SOURCE OCCURRING**

- 3 = Present continuously or for long periods (>1000 hours/year)
- 2 = Likely to occur (>10 < 1000 hours/year)
- 1 = Not likely to occur or infrequent and for short periods (<10 hours/year)
- 0 = Not present

Customer: **Generic**

Pressure System: **Dissolved Acetylene Cylinder**

Location: **Outdoors**

System Description: **Dissolved Acetylene Cylinder Storage**

Part 3: **Risk Assessment - Normal Operations**

Identified Risk & Location	Likelihood of Release			Consequence of Ignition	Severity (L M H)	Assessed Level of Risk See table below	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2					
Internal Combustion Engines	1	1	1	Localised Fire. Confined to cylinder involved.	L	P5		
Smoking / Naked Flames	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Site Rules and signage	
Impact	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Driver/operator training and procedures	
Internal Combustion Engine (acetylene ingress in to engine - over speed failure)	1	1	1	Damage to vehicle	M	P4	Proximity of vehicle to release	
Electrical lighting	1	1	1	Localised Fire. Confined to light involved.	L	P5	Lighting suitably designed and located at height.	
Short circuit	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Electrical arc	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Earth fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Conductor fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Lightning strike	1	1	1	Major localised damage	M	P4		No evidence in industry of this occurring. Surrounding building may give protection to cylinders.
Static electrical discharge	1	1	1	Localised fire	L	P5	Suitable equipment installed and maintained	
Sparking - Loose contactors on vehicles	1	1	1	Damage to vehicle	L	P5	Vehicle maintenance and proximity of vehicle to release.	

**DEFINITIONS**

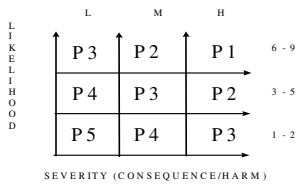
*Severity*

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

*Risk Definitions*

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: **Generic**

Pressure System: **Dissolved Acetylene Cylinder**

Location: **Outdoors**

System Description: **Dissolved Acetylene Cylinder Storage**

**Part 4: Risk Assessment - Filling Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire	Consequence of Ignition	Severity	Assessed Level of Risk	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2		(L M H)	See table below		
NOT APPLICABLE TO CYLINDER STORAGE								



Customer: **Generic**

Pressure System: **Dissolved Acetylene Cylinder**

Location: **Outdoors**

System Description: **Dissolved Acetylene Cylinder Storage**

**Part 5: Risk Assessment - Maintenance Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire	Consequence of Ignition	Severity	Assessed Level of Risk	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2		(L M H)	See table below		
Hot Work	1	1	1	Localised Fire. Confined to cylinder involved.	L	P5	Safe system of work	
Hot surfaces	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Laser / intense radiation sources	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Impact	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Driver/operator training and procedures	
Grinding	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Internal Combustion Engine (acetylene ingress in to engine - over speed failure)	1	1	1	Damage to vehicle	M	P4	Proximity of vehicle to release	
Electrical lighting	1	1	1	Localised Fire. Confined to light involved.	L	P5	Lighting suitably designed and located at height.	
Short circuit	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Electrical arc	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Earth fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Conductor fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Lightning strike	1	1	1	Major localised damage	M	P4		No evidence in industry of this occurring. Surrounding building may give protection to cylinders.
Static electrical discharge	1	1	1	Localised fire	L	P5	Suitable equipment installed and maintained	
Sparking - Loose contactors on vehicles	1	1	1	Damage to vehicle	L	P5	Vehicle maintenance and proximity of vehicle to release.	
Excessive temperature rise due to overload of equipment	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment used and maintained	

**DEFINITIONS**

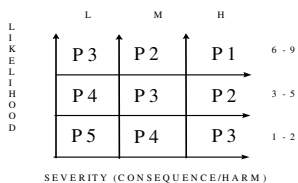
**Severity**

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

**Risk Definitions**

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

**Matrix**



Customer: **Generic**

Pressure System: **Bulk Gaseous Hydrogen Installation**

Location: **Outdoors**

System Description: **Trailer fill station with high pressure storage and pressure control assembly**

**Part 1: Dangerous Substance & Hazardous Area Classification**

DANGEROUS SUBSTANCE CHARACTERISTICS										
Substance Name	Composition	Phase (gas /liquid)	Flammable Limits (in air)		Flash Point (deg C)	Density (Water = 1)	Gas relative density (Air = 1)	Ignition Temperature (deg C)	Group & Temperature Class	CHIP Regulations Classification
			LEL (%)	UEL (%)						
Hydrogen	100%	Gas	4	76		0.082	0.07	560	IIC T1	

Potential Release Source	Location	Likelihood of release	Dangerous Substance Operating Conditions		Ventilation		Hazardous Area			Remarks
			Pressure (barg)	Temperature (deg C)	Type	Degree / Availability	Zone Type (0-1-2)	Zone extent vert.	Zone extent horiz.	
Venting Fill Hose	External To Vent Stack	2	230	ambient	Natural	VL	1	2m	2m	Hose vented prior to fill commencing and at completion of fill, controlled by the driver. Hose inspected prior to fill and changed at appropriate intervals, three years.
Mechanical Venting	External To Vent Stack	2	230	ambient	Natural	VL	1	2m	2m	Venting controlled by driver or maintenance personnel to depressure part of the system.
Safety Valves	External To Vent Stack	2	230	ambient	Natural	VL	1	2m	2m	Controlled over pressure release to safeguard system
Mechanical Joint failure	External	1	230	ambient	Natural	VL	2	5m	5m	Regular inspection and replacement schedule
Mechanical Joints - bubble leak	External	1	230	ambient	Natural	VL	2	50mm	50mm	There are mechanical joints between components e.g. valves and piping. These are pressure tested and leak checked.
Pressure accessories. Valves, regulators, filters, gauges etc. - Bubble leaks	External	1	230	ambient	Natural	VL	2	50mm	50mm	Pressure accessories are designed,manufactured, tested and appropriate for the gas.
Valve Packing - bubble leak	External	1	230	ambient	Natural	VL	2	50mm	50mm	Valve packing is adjusted to minimise leakage but maintain mechanical operability.
Hose assembly leak - bubble leak	External	1	230	ambient	Natural	VL	2	50mm	50mm	Regular inspection and replacement schedule
Failure of a cylinder.	External	0	230	ambient	Natural	VL	NA	NA	NA	Cylinders are designed, manufactured and tested in accordance with national regulations, and subjected to periodic testing.
Failure of pipework.	External	0	230	ambient	Natural	VL	NA	NA	NA	Pipework is designed, manufactured and tested in accordance with recognised standards, suitable for the gas, and subjected to periodic testing where required.
Hose failure	External	0	230	ambient	Natural	VL	NA	NA	NA	Regular inspection and replacement schedule
Hose Failure - Tow away	External	0	230	ambient	Natural	VL	NA	NA	NA	Vehicles fitted with anti tow away devices

**DEFINITIONS**

**LIKELIHOOD OF RELEASE**

- 3 = Continuous (permanent or long periods of release to atmosphere during normal operation)
- 2 = Primary (release expected during normal operation)
- 1 = Secondary (release NOT expected during normal operation)
- 0 = Probability considered negligible, DSEAR risk assessment not required.

**VENTILATION - TYPE**

- Natural = Open air or, Open building with vents in walls/roof designed with regard to relative density of gas/vapour equivalent to open-air or, Building that is not open but with permanent natural ventilation openings

Artificial = General or local means of air movement/ air replacement within a building or open air to aid/control product dispersal

**VENTILATION - DEGREE**

- Degree and availability influences the effectiveness of controlling dispersion and persistence of the explosive atmosphere classified as follows:
- VH = High ventilation (can reduce concentration virtually instantly to below LEL, resulting in negligible zone extent, but subject to ventilation availability/reliability)
- VM = Medium ventilation (can control concentration whilst release in progress to give stable zone, and explosive atmosphere does not exist after release stopped)
- VL = Low ventilation (CANNOT control concentration whilst release in progress, and/or cannot prevent persistence of explosive atmosphere after release stopped)

**ZONE TYPE**

- Based upon the likelihood of presence of explosive atmosphere dependent upon the grade of release and ventilation (according to EN60079-10)
- 0 = Where an explosive atmosphere is present continuously / for long periods / frequently (normally 'continuous' grade of release)
- 1 = Where an explosive atmosphere is likely to occur in normal operation occasionally (normally 'primary' grade of release)
- 2 = Where an explosive atmosphere is NOT likely to occur in normal operation, but if it does, will persist for a short period only (normally 'secondary' grade of release)

**LEAK RATES**

	Kg/s	Explanation
Bubbles	Less than small	
Small	9 x 10 <sup>-5</sup>	0.1mm hole as defined in IP15 2nd ED, Table C6 page 118

Customer: **Generic**

Pressure System: **Bulk Gaseous Hydrogen Installation**

Location: **Outside**

System Description: **Trailer fill station with high pressure storage and pressure control assembly**

**Part 2: Ignition Sources & Personnel Exposure**

Ignition Source Category	Ignition Source	Likelihood of Ignition Source occurring			Remarks
		Normal Operation	Filling Operations	Maintenance Operations	
<b>Heat Energy</b>					
	Heating Installations	0	0	0	
	Internal Combustion Engines	0	1	1	Exhaust temperature may reach ignition temperature. Vehicle only present during filling or maintenance operations
	Smoking / Naked Flames	1	1	1	Hot surface, sparks, flame
	Hot Work (eg welding / brazing)	0	0	1	Hot surface, sparks, flame
	Hot surfaces	0	0	1	Hot surface, sparks, flame
	Laser / intense radiation sources	0	0	0	This would be an unusual ignition source and would need to be covered by a specific risk assessment.
<b>Mechanical Energy</b>					
	Friction / overheating	0	1	1	Particulate ignition of hydrogen
	Ultrasonic	0	0	0	
	Impact	1	1	1	Hot surface due to friction
	Grinding	0	0	1	Hot surface / sparks
	Compression	0	0	0	
	Internal Combustion Engine	0	1	1	Mechanical failure of engine due to engine overspeed from ingress of hydrogen
<b>Chemical Energy</b>					
	Self-heating	0	0	0	
	Impact / heat sensitive materials	0	0	0	
	Runaway exothermic reaction	0	0	0	
<b>Electrical Energy</b>					
	Electrical Lighting	1	1	1	Electrical sparks or heat only occur under fault conditions
	Electromagnetic radiation	0	0	0	
	Short circuit	1	1	1	Electrical sparks or heat
	Electrical arc	1	1	1	Electrical sparks or heat
	Earth fault	1	1	1	Electrical sparks or heat
	Conductor fault	1	1	1	Electrical sparks or heat
	Lightning strike	1	1	1	Electrical sparks or heat
	Static electrical discharge	1	2	1	Spark
	Sparking - Loose contactors on vehicles	1	1	1	Electrical sparks or heat
	Excessive temperature rise due to overload of equipment	0	0	1	Heat
	Induction heating	0	0	0	
	Resistive heating	0	0	0	
	Connection to inappropriate electrical supply	0	0	0	

**DEFINITIONS**

**LIKELIHOOD OF IGNITION SOURCE OCCURRING**

- 3 = Present continuously or for long periods (>1000 hours/year)
- 2 = Likely to occur (>10 < 1000 hours/year)
- 1 = Not likely to occur or infrequent and for short periods (<10 hours/year)
- 0 = Not present

Customer: **Generic**

Pressure System: **Bulk Gaseous Hydrogen Installation**

Location: **Outdoors**

System Description: **Trailer fill station with high pressure storage and pressure control assembly**

**Part 3: Risk Assessment - Normal Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of Explosion or Fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk See table below	Existing Control Measures	Remarks / Additional Requirements
	Worst case from Part 1	From Part 2	Part 1 X Part 2					
Smoking / Naked Flames	2	1	2	Jet flame, localised fire.	M	P4	Site Rules and signage	
Impact	2	1	2	Localised Fire.	M	P4	Driver/operator training and procedures. Safety barriers	
Electrical lighting	2	1	2	Localised Fire. Confined to light involved.	L	P5	Lighting suitably designed and located at height.	
Short circuit	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Electrical arc	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Earth fault	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Conductor fault	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Lightning strike	2	1	2	Major localised damage	M	P4	Vent stack at high level bonded and earthed	
Static electrical discharge	2	1	2	Localised fire	L	P5	Bonded and earthed	
Sparking - Loose contactors on vehicles	2	1	2	Damage to vehicle	L	P5	Vehicle maintenance and proximity of vehicle to release.	

**DEFINITIONS**

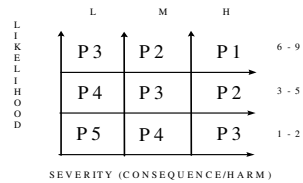
*Severity*

- H = Major impact or major injury/fatality
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*Risk Definitions*

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- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: **Generic**

Pressure System: **Bulk Gaseous Hydrogen Installation**

Location: **Outdoors**

System Description: **Trailer fill station with high pressure storage and pressure control assembly**

**Part 4: Risk Assessment - Filling Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of Explosion or Fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk See table below	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2					
Internal Combustion Engines - Heat Energy	2	1	2	Localised fire. Confined to equipment involved	M	P4	Existing vehicle design e.g hot surfaces shielded	
Smoking / Naked Flames	2	1	2	Jet flame, localised fire.	M	P4	Site Rules and signage	
Friction / overheating	2	1	2	Localised fire. Confined to equipment involved	L	P5	Equipment routinely maintained	
Internal Combustion Engine - Mechanical Energy	2	1	2	Localised fire, Damage to vehicle	M	P4	All protective devices and vents routed to high level. During filling operation engine not running. Fill supervised.	
Impact	2	1	2	Localised Fire.	M	P4	Driver/operator training and procedures. Safety barriers	
Electrical Lighting	2	1	2	Localised fire. Confined to equipment involved	L	P5	Lighting suitably designed and located at height.	
Short circuit	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Electrical arc	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Earth fault	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Conductor fault	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Lightning strike	2	1	2	Major localised damage	M	P4	Vent stack at high level bonded and earthed	Hydrogen being vented at high level during a lightning strike will ignite resulting flame at high level with no personnel exposure.
Static electrical discharge	2	2	4	Localised fire	M	P3	All equipment bonded and earthed. Driver training	Confirm existing control by Annual inspection
Sparking - Loose contactors on vehicles	2	1	2	Damage to vehicle	M	P4	Vehicle maintenance and proximity of vehicle to release.	

**DEFINITIONS**

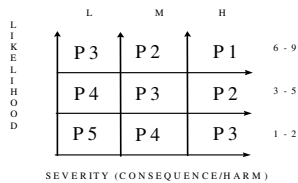
*Severity*

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*Risk Definitions*

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- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: **Generic**

Pressure System: **Bulk Gaseous Hydrogen Installation**

Location: **Outdoors**

System Description: **Trailer fill station with high pressure storage and pressure control assembly**

**Part 5: Risk Assessment - Maintenance Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of Explosion or Fire	Consequence of Ignition	Severity	Assessed Level of Risk	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2					
Internal Combustion Engines - Heat Energy	2	1	2	Localised fire. Confined to equipment involved	M	P4	Existing vehicle design e.g hot surfaces shielded and vehicle not running during maintenance operation.	For the case of portable power generators, they should be kept outside the hazardous area.
Smoking / Naked Flames	2	1	2	Jet flame, localised fire.	M	P4	Site Rules and signage	
Hot Work	2	1	2	Localised Fire.	M	P4	Safe system of work e.g. Permit to work, gas analysis, venting, purging and suitable isolations. Competent persons	
Hot surfaces	2	1	2	Localised Fire.	M	P4	Safe system of work e.g. Permit to work, gas analysis, venting, purging and suitable isolations. Competent persons	
Friction / overheating	2	1	2	Localised Fire.	M	P4	Equipment routinely maintained	
Impact	2	1	2	Fire / rapid release of stored energy with knock on effects on other cylinders or buildings.	M	P4	Vehicle impact - Training and procedures. Tool impact - Safe system of work e.g. Permit to work, gas analysis, venting, purging and suitable isolations. Competent persons	
Grinding	2	1	2	Localised Fire.	M	P4	Safe system of work e.g. Permit to work, gas analysis, venting, purging and suitable isolations. Competent persons	
Internal Combustion Engine (hydrogen ingress in to engine - over speed failure)	2	1	2	Damage to vehicle	M	P4	Proximity of vehicle to release	
Electrical lighting	2	1	2	Localised Fire. Confined to light involved.	L	P5	Lighting suitably designed and located at height.	Personal or portable lighting shall be suitable for the area.
Short circuit	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	Personal or portable equipment shall be suitable for the area.
Electrical arc	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	Personal or portable equipment shall be suitable for the area.
Earth fault	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	Personal or portable equipment shall be suitable for the area.
Conductor fault	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	Personal or portable equipment shall be suitable for the area.
Lightning strike	2	1	2	Major localised damage	M	P4	Vent stack at high level bonded and earthed	Hydrogen being vented at high level during a lightning strike will ignite resulting flame at high level with no personnel exposure.
Static electrical discharge	2	1	2	Localised fire	L	P5	Suitable equipment installed and maintained.	Personal or portable equipment shall be suitable for the area e.g mobile phones not allowed.
Sparking - Loose contactors on vehicles	2	1	2	Damage to vehicle	L	P5	Vehicle maintenance and proximity of vehicle to release.	
Excessive temperature rise due to overload of equipment	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment used and maintained	Personal or portable equipment shall be suitable for the area.

**DEFINITIONS**

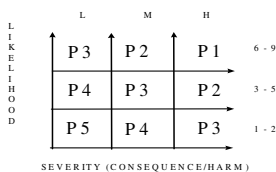
*Severity*

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- M = Serious impact or lost time injury
- L = Minor impact or First aid case

*Risk Definitions*

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: **Generic**

Pressure System: **Gaseous Hydrogen Storage**

Location: **Outdoors**

System Description: **Hydrogen Cylinder Storage**

**Part 1: Dangerous Substance & Hazardous Area Classification**

DANGEROUS SUBSTANCE CHARACTERISTICS										
Substance Name	Composition	Phase (gas /liquid)	Flammable Limits (in air)		Flash Point (deg C)	Density (Water = 1)	Gas relative density (Air = 1)	Ignition Temperature (deg C)	Group & Temperature Class	CHIP Regulations Classification
			LEL (%)	UEL (%)						
Hydrogen	100%	Gas	4	75		0.082	0.07	560°C	IIC T1	

Potential Release Source	Location	Likelihood of release	Dangerous Substance Operating Conditions		Ventilation		Hazardous Area			Remarks
			Pressure (barg)	Temperature (deg C)	Type	Degree / Availability	Zone Type (0-1-2)	Zone extent vert. (M)	Zone extent horiz. (M)	
Leaking Valve Outlet (damaged valve seat, not closed properly)	External	1	230 bar (max)	Ambient	Natural	VL	2	< 240mm (up)	< 640mm	Bubble leaks, see table below. These leaks are minor and rapidly disperse.
Valve Neck Leak	External	1	230 bar (max)	Ambient	Natural	VL	2	< 240mm (up)	< 130mm	Bubble leaks, see table below. These leaks are minor and rapidly disperse.
Cylinder Shell Corrosion	External	0	230 bar (max)	Ambient	Natural	VL	N/A	N/A	N/A	Cylinder are inspected externally on every fill and internally at periodic re test.
Puncture (FLT)	External	0	230 bar (max)	Ambient	Natural	VL	NA	NA	NA	Fork Lift Operators trained. Cylinders Handled in Pallets.
Cylinder Failure	External	0	230 bar (max)	Ambient	Natural	VL	NA	NA	NA	Cylinders manufactured to recognised code and inspected periodically .
Cylinder Fall - Valve damage	External	0	230 bar (max)	Ambient	Natural	VL	NA	NA	NA	Valves are suitably protected. Cylinders stable by design & handled in pallets. Operators trained.
Inadvertent Valve Opening	External	0	230 bar (max)	Ambient	Natural	VL	NA	NA	NA	Cylinder Valve Guard Fitted. Operator training. Valve closed quickly. Cylinders normally kept in pallets
Malicious Valve Opening	External	0	230 bar (max)	Ambient	Natural	VL	N/A	NA	NA	Site Security.

**DEFINITIONS**

**LIKELIHOOD OF RELEASE**

- 3 = Continuous (permanent or long periods of release to atmosphere during normal operation)
- 2 = Primary (release expected during normal operation)
- 1 = Secondary (release NOT expected during normal operation)
- 0 = Probability considered negligible, DSEAR risk assessment not required.

**VENTILATION - TYPE**

- Natural = Open air or, Open building with vents in walls/roof designed with regard to relative density of gas/vapour equivalent to open-air or, Building that is not open but with permanent natural ventilation openings
- Artificial = General or local means of air movement/ air replacement within a building or open air to aid/control product dispersal

**VENTILATION - DEGREE**

- Degree and availability influences the effectiveness of controlling dispersion and persistence of the explosive atmosphere classified as follows:
- VH = High ventilation (can reduce concentration virtually instantly to below LEL, resulting in negligible zone extent, but subject to ventilation availability/reliability)
- VM = Medium ventilation (can control concentration whilst release in progress to give stable zone, and explosive atmosphere does not exist after release stopped)
- VL = Low ventilation (CANNOT control concentration whilst release in progress, and/or cannot prevent persistence of explosive atmosphere after release stopped)

**ZONE TYPE**

- Based upon the likelihood of presence of explosive atmosphere dependent upon the grade of release and ventilation (according to EN60079-10)
- 0 = Where an explosive atmosphere is present continuously / for long periods / frequently (normally 'continuous' grade of release)
- 1 = Where an explosive atmosphere is likely to occur in normal operation occasionally (normally 'primary' grade of release)
- 2 = Where an explosive atmosphere is NOT likely to occur in normal operation, but if it does, will persist for a short period only (normally 'secondary' grade of release)

**LEAK RATES**

	Kgs	Explanation
Bubbles	Less than small	
Small	9 x 10 <sup>-5</sup>	0.1mm hole as defined in IP15 2nd ED, Table C6 page 118

Customer: **Generic**  
 Pressure System: **Gaseous Hydrogen Storage**  
 System Description: **Hydrogen Cylinder Storage**

Location: **Outdoor**

**Part 2: Ignition Sources & Personnel Exposure**

Ignition Source Category	Ignition Source	Likelihood of Ignition Source occurring			Remarks
		Normal Operation	Filling Operations	Maintenance Operations	
<b>Heat Energy</b>					
	Heating Installations	0	0	0	
	Internal Combustion Engines	1	0	0	Exhaust temperature may reach ignition temperature
	Smoking / Naked Flames	1	0	0	Hot surface, sparks, flame
	Hot Work (eg welding / brazing)	0	0	1	Hot surface, sparks, flame
	Hot surfaces	0	0	1	Hot surface, sparks, flame
	Laser / intense radiation sources	0	0	1	NDE / Testing
<b>Mechanical Energy</b>					
	Friction / overheating	0	0	0	
	Ultrasonic	0	0	0	
	Impact	1	0	1	Hot surface due to friction
	Grinding	0	0	1	Hot surface / sparks
	Compression	0	0	0	
	Internal Combustion Engine	1	0	1	Mechanical failure of engine due to engine overspeed from ingress of hydrogen
<b>Chemical Energy</b>					
	Self-heating	0	0	0	
	Impact / heat sensitive materials	0	0	0	
	Runaway exothermic reaction	0	0	0	
<b>Electrical Energy</b>					
	Electrical Lighting	1	0	1	Electrical sparks or heat only occur under fault conditions
	Electromagnetic radiation	0	0	0	
	Short circuit	1	0	1	Electrical sparks or heat
	Electrical arc	1	0	1	Electrical sparks or heat
	Earth fault	1	0	1	Electrical sparks or heat
	Conductor fault	1	0	1	Electrical sparks or heat
	Lightning strike	1	0	1	Electrical sparks or heat
	Static electrical discharge	1	0	1	Spark
	Sparking - Loose contactors on vehicles	1	0	1	Electrical sparks or heat
	Excessive temperature rise due to overload of equipment	0	0	1	Heat
	Induction heating	0	0	0	
	Resistive heating	0	0	0	
	Connection to inappropriate electrical supply	0	0	0	

**DEFINITIONS**

**LIKELIHOOD OF IGNITION SOURCE OCCURRING**

- 3 = Present continuously or for long periods (>1000 hours/year)
- 2 = Likely to occur (>10 < 1000 hours/year)
- 1 = Not likely to occur or infrequent and for short periods (<10 hours/year)
- 0 = Not present



Customer: **Generic**

Pressure System: **Gaseous Hydrogen Storage**

Location: **Outdoors**

System Description: **Hydrogen Cylinder Storage**

**Part 3: Risk Assessment - Normal Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk See table below	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2					
Internal Combustion Engines	1	1	1	Localised Fire. Confined to cylinder involved.	L	P5		
Smoking / Naked Flames	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Site Rules and signage	
Impact	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Driver/operator training and procedures	
Internal Combustion Engine (Hydrogen ingress in to engine - over speed failure)	1	1	1	Damage to vehicle	M	P4	Proximity of vehicle to release	
Electrical lighting	1	1	1	Localised Fire. Confined to light involved.	L	P5	Lighting suitably designed and located at height.	
Short circuit	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Electrical arc	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Earth fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Conductor fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Lightning strike	1	1	1	Mejor localised damage	M	P4		No evidence in industry of this occurring. Surrounding building may give protection to cylinders.
Static electrical discharge	1	1	1	Localised fire	L	P5	Suitable equipment installed and maintained	
Sparking - Loose contactors on vehicles	1	1	1	Damage to vehicle	L	P5	Vehicle maintenance and proximity of vehicle to release.	

**DEFINITIONS**

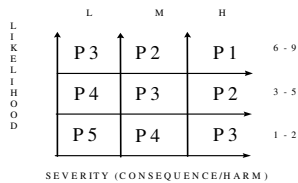
*Severity*

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

*Risk Definitions*

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: **Generic**

Pressure System: **Gaseous Hydrogen Storage**

Location: **Outdoors**

System Description: **Hydrogen Cylinder Storage**

**Part 4: Risk Assessment - Filling Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire	Consequence of Ignition	Severity	Assessed Level of Risk	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2		(L M H)	See table below		
NOT APPLICABLE TO CYLINDER STORAGE								

Customer: **Generic**

Pressure System: **Gaseous Hydrogen Storage**

Location: **Outdoors**

System Description: **Hydrogen Cylinder Storage**

**Part 5: Risk Assessment - Maintenance Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source Occurring	Likelihood of Explosion or Fire	Consequence of Ignition	Severity	Assessed Level of Risk	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2		(L M H)	See table below		
Hot Work	1	1	1	Localised Fire. Confined to cylinder involved.	L	P5	Safe system of work	
Hot surfaces	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Laser / intense radiation sources	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Impact	1	1	1	Fire / rapid release of stored energy with knock on effects on other cylinders or buildings.	M	P4	Driver training and procedures	
Grinding	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Internal Combustion Engine (hydrogen ingress in to engine - over speed failure)	1	1	1	Damage to vehicle	M	P4	Proximity of vehicle to release	
Electrical lighting	1	1	1	Localised Fire. Confined to light involved.	L	P5	Lighting suitably designed and located at height.	
Short circuit	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Electrical arc	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Earth fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Conductor fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Lightning strike	1	1	1	Major localised damage	M	P4		No evidence in industry of this occurring. Surrounding building may give protection to cylinders.

**DEFINITIONS**

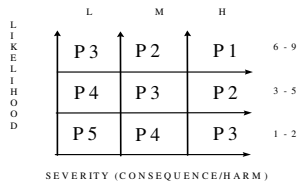
*Severity*

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

*Risk Definitions*

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: **Generic**

Pressure System: **Gaseous Cylinder Hydrogen Manifold**

Location: **Outdoors**

System Description: **Cylinder Manifold.**

**Part 1: Dangerous Substance & Hazardous Area Classification**

DANGEROUS SUBSTANCE CHARACTERISTICS										
Substance Name	Composition	Phase (gas /liquid)	Flammable Limits (in air)		Flash Point (deg C)	Density (Kg/m3)	Gas relative density (Air = 1)	Ignition Temperature (deg C)	Group & Temperature Class	CHIP Regulations Classification
			LEL (%)	UEL (%)						
Hydrogen	100%	Gas	4	76		0.082	0.07	560°C	IIC T1	
Potential Release Source	Location	Likelihood of release	Dangerous Substance Operating Conditions		Ventilation		Hazardous Area			Remarks
			Pressure (barg)	Temperature (deg C)	Type	Degree / Availability	Zone Type (0-1-2)	Zone extent vert. (M)	Zone extent horiz. (M)	
Venting the Manifold Header	Vented to safe area at high level.	2	230	50	Natural	VL	1	2m	2m	Header rail vented at cylinder change over. Hose/pigtail inspected prior to fill and changed at appropriate intervals, three years.
Safety Valves	Vented to safe area at high level.	2	230	50	Natural	VL	1	2m	2m	Controlled over pressure release to safeguard system
Mechanical Joints - Failure	External	1	230	50	Natural	VL	2	5m	5m	There are mechanical joints between components e.g. valves and piping. These are pressure tested and leak checked.
Mechanical Joints - Bubble Leak	External	1	230	50	Natural	VL	2	50mm	50mm	There are mechanical joints between components e.g. valves and piping. These are pressure tested and leak checked.
Pressure accessories. Valves, regulators, filters, gauges etc - Bubble Leaks	External	1	230	50	Natural	VL	2	50mm	50mm	Pressure accessories are designed, manufactured, tested and appropriate for the gas.
Valve Packing - bubble leak	External	1	230	50	Natural	VL	2	50mm	50mm	Valve packing is adjusted to minimise leakage but maintain mechanical operability.
Failure of a cylinder.	External	0	230	50	Natural	VL	<b>Outside Scope of Area Classification</b>			Cylinders are designed, manufactured and tested in accordance with national regulations, and subjected to periodic testing.
Failure of pipework.	External	0	230	50	Natural	VL				Pipework is designed, manufactured and tested in accordance with recognised standards, suitable for the gas, and subjected to periodic testing where required.
Failure of flexible hose / pigtail	External	0	230	50	Natural	VL				Hose/Pigtail is designed, manufactured and tested in accordance with recognised standards, suitable for the gas, and subjected to periodic testing/exchange where required.

**DEFINITIONS**

**LIKELIHOOD OF RELEASE**

- 3 = Continuous (permanent or long periods of release to atmosphere during normal operation)
- 2 = Primary (release expected during normal operation)
- 1 = Secondary (release NOT expected during normal operation)
- 0 = Probability considered negligible, DSEAR risk assessment not required.

**VENTILATION - TYPE**

- Natural = Open air
- or, Open building with vents in walls/roof designed with regard to relative density of gas/vapour equivalent to open-air
- or, Building that is not open but with permanent natural ventilation openings

Artificial = General or local means of air movement/ air replacement within a building or open air to aid/control product dispersal

**VENTILATION - DEGREE**

- Degree and availability influences the effectiveness of controlling dispersion and persistence of the explosive atmosphere classified as follows:
- VH = High ventilation (can reduce concentration virtually instantly to below LEL, resulting in negligible zone extent, but subject to ventilation availability/reliability)
- VM = Medium ventilation (can control concentration whilst release in progress to give stable zone, and explosive atmosphere does not exist after release stopped)
- VL = Low ventilation (CANNOT control concentration whilst release in progress, and/or cannot prevent persistence of explosive atmosphere after release stopped)

**ZONE TYPE**

- Based upon the likelihood of presence of explosive atmosphere dependent upon the grade of release and ventilation (according to EN60079-10)
- 0 = Where an explosive atmosphere is present continuously / for long periods / frequently (normally 'continuous' grade of release)
- 1 = Where an explosive atmosphere is likely to occur in normal operation occasionally (normally 'primary' grade of release)
- 2 = Where an explosive atmosphere is NOT likely to occur in normal operation, but if it does, will persist for a short period only (normally 'secondary' grade of release)

**LEAK RATES**

	Kg/s	Explanation
Bubbles	Less than small	
Small	0 x 10 <sup>-5</sup>	0.1mm hole as defined in IP15 2nd ED. Table C6 page 118

Customer: **Generic**

Pressure System: **Gaseous Cylinder Hydrogen Manifold**

Location: **Outdoors**

System Description: **Cylinder Manifold.**

**Part 2: Ignition Sources & Personnel Exposure**

Ignition Source Category	Ignition Source	Potential for Ignition Risk within the Specified Operation			Remarks
		Normal Operation	Changing Cylinder(s)	Maintenance Operations	
<b>Heat Energy</b>					
	Heating Installations	0	0	0	
	Internal Combustion Engines	0	0	1	Exhaust temperature may reach ignition temperature. Vehicle only present during filling or maintenance operations
	Smoking / Naked Flames	0	0	0	Site Rules
	Hot Work (eg welding / brazing)	0	0	1	Hot surface, sparks, flame
	Hot surfaces	0	0	1	Hot surface, sparks, flame
	Laser / intense radiation sources	0	0	1	NDE / Testing
<b>Mechanical Energy</b>					
	Friction / overheating	0	0	0	
	Ultrasonic	0	0	0	
	Impact	1	1	1	Hot surface due to friction
	Grinding	0	0	1	Hot surface, sparks, flame
	Compression	0	0	1	
	Internal Combustion Engines	1	0	1	Mechanical failure of engine due to engine overspeed from ingress of hydrogen
<b>Chemical Energy</b>					
	Self-heating	Not applicable	Not applicable	Not applicable	
	Impact / heat sensitive materials	Not applicable	Not applicable	Not applicable	
	Runaway exothermic reaction	Not applicable	Not applicable	Not applicable	
<b>Electrical Energy</b>					
	Electrical Lighting	1	1	1	Electrical sparks or heat only occurs under fault conditions
	Electromagnetic radiation	0	0	0	
	Short circuit	0	0	0	
	Electrical arc	1	1	1	Electrical sparks or heat
	Earth fault	1	1	1	Electrical sparks or heat
	Conductor fault	0	0	0	
	Lightning strike				
	Static electrical discharge	1	1	1	Spark
	Loose contact	0	0	0	
	Excessive temperature rise due to overload	0	0	0	
	Induction heating	0	0	0	
	Resistive heating	0	0	0	
	Connection to inappropriate electrical supply	0	0	0	

**DEFINITIONS**

**LIKELIHOOD OF IGNITION SOURCE OCCURRING**

- 3 = Present continuously or for long periods (>1000 hours/year)
- 2 = Likely to occur (>10 < 1000 hours/year)
- 1 = Not likely to occur or infrequent and for short periods (<10 hours/year)
- 0 = Not present

Customer: **Generic**

Pressure System: **Gaseous Cylinder Hydrogen Manifold**

Location: **Outdoors**

System Description: **Cylinder Manifold.**

**Part 3: Risk Assessment - Normal Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk See table below	Existing Control Measures	Remarks / Additional Requirements	Potential Ignition Source
	From Part 1	From Part 2	Part 1 X Part 2						
Unauthorised vehicle in area.	1	1	1	Localised fire. Damage to installation.		P4	No personnel normally in area. BCGA safety distances. Site specific access rules. Signage.		Energy from vehicle or associated equipment.
Smoking/Naked Flames	1	1	1	Localised fire. Damage to installation.		P4	No personnel normally in area. BCGA safety distances. Site specific access rules. Signage.		Naked Flames
Vehicle Impact	1	1	1	Localised fire. Damage to installation.		P3	Protected perimeter, fences, bollards etc. Location. Site specific traffic rules.		Energy from vehicle or associated equipment.
Electrical Lighting	1	1	1	Localised fire		P4	Suitable equipment classified for the zoned area, sited correctly		Energy from lighting.
Electrical Arc	1	1	1	Localised fire		P4	Suitable equipment classified for the zoned area, sited correctly		Energy from equipment.
Earth Fault	1	1	1	Localised fire		P4	Sytem installed and tested routinely, for bonding and earthing.		Earth at a high potential possible static discharge.
Lightning Strike	1	1	1	Localised fire		P4	Lightning protected if required, by location. System earthed and bonded.		Static discharge.
Static electrical discharge.	1	1	1	Localised fire		P4	Sytem installed and tested routinely, for bonding and earthing.		Static discharge.

**DEFINITIONS**

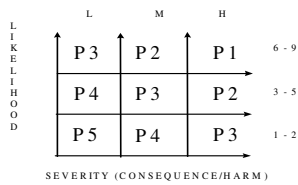
**Severity**

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

**Risk Definitions**

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

**Matrix**



Customer: **Generic**

Pressure System: **Gaseous Cylinder Hydrogen Manifold**

Location: **Outdoors**

System Description: **Cylinder Manifold.**

**Part 4: Risk Assessment - Cylinder Change Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk See table below	Existing Control Measures	Remarks / Additional Requirements	Potential Ignition Source
	From Part 1	From Part 2	Part 1 X Part 2						
Impact	1	1	1	Localised fire	L	P5	Cylinder handling arrangements.		Sparks
Electrical Lighting	1	1	1	Localised fire	L	P5	Suitable equipment classified for the zoned area, sited correctly		Energy from lighting.
Electrical Arc	1	1	1	Localised fire	L	P5	Suitable equipment classified for the zoned area, sited correctly		Energy from equipment.
Earth Fault	1	1	1	Localised fire	L	P5	System installed and tested routinely, for bonding and earthing.		Earth at a high potential possible static discharge.
Lightning Strike	1	1	1	Localised fire	L	P5	Lightning protected if required, by location. System earthed and bonded.		Static discharge.
Static electrical discharge.	1	1	1	Localised fire	L	P5	System installed and tested routinely, for bonding and earthing.		Static discharge.

**DEFINITIONS**

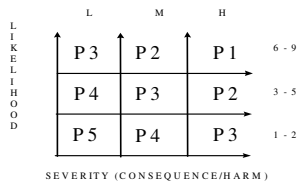
*Severity*

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

*Risk Definitions*

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: **Generic**

Pressure System: **Gaseous Cylinder Hydrogen Manifold**

Location: **Outdoors**

System Description: **Cylinder Manifold.**

**Part 5: Risk Assessment - Maintenance Operations**

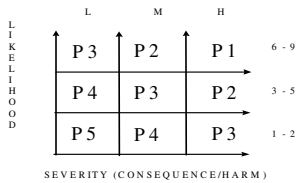
Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk See table below	Existing Control Measures	Remarks / Additional Requirements	Potential Ignition Source
	From Part 1	From Part 2	Part 1 X Part 2						
Hot Work	1	1	1	Localised fire	L	P5	Permit to work. System depressurised/Purged. Work procedures/Competent		Hot surface/Naked flame
Hot surfaces	1	1	1	Localised fire	L	P5	Permit to work. System depressurised/Purged. Work procedures/Competent		Hot surface/Naked flame
Impact	1	1	1	Localised fire	L	P5	Permit to work. System depressurised/Purged. Work procedures/Competent		Hot surface/sparks
Grinding	1	1	1	Localised fire	L	P5	Permit to work. System depressurised/Purged. Work procedures/Competent		Hot surface/sparks
Compression	1	1	1	Localised fire	L	P5	Permit to work. System depressurised/Purged. Work procedures/Competent		Static discharge/Friction.
Electrical Lighting	1	1	1	Localised fire	L	P5	Suitable equipment classified for the zoned area, sited correctly		Energy from lighting.
Electrical Arc	1	1	1	Localised fire	L	P5	Suitable equipment classified for the zoned area, sited correctly		Energy from equipment.
Earth Fault	1	1	1	Localised fire	L	P5	System installed and tested routinely, for bonding and earthing.		Earth at a high potential possible static discharge.
Lightning Strike	1	1	1	Localised fire	L	P5	Lightning protected if required, by location. System earthed and bonded.		Static discharge.
Static electrical discharge.	1	1	1	Localised fire	L	P5	System installed and tested routinely, for bonding and earthing.		Static discharge.

**DEFINITIONS**

**Severity**  
 H = Major impact or major injury/fatality  
 M = Serious impact or lost time injury  
 L = Minor impact or First aid case

**Risk Definitions**  
 P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level  
 P2 = Substantial risk which must be improved through risk reduction methods  
 P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.  
 P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.  
 P5 = No action required

**Matrix**





Customer: **Generic**

Pressure System: **LPG Storage**

Location: **Outdoors**

System Description: **LPG Cylinder Storage**

**Part 1: Dangerous Substance & Hazardous Area Classification**

DANGEROUS SUBSTANCE CHARACTERISTICS										
Substance Name	Composition	Phase (gas /liquid)	Flammable Limits (in air)		Flash Point (deg C)	Density (Water = 1)	Gas relative density (Air = 1)	Ignition Temperature (deg C)	Group & Temperature Class	CHIP Regulations Classification
			LEL (%)	UEL (%)						
Propane	100%	Liquid	2.2	9.5		0.58	1.56	469	IIA T1	

Potential Release Source	Location	Likelihood of release	Dangerous Substance Operating Conditions		Ventilation		Hazardous Area			Remarks
			Pressure (barg)	Temperature (deg C)	Type	Degree / Availability	Zone Type (0-1-2)	Zone extent vert. (M)	Zone extent horiz. (M)	
Leaking Valve Outlet (damaged valve seat, not closed properly)	External	1	19 bar (max)	Ambient	Natural	VL	2	< 10mm (down)	< 15mm	Bubble leaks, see table below. These leaks are minor and rapidly disperse.
Valve Neck Leak	External	1	19 bar (max)	Ambient	Natural	VL	2	< 10mm (down)	< 15mm	Bubble leaks, see table below. These leaks are minor and rapidly disperse.
Relief Valve operating due to over fill	External	1	19 bar (max)	Ambient	Natural	VL	2	< 100mm (down)	< 1 m	
Relief Valve fails open	External	0	19 bar (max)	Ambient	Natural	VL	N/A	N/A	N/A	
Cylinder Shell Corrosion	External	0	19 bar (max)	Ambient	Natural	VL	N/A	N/A	N/A	Cylinder are inspected externally on every fill and internally at periodic re-test.
Puncture (FLT)	External	1	19 bar (max)	Ambient	Natural	VL	NA	NA	NA	Catastrophic failure - hazardous area classification not applicable.
Cylinder Failure	External	0	19 bar (max)	Ambient	Natural	VL	NA	NA	NA	Cylinders manufactured to recognised code and inspected periodically .
Cylinder Fall - Valve damage	External	0	19 bar (max)	Ambient	Natural	VL	NA	NA	NA	Valves are suitably protected. Cylinders stable by design & handled in pallets. Operators trained.
Inadvertent Valve Opening	External	0	19 bar (max)	Ambient	Natural	VL	NA	NA	NA	Cylinder Valve Guard Fitted. Operator training. Valve closed quickly. Cylinders normally kept in pallets
Malicious Valve Opening	External	0	19 bar (max)	Ambient	Natural	VL	N/A	NA	NA	Site Security.

**DEFINITIONS**

**LIKELIHOOD OF RELEASE**

- 3 = Continuous (permanent or long periods of release to atmosphere during normal operation)
- 2 = Primary (release expected during normal operation)
- 1 = Secondary (release NOT expected during normal operation)
- 0 = Probability considered negligible, DSEAR risk assessment not required.

**VENTILATION - TYPE**

- Natural = Open air
- or, Open building with vents in walls/roof designed with regard to relative density of gas/vapour equivalent to open-air
- or, Building that is not open but with permanent natural ventilation openings

Artificial = General or local means of air movement/ air replacement within a building or open air to aid/control product dispersal

**VENTILATION - DEGREE**

- Degree and availability influences the effectiveness of controlling dispersion and persistence of the explosive atmosphere classified as follows:
- VH = High ventilation (can reduce concentration virtually instantly to below LEL, resulting in negligible zone extent, but subject to ventilation availability/reliability)
- VM = Medium ventilation (can control concentration whilst release in progress to give stable zone, and explosive atmosphere does not exist after release stopped)
- VL = Low ventilation (CANNOT control concentration whilst release in progress, and/or cannot prevent persistence of explosive atmosphere after release stopped)

**ZONE TYPE**

- Based upon the likelihood of presence of explosive atmosphere dependent upon the grade of release and ventilation (according to EN60079-10)
- 0 = Where an explosive atmosphere is present continuously / for long periods / frequently (normally 'continuous' grade of release)
- 1 = Where an explosive atmosphere is likely to occur in normal operation occasionally (normally 'primary' grade of release)
- 2 = Where an explosive atmosphere is NOT likely to occur in normal operation, but if it does, will persist for a short period only (normally 'secondary' grade of release)

**LEAK RATES**

	Kg/s	Explanation
Bubbles	Less than small	
Small	9 x 10 <sup>-5</sup>	0.1mm hole as defined in IP15 2nd ED. Table C6 page 118

Customer: **Generic**

Pressure System: **LPG Storage**

Location: **Outdoors**

System Description: **LPG Cylinder Storage**

**Part 2: Ignition Sources & Personnel Exposure**

Ignition Source Category	Ignition Source	Likelihood of Ignition Source occurring			Remarks
		Normal Operation	Filling Operations	Maintenance Operations	
<b>Heat Energy</b>					
	Heating Installations	0	0	0	
	Internal Combustion Engines	1	0	0	Exhaust temperature may reach ignition temperature
	Smoking / Naked Flames	1	0	0	Hot surface, sparks, flame
	Hot Work (eg welding / brazing)	0	0	1	Hot surface, sparks, flame
	Hot surfaces	0	0	1	Hot surface, sparks, flame
	Laser / intense radiation sources	0	0	1	NDE / Testing
<b>Mechanical Energy</b>					
	Friction / overheating	0	0	0	
	Ultrasonic	0	0	0	
	Impact	1	0	1	Hot surface due to friction
	FLT/vehicle impact (puncture)	1	0	1	Sparks due to contact with cylinder
	Grinding	0	0	1	Hot surface / sparks
	Compression	0	0	0	
	Internal Combustion Engine	1	0	1	Mechanical failure of engine due to engine overspeed from ingress of LPG
<b>Chemical Energy</b>					
	Self-heating	0	0	0	
	Impact / heat sensitive materials	0	0	0	
	Runaway exothermic reaction	0	0	0	
<b>Electrical Energy</b>					
	Electrical Lighting	1	0	1	Electrical sparks or heat only occur under fault conditions
	Electromagnetic radiation	0	0	0	
	Short circuit	1	0	1	Electrical sparks or heat
	Electrical arc	1	0	1	Electrical sparks or heat
	Earth fault	1	0	1	Electrical sparks or heat
	Conductor fault	1	0	1	Electrical sparks or heat
	Lightning strike	1	0	1	Electrical sparks or heat
	Static electrical discharge	1	0	1	Spark
	Sparking - Loose contactors on vehicles	1	0	1	Electrical sparks or heat
	Excessive temperature rise due to overload of equipment	0	0	1	Heat
	Induction heating	0	0	0	
	Resistive heating	0	0	0	
	Connection to inappropriate electrical supply	0	0	0	

**DEFINITIONS**

**LIKELIHOOD OF IGNITION SOURCE OCCURRING**

- 3 = Present continuously or for long periods (>1000 hours/year)
- 2 = Likely to occur (>10 < 1000 hours/year)
- 1 = Not likely to occur or infrequent and for short periods (<10 hours/year)
- 0 = Not present

Customer: **Generic**

Pressure System: **LPG Storage**

Location: **Outdoors**

System Description: **LPG Cylinder Storage**

**Part 3: Risk Assessment - Normal Operations**

Identified Risk & Location	Likelihood of Release		Likelihood of Ignition Source occurring		Likelihood of explosion or fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2							
Internal Combustion Engines	1	1	1			Localised Fire. Confined to cylinder involved.	L	P5		
Smoking / Naked Flames	1	1	1			Localised Fire, confined to cylinder involved.	L	P5	Site Rules and signage	
Impact	1	1	1			Localised Fire, confined to cylinder involved.	L	P5	Driver/operator training and procedures	
FLT/vehicle impact (puncture)	1	1	1			Major fire with knock on effect on other cylinders. Possible injury to FLT driver	M	P4	Driver/operator training and procedures. Stored in pallets. FLT access from protected side of pallet.	
Internal Combustion Engine (LPG ingress in to engine - over speed failure)	1	1	1			Damage to vehicle	M	P4	Proximity of vehicle to release	
Electrical lighting	1	1	1			Localised Fire. Confined to light involved.	L	P5	Lighting suitably designed and located at height.	
Short circuit	1	1	1			Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Electrical arc	1	1	1			Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Earth fault	1	1	1			Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Conductor fault	1	1	1			Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Lightning strike	1	1	1			Major localised damage	M	P4		No evidence in industry of this occurring. Surrounding building may give protection to cylinders.
Static electrical discharge	1	1	1			Localised fire	L	P5	Suitable equipment installed and maintained	
Sparking - Loose contactors on vehicles	1	1	1			Damage to vehicle	L	P5	Vehicle maintenance and proximity of vehicle to release.	

**DEFINITIONS**

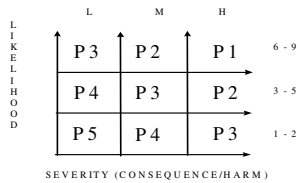
*Severity*

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

*Risk Definitions*

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: **Generic**

Pressure System: **LPG Storage**

Location: **Outdoors**

System Description: **LPG Cylinder Storage**

**Part 4: Risk Assessment - Filling Operations**

Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2			See table below		
NOT APPLICABLE TO CYLINDER STORAGE								

**DEFINITIONS**

*Severity*

- H = Major impact or major injury/fatality
- M = Serious impact or lost time injury
- L = Minor impact or First aid case

*Risk Definitions*

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*

	L	M	H	
↑	P 3	P 2	P 1	6 - 9
↑	P 4	P 3	P 2	3 - 5
↑	P 5	P 4	P 3	1 - 2
↑				

SEVERITY (CONSEQUENCE/HARM)

Customer: **Generic**

Pressure System: **LPG Storage**

Location: **Outdoors**

System Description: **LPG Cylinder Storage**

**Part 5: Risk Assessment - Maintenance Operations**

Identified Risk & Location	Likelihood of Ignition			Consequence of Ignition	Severity (L M H)	Assessed Level of Risk	Existing Control Measures	Remarks / Additional Requirements
	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of explosion or fire					
	From Part 1	From Part 2	Part 1 X Part 2			See table below		
Hot Work	1	1	1	Localised Fire. Confined to cylinder involved.	L	P5	Safe system of work	
Hot surfaces	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Laser / intense radiation sources	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Impact	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Driver training and procedures	
FLT/vehicle impact (puncture)	1	1	1	Major fire with knock on effect on other cylinders. Possible injury to FLT driver	M	P4	Driver/operator training and procedures. Stored in pallets. FLT access from protected side of pallet	
Grinding	1	1	1	Localised Fire, confined to cylinder involved.	L	P5	Safe system of work	
Internal Combustion Engine (LPG ingress in to engine - over speed failure)	1	1	1	Damage to vehicle	M	P4	Proximity of vehicle to release	
Electrical lighting	1	1	1	Localised Fire. Confined to light involved.	L	P5	Lighting suitably designed and located at height.	
Short circuit	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Electrical arc	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Earth fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Conductor fault	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	
Lightning strike	1	1	1	Major localised damage	M	P4		No evidence in industry of this occurring. Surrounding building may give protection to cylinders.
Static electrical discharge	1	1	1	Localised fire	L	P5	Suitable equipment installed and maintained	
Sparking - Loose contactors on vehicles	1	1	1	Damage to vehicle	L	P5	Vehicle maintenance and proximity of vehicle to release.	
Excessive temperature rise due to overload of equipment	1	1	1	Localised fire. Confined to equipment involved	L	P5	Suitable equipment used and maintained	

**DEFINITIONS**

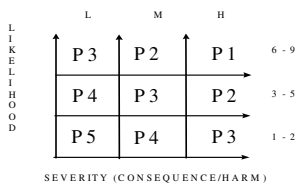
*Severity*

- H = Major impact or major injury/fatality
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- L = Minor impact or First aid case

*Risk Definitions*

- P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level
- P2 = Substantial risk which must be improved through risk reduction methods
- P3 = Moderate risk efforts should be made to reduce the risk within a defined time period.
- P4 = Risk is considered tolerable no additional controls required monitoring is required to ensure controls are maintained.
- P5 = No action required

*Matrix*



Customer: Generic

Pressure System: Oxygen System

Location: Outdoors

System Description: Liquid Oxygen Storage and Low Pressure Gaseous Distribution.

Part 1: Dangerous Substance Area Classification

DANGEROUS SUBSTANCE CHARACTERISTICS										
Substance Name	Composition	Phase (gas/liquid)	Flammable Limits (in air)		Flash Point (deg C)	Density (Kg/m3)	Gas relative density (Air = 1)	Ignition Temperature (deg C)	Group & Temperature Class	CHIP Regulations Classification
			LEL (%)	UEL (%)						
Oxygen	100%	Liquid				1141				
	100%	Gas				1.31	1.1			

Potential Release Source	Location	Likelihood of release	Dangerous Substance Operating Conditions		Ventilation		Hazardous Area			Remarks
			Pressure (barg)	Temperature (deg C)	Type	Degree / Availability	Zone Type (0-1-2)	Zone extent vert. (M)	Zone extent horiz. (M)	
Filling Hose	External	2	23	-183	Natural	VL	AREA CLASSIFICATION NOT APPLICABLE TO OXYGEN.			Hose vented to safe area.
Safety Valves/Bursting Discs	External	2	23	-183	Natural	VL				Controlled over pressure release to safeguard system
Mechanical Joints	External	1	23	-183	Natural	VL				There are mechanical joints between components e.g. valves and piping. These are pressure tested and leak checked.
Pressure accessories. Valves, regulators, filters, gauges etc.	External	1	23	-183	Natural	VL				Pressure accessories are designed, manufactured, tested and appropriate for the gas.
Valve Packing	External	1	23	-183	Natural	VL				Valve packing is adjusted to minimise leakage but maintain mechanical operability.
Failure of a vessel	External	1	23	-183	Natural	VL				Vessels are designed, manufactured and tested in accordance with national regulations, and subjected to periodic testing.
Failure of pipework.	External	1	23	-183	Natural	VL				Pipework is designed, manufactured and tested in accordance with recognised standards, suitable for the gas, and subjected to periodic testing where required.
Failure of supply hose.	External	1	23	-183	Natural	VL				Hose is designed, manufactured and tested in accordance with recognised standards, suitable for the gas, and subjected to periodic testing/exchange where required.

DEFINITIONS

GRADE OF RELEASE  
 3 = Continuous (permanent or long periods of release to atmosphere during normal operation)  
 2 = Primary (release expected during normal operation)  
 1 = Secondary (release NOT expected during normal operation)  
 0 = Probability considered negligible, DSEAR risk assessment not required.

VENTILATION - TYPE  
 Natural = Open air  
 or, Open building with vents in walls/roof designed with regard to relative density of gas/vapour equivalent to open-air or, Building that is not open but with permanent natural ventilation openings  
 Artificial = General or local means of air movement/ air replacement within a building or open air to aid/control product dispersal

VENTILATION - DEGREE  
 Degree and availability influences the effectiveness of controlling dispersion and persistence of the explosive atmosphere classified as follows:  
 VH = High ventilation (can reduce concentration virtually instantly to below LEL, resulting in negligible zone extent, but subject to ventilation availability/reliability)  
 VM = Medium ventilation (can control concentration whilst release in progress to give stable zone, and explosive atmosphere does not exist after release stopped)  
 VL = Low ventilation (CANNOT control concentration whilst release in progress, and/or cannot prevent persistence of explosive atmosphere after release stopped)

ZONE TYPE  
 Based upon the likelihood of presence of explosive atmosphere dependent upon the grade of release and ventilation (according to EN60079-10)  
 0 = Where an explosive atmosphere is present continuously / for long periods / frequently (normally 'continuous' grade of release)  
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 2 = Where an explosive atmosphere is NOT likely to occur in normal operation, but if it does, will persist for a short period only (normally 'secondary' grade of release)

Customer: **Generic**

Pressure System: **Oxygen System**

Location: **Outdoors**

System Description: **Liquid Oxygen Storage and Low Pressure Gaseous Distribution.**

**Part 2: Personnel Exposure**

Ignition Source Category	Ignition Source	Likelihood of Ignition Source occurring			Remarks
		Normal Operation	Filling Operations	Maintenance Operations	
<b>Heat Energy</b>					
	Smoking / Naked Flames	1	1	1	Hot surface, sparks, flame
	Hot Work (eg welding / brazing)	0	0	1	Hot surface, sparks, flame
<b>Mechanical Energy</b>					
	Friction / overheating from a pump	0	1	1	Particulate ignition of hydrogen
	Impact	1	1	1	Hot surface due to friction
	Grinding	0	0	1	Hot surface / sparks
	Compression	0	0	0	Not applicable to low pressure systems
	Internal Combustion Engine	0	1	1	Mechanical failure of engine due to engine overspeed from ingress of hydrogen
<b>Chemical Energy</b>					
	Contamination	1	1	1	Hydrocarbons, particulates etc
	Combustible material	1	1	1	Hydrocarbons, wood etc
<b>Electrical Energy</b>					
	Electrical spark	1	1	1	Electrical sparks or heat

**DEFINITIONS**

**LIKELIHOOD OF IGNITION SOURCE OCCURRING**

- 3 = Present continuously or for long periods (>1000 hours/year)
- 2 = Likely to occur (>10 < 1000 hours/year)
- 1 = Not likely to occur or infrequent and for short periods (<10 hours/year)
- 0 = Not present

Customer: **Generic**  
 Pressure System: **Oxygen System** **Outdoors**  
 System Description: **Liquid Oxygen Storage and Low Pressure Gaseous Distribution.**

**Part 3: Risk Assessment**

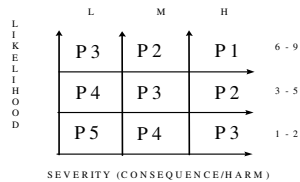
Identified Risk & Location	Likelihood of Release	Likelihood of Ignition Source occurring	Likelihood of Explosion or Fire	Consequence of Ignition	Severity (L M H)	Assessed Level of Risk See table below	Existing Control Measures	Remarks / Additional Requirements
	From Part 1	From Part 2	Part 1 X Part 2					
Smoking / Naked Flames	2	1	2	Localised fire. Severe burns possibly leading to fatality	H	P3	Site rules and signage, Training, Oxygen awareness, Procedures and competent persons.	Periodic refresher training
Hot Work (eg welding / brazing)	2	1	2	Localised fire. Severe burns possibly leading to fatality	H	P3	Safe system of work which may include a permit to work.	Where activities are carried out in a confined space, a specific risk assessment shall be conducted to consider the possibility of oxygen saturation.
Grinding	2	1	2	Localised fire. Severe burns possibly leading to fatality	H	P3	Safe system of work which may include a permit to work.	Where activities are carried out in a confined space, a specific risk assessment shall be conducted to consider the possibility of oxygen saturation.
Internal Combustion Engine	2	1	2	Localised fire, Damage to vehicle	M	P4	Source of release is remote from engine intake in a freely ventilated area.	
Combustible material	2	1	2	Localised Fire. Equipment damage only	L	P5	Location in accordance with BCGA Code of Practice CP36. Training, signage and procedures.	
Electrical spark	2	1	2	Localised fire. Confined to equipment involved	L	P5	Suitable equipment installed and maintained	No requirement for classified equipment
Hazards associated within the pressure system								
Friction / overheating from a pump	3	1	3	Localised Fire.	L	P4	System designed, manufactured, installed, commissioned and maintained in accordance with recognised standards and codes.	Ensure only oxygen compatible materials are used.
Contamination	3	1	3	Localised Fire.	L	P4	System designed, manufactured, installed, commissioned and maintained in accordance with recognised standards and codes.	Ensure only oxygen compatible materials are used.
Impact	3	1	3	Localised Fire.	L	P4	System designed, manufactured, installed, commissioned and maintained in accordance with recognised standards and codes.	Ensure system is clean and materials are suitable for oxygen service.

**DEFINITIONS**

*Severity*  
 H = Major impact or major injury/fatality  
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*Risk Definitions*  
 P1 = Intolerable risk - work must not be started or continued until the risk has been reduced to an acceptable level  
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*Matrix*





## **HISTORY AND OBJECTIVES OF BCGA**

The British Compressed Gases Association was established in August 1971 as the successor to the British Acetylene Association, formed in 1901. Its Members consist of producers, suppliers of gases equipment and container manufacturers and users operating in the compressed gas field.

The main objective of the Association is the advancement of technology and safe practice in the manufacture, handling and use of all gases and the design and manufacture of all containers, apparatus, appliances, plant, etc. BCGA also provides advice and makes representations, insofar as these relate to particular problems of the compressed gases industry, on behalf of its Members to all regulatory bodies, including the UK Government, concerning legislation both existing and proposed.

Policy is determined by a Council elected from Member Companies, with detailed technical studies being undertaken by a Technical Committee and its specialist Sub-Committees appointed for this purpose.

Further details of the Association may be obtained from:

**BRITISH COMPRESSED GASES ASSOCIATION**

4a Mallard Way, Pride Park, Derby,

DE24 8GX

Tel 01332 225120

Website : [www.bcg.co.uk](http://www.bcg.co.uk)

