TITLE PAGE

Company name	Easigas	
Contact persons at the company	Rudi van der Westhuizen Lisa Taljaard	
Contact details	Rudi.VanDerWesthuizen@easigas.com Cell: +27 (0)83 567 3389	
Facility or installation name and physical address	Easigas Eveready Road Sidwell; Port Elizabeth	
Geographic location of the installation	S 33.913134; E 25.595363	
Type of risk assessment	Existing installation; 5-year review	X
	Proposed / new installation	
	Existing, modified installation	X
Date of site survey	20 July 2020	
Date of risk assessment	20 July 2020 – 31 August 2020	
Date of report	9 September 2020	
Risk assessor	Dr Alfonso Niemand Nature & Business Alliance Africa (Pty) Ltd	
Contact details of risk assessor	13 Sedona Complex Flora Haase Street; Amorosa; Port Elizabeth PO Box 1753; Strubens Valley; 1735 Tel 083 225 4426 alfonso@natbus-alliance.co.za	
Report reference number	MHI-538/20-2	
Classification of site	MHI	

Nature & Business Alliance Africa (Pty) Ltd
MHI Risk Assessors

MHI-0004

Final Copy – Authorised for Submission to Authorities

CONTROL PAGE

Date of last revision of this report	8 November 2021 Clarified for EIA BAR report
Names of persons present during MHI site survey	Rudi van der Westhuizen
Reference numbers for previous risk assessments of the installation	Unknown

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. Easigas requested a quantitative assessment 5-year review of the MHI risks associated with its LPG installation at Eveready Road, Sidwell, Port Elizabeth. The company also proposes to install a new 400 000-liters bulk LPG tank on the depot premises. Nature & Business Alliance Africa (Pty) Ltd has been appointed for this purpose.
2. The identification of different hazardous installations or materials within the premises are given in the table below:

T1	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	LPG tank storage tanks	1075 68476-85-7	2.1	Tank 1: 90 000 liters Tank 2: 45 000 liters Tank 3: 45 000 liters Tank 4: 45 000 liters Tank 5: 90 000 liters Tank 6 (new): 400 000 liters All tanks 7 barg	-	135 000 liters per week	90 000-liters 49 500-kg
2	LPG road tanker	1075 68476-85-7	2.1	45 000 liters 7 barg	-	135 000 liters per week	45 000 liters 24 750 kg
3	LPG cylinders	1075 68476-85-7	2.1	10 000 cylinders in total 9/19/48-kg range	-	4 000 cylinders per week	48-kg

Risk judgement

1. The risk associated with the operations on this site are judged as follows:

   a) The cumulative individual safety risks for the site is 1.39 E-2 d/p/yr.
   b) Individual risk at the site is higher than tolerable for the public (1.0 E-4 d/p/yr) and for employees (1.0 E-3 d/p/yr) on site.
   c) The individual risk transect indicates that the risks are lower than the norm for employees and the public.
   d) Societal safety risks on this site are acceptably low.

2. The LPG tank installation on the premises comprises an MHI, because a major incident on site would impact on members of the public outside the boundaries of the site e.g. a BLEVE or VCE on the LPG storage tanks or LPG delivery road tanker, respectively.
3. The LPG delivery road tanker comprises an MHI while it is parked on the premises of Easigas. However, this risk is lower than when the road tanker drives in streets as a result of possible collisions with vehicles. Refer to Appendix 8 for societal and individual risk criteria.

4. Domino effects

The following domino effects have been identified for this site:

Trigger	Impact receptor
1. Shrapnel from BLEVE on LPG tank	LPG road tanker
2. Shrapnel from BLEVE on LPG road tanker	LPG storage tank
3. Shrapnel from BLEVE on an LPG cylinder	LPG road tanker LPG storage tank

Risk treatment

1. Risk reduction options including recommended preventative and mitigative measures

   a) The national Chief Inspector of the Department of Employment and Labour must be notified about the status of the proposed LPG installation.
   b) The provincial Chief Inspector of the Department of Employment and Labour must be notified about the status of the proposed LPG installation.
   c) The Fire Department of Nelson Mandela Bay Municipality must be notified about the status of the proposed LPG installation.
   d) An advertisement must be published in a local community newspaper, as follows:

NOTIFICATION OF
MAJOR HAZARD INSTALLATION
EASIGAS, SIDWELL

Notice is hereby given in accordance with Section 3(b) of the Major Hazard Installation Regulations R.692 of 30 July 2001 that an approved inspection authority conducted a major hazard installation risk assessment review on the LPG depot of Easigas at Eveready Road, Sidwell, Port Elizabeth. The risk assessment report can be obtained in electronic format from the following address:

Nature & Business Alliance Africa (Pty) Ltd
Tel 011-958 2132
E-mail: alfonso@yebo.co.za

Interested and affected parties have 60 days from the date of publication of this advertisement to submit comments on the major hazard installation to the Head of the Emergency Services of Nelson Mandela Bay Municipality or to the Provincial Chief Inspector of the Department of Employment and Labour in Eastern Cape.

e) A permanent warning sign must be installed at the entrance to the site, as follows:

f) Ensure that no flammable or explosive liquid or gas is stored in the redundant municipal gas storage tank next to the proposed new 400 000-liter LPG tank.
g) The emergency management plan must be updated when personnel changes or contact details occurs, in accordance with the guidelines given in this report.
h) Operating procedures for the site must be kept up to date to include preventative measures against the uncontrolled release of the following hazardous substances:

- LPG from the delivery road tanker.
- LPG from the storage tank.
- LPG from the cylinder filling platform.

i) The outcome of the risk assessment must be brought to the attention of all the employees at the site.
j) A Maintenance Plan must be compiled and kept up to date for all the hazardous equipment used on the facility. The Plan must contain at least the following:
    - List of all equipment and facilities on the facility.
    - Maintenance frequency.
    - Particulars of maintenance activities that must be performed on the listed equipment.
    - Responsible person.

k) All hazardous equipment and facilities on the facility must be inspected on a regular basis by means of an Inspection Register. The Register must contain at least the following:
    - List of all equipment and facilities on the facility.
    - Equipment items that must be inspected.
    - Facilities that must be inspected.
    - Areas that must be inspected.
    - Inspection findings.
    - Responsible person who carried out the inspection.

l) All authorised operators must be trained in the application of the operating procedures applicable to their jobs.
m) All operating personnel at the facility must be made aware and kept aware of the dangers involving LPG.
n) The facility must remain under safety and security access control for 24 hours per day. The security guard must comply with the following requirements:
    - The guard must be trained in the potential major incidents that could occur at the site as well as the emergency procedure that must be followed.
    - The guard must be linked via SMS or cellular phone with a responsible standby person at the site.
    - The guard must be able to contact the local Fire Department immediately.

o) The Emergency Evacuation Procedure aimed at workers and visitors must be updated at least annually in collaboration with the emergency services of Nelson Mandela Bay Municipality.
p) The LPG delivery road tanker must not reverse on site.
q) The LPG road tanker must be inspected when it comes onto the site, for possible overheated tyres, smell of heated rubber, LPG leaks or other defects that can place the site at risk.
r) The Emergency Management Plan and Emergency Evacuation Procedure must be tested at least once every 12 months by means of mock emergencies. The emergency services of Nelson Mandela Bay Municipality must be invited to participate in these tests.
s) Customer and staff parking bays must be located in an area where public vehicles will not cause obstruction to emergency vehicles.
t) Prior to any construction work on site, the local office of the Department of Employment and Labour must be notified in writing, in accordance with the Construction Regulations of the Department of Employment and Labour.
u) No modifications may be made to the facilities on site unless an MHI risk assessment has been done beforehand.
v) Train all staff in emergency preparedness for an LPG leak, in collaboration with the fire department of Nelson Mandela Bay Municipality.
w) The highest risks at the site are quite manageable, namely a BLEVE on the LPG storage tanks or on the delivery road tanker.
x) Ensure that the nameplates on all LPG storage tanks are clearly visible and legible.
y) Test the deluge systems at the road tanker loading bays at least monthly to ensure that it is in good working order and effective.
z) The site CCTV surveillance system must be inspected regularly to ensure its good functional operation and all employees in the control room must be trained in the use of the system.
aa) Ensure that the windsock on site remains in a good functional state.
bb) The LPG detection and alarm system at the site must be inspected and tested regularly to ensure that it remains in a good working order.

2. Conclusions on ALARP risk mitigation measures

It is recommended that ALARP mitigation measures are applied at this site, as outlined above in this report. The risk criteria in comparison with the site assessment are given in the table below.

Frequency, deaths/person/year		Site assessment
Public		
Intolerable	>1.0 E-4	
Tolerable	1.0 E-4 to 1.0 E-6	
Broadly acceptable	<1.0 E-6	X
Employees		
Intolerable	>1.0 E-3	
Tolerable	1.0 E-3 to 1.0 E-5	
Broadly acceptable	<1.0 E-5	X
Graph of ALARP		
Intolerable		
Tolerable with mitigation (ALARP)		
Acceptably low		X

3. Domino effects

The following domino effects have been identified for this site:

Table 9.2: Potential domino effects

Trigger	Impact receptor
4. Shrapnel from BLEVE on LPG tank	LPG storage tank LPG road tanker
5. Shrapnel from BLEVE on LPG road tanker	LPG storage tank

Land use planning

1. Restricted development distance

The site is located in a predominantly industrial area, which have partly been developed.

2. Plot of three land-use planning zones on a map of the area

Figure 9.1: Land-use planning zones

Key
Red: Inner zone > 10 chances of a major incident per million per annum (1.0 E-5 per year).

Orange: Middle zone > 1 chance of a major incident per million per annum (1.0 E-6 per year).

Yellow: Outer zone > 0.3 chances of a major incident per million per annum (3.0 E-7 per year).

3. Highlighting of possible land-use planning conflicts for new installations

    a) There are no development conflicts for this site at the time of the risk assessment.
    b) If new development around the site is planned, the local authority must take the land-use planning zones in Figure 9.1 into consideration.

Conclusions

1. A total of 24 hazard scenarios have been analysed in this risk assessment.
2. The Occupational Health and Safety Act (Act 85 of 1993) defines a major hazard installation as "*an installation-*
    - *where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily; or*
    - *where any substance is produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident*".

    The Explanatory Notes on the Major Hazard Installation Regulations issued in April 2005 by the Chief Directorate of Occupational Health and Safety of the Department of Employment and Labour explains the following:

    "*What is important here is to know that there are two reasons that can determine when an installation is a major hazard installation (MHI). The first reason is when there is more than the prescribed quantity of a substance. The quantities and type of substances are prescribed in the General Machinery Regulation 8 and its Schedule A, on notifiable substances. The second reason is where substances are produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident. The important issue is the potential of an incident and not whether the incident is a major incident or not. The potential will be determined by the risk assessment.*

    A major incident means an occurrence of catastrophic proportions, resulting from the use of plant or machinery, or from activities at a workplace.
    It is impossible to put a specific value to "catastrophic" because it will always differ from person to person and from place to place. However, when the outcome of a risk assessment indicates that there is a possibility that the public will be involved in an incident, then the incident can be seen as catastrophic".

3. The facility is classified as a major hazard installation, because a major incident at the site will impact members of the public outside the boundaries of the premises.
4. There are no development conflicts for this site.
5. To the best knowledge of the risk assessor there are no major hazard installation within reach of the worst-case major incident that can occur at this site.
6. If new development around the site is planned, the local authority must take the land-use planning zones in Figure 9.1 into consideration.

TABLE OF APPENDICES

TABLE OF ACRONYMS AND DEFINITIONS

AIChE	American Institute of Chemical Engineers, USA
AIHA	American Industrial Hygiene Association
ALARP	As low as reasonably practicable
ALOHA	Areal Locations of Hazardous Atmospheres
Baseline risk assessment	A quantitative assessment of the safety risks associated with a particular major hazard installation, irrespective of the organisational mitigation measures implemented at the installation.
BEVI	Netherlands: *Besluit externe veiligheid inrichtingen* (Decree on safety of devices)
BLEVE	Boiling liquid expanding vapour explosion
BP	Boiling point
CASRN	Chemical abstracts service registry number
CCPS	Centre for Chemical Process Safety, USA
CCTV	Closed circuit television
CFD	Computational fluid dynamics
d/p/yr	Deaths per person per year (individual risk measure)
EIA	Environmental impact assessment
EPA	Environmental Protection Agency, USA
ERPG-1	values estimate the concentrations at which most people will begin to experience health effects if they are exposed to a hazardous airborne chemical for 1 hour. Sensitive members of the public—such as old, sick, or very young people—aren't covered by these guidelines and they may experience adverse effects at concentrations below the values. A chemical may have up to three ERPG values, each of which corresponds to a specific tier of health effects. It is developed by the American Industrial Hygiene Association is used by the US National Oceanic and Atmospheric Administration ERPG-1 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing more than mild, transient adverse health effects or without perceiving a clearly defined objectionable odor.
ERPG-2	ERPG-2 is the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without

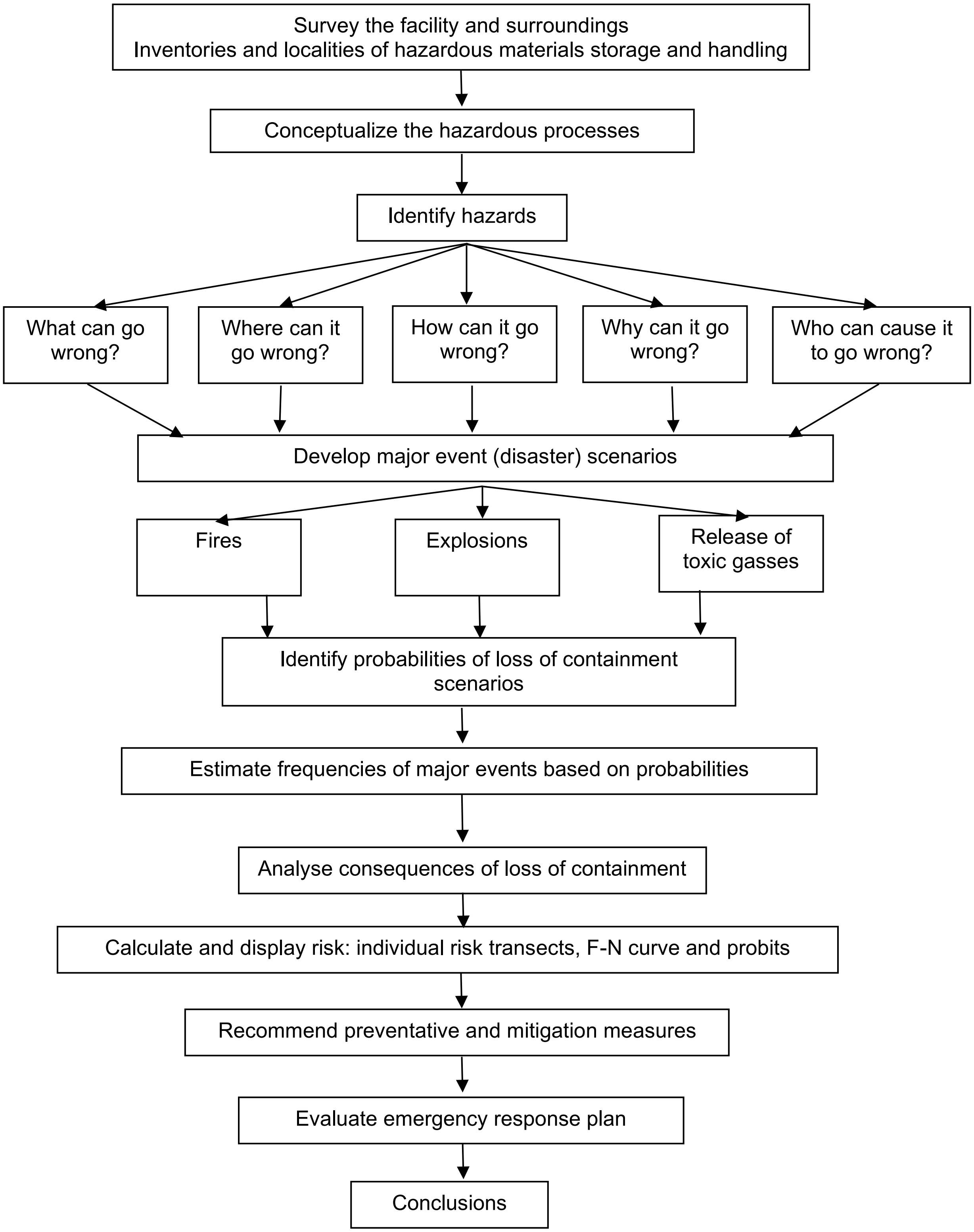
	experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.
ERPG-3	ERPG-3 is the most serious maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.
Event	An occurrence (a condition or situation) that is caused by a fault and that can trigger a major incident. This is best explained by means of an example: A leak in a storage tank that contains a flammable liquid is an event. The leak was caused by corrosion (the fault). If the leaking liquid is set alight, a fire will start, which would be a major incident, because it can cause injury or death due to thermal radiation or an explosion.
FMECA	Failure mode effect and criticality analysis
FP	Flash point
HAZAN	Hazard analysis
HAZID	Hazard identification
Human impact	The effect that a major incident could have on human beings, whether they are present inside the facility or whether they are present beyond the facility boundaries within the surrounding community, including minor injury, major injury and fatality and the destructive effect on assets.
HFO	Heavy fuel oil or heavy furnace oil
IBC	Intermediate bulk container
IR	Individual risk
ERPG	Immediately dangerous to life or health. It is defined by the US National Institute for Occupational Safety and Health as exposure to airborne contaminants that is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment.
IZ	Inner zone
LFO	Light fuel oil
LOC	Loss of containment
LOPA	Layer of protection analysis
LPG	Liquefied petroleum gas

Major incident	An occurrence of catastrophic proportions, resulting from the use of facility or machinery, or from activities at a work place. A "catastrophic occurrence" is interpreted [28] as an occurrence (incident), which can be fatal, disastrous, of definite threat to the health and lives of employees and members of the public. It is important to note that human lives (injury, fatal or not) as well as assets (damage) are included in this definition.
MHI	Major hazard installation
MOP	Mean operating pressure
MZ	Middle zone
NIOSH	US National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration, USA
OHS Act	Occupational Health and Safety Act, 1993 (Act 85 of 1993)
OZ	Outer zone
PAC	Protective action criteria. These are essential components for planning and response to uncontrolled releases of hazardous chemicals. These criteria, combined with estimates of exposure, provide the information necessary to evaluate chemical release events for the purpose of taking appropriate protective actions to save lives. PAC values are inter alia based on the exposure limit values.
PADHI	Planning advice for developments near hazardous installations
Probit function	Mathematical probability unit function. The probit function is a statistical analysis method based on a binary response, such as death or no death, as a result of a specified threatening major incident. It is used, inter alia, for the modelling of major incidents that can cause human fatalities and is usually based on a linear probability regression estimate (probit) equation.
PRV	Pressure relieve valve
PSM	Process safety management
QRA	Quantitative risk assessment
Residual risk assessment	A quantitative assessment of the safety risks associated with a particular major hazard installation, after successful implementation of all organisational mitigation measures, assuming that these measures are infallible.

SANAS	South African National Accreditation System
SLOD	Significant likelihood of death
SLOT	Specified level of toxicity
TNT	Trinitrotoluene
UK HSE	United Kingdom's Health and Safety Executive
VCE	Vapour cloud explosion
Zones	Zones in this report refer to the various safety distances from a major hazard installation and are classified as inner zone, middle zone, and outer zone. These zone classifications are used by the local authority to advise against or don't advise against a particular new development that is planned near an existing major hazard installation.

1 Introduction

1. The following quantitative risk assessment algorithm was followed:



2. This risk assessment focuses on the requirements of the Major Hazard Installation Regulations R.692 of 30 July 2001 issued in terms of the Occupational Health and Safety Act (Act No 85 of 1993) and SABS Standard SANS 1461:2018 Edition 1.

3. The risk assessment does not address the following aspects:

    - The storage and use of radioactive materials. The National Nuclear Regulatory Act (Act No 47 of 1999) governs this aspect.
    - The environmental impacts that the facility, or part of it, could have on the biophysical and socio-economic environment. The National Environmental Management Act, 1998 (Act No 107 of 1998) and the related EIA regulations govern this aspect.
    - Future development of residential, commercial, industrial or recreational areas around the site.
    - Future modifications that may be made to the existing redundant pipeline and related equipment.

4. Scope of the risk assessment: This major hazard installation risk assessment has been conducted against the requirements of the following legal prescriptions:

    - The Major Hazard Installation (MHI) Regulations of 2001 under the Occupational Health and Safety Act, 1993 (Act 85 of 1993).
    - South African Bureau of Standards 1461:2018 Edition 1, Major Hazard installation – Risk Assessments.
    - The following hazardous materials are included in this risk assessment:

T1	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	LPG tank storage tanks	1075 68476-85-7	2.1	Tank 1: 90 000 liters Tank 2: 45 000 liters Tank 3: 45 000 liters Tank 4: 45 000 liters Tank 5: 90 000 liters Tank 6 (new): 400 000 liters All tanks 7 barg	-	135 000 liters per week	90 000-liters 49 500-kg
2	LPG road tanker	1075 68476-85-7	2.1	45 000 liters 7 barg	-	135 000 liters per week	45 000 liters 24 750 kg
3	LPG cylinders	1075 68476-85-7	2.1	10 000 cylinders in total 9/19/48-kg range	-	4 000 cylinders per week	48-kg

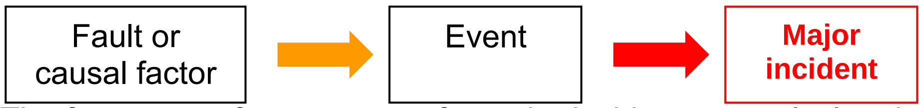
5. Legal aspects:

    a) Nature & Business Alliance Africa (Pty) Ltd conducts its risk assessments in accordance with a quality manual that complies with the requirements of the ISO/IEC-17020 Standards for Various Bodies Performing Inspections. Nature & Business Alliance Africa (Pty) Ltd is accredited by the South African National Accreditation System (SANAS) as a Type A Major Hazard Risk Installation Inspection Body (accreditation number MHI-0004).

b) Nature & Business Alliance Africa (Pty) Ltd is registered by the Department of Employment and Labour as an Approved Inspection Authority (AIA) for toxic, flammable, and explosive substances (registration number MHI-0002).
c) This risk assessment specifically pertains to the facilities assessed in this report. Modifications or alterations made to the site, equipment, facilities or operating procedures and parameters after completion of this risk assessment are not covered by the assessment outcomes and are explicitly excluded. Nature & Business Alliance Africa (Pty) Ltd will not be liable for damage to any assets, injury to any persons or the death of any person as a direct result of the activities of the client or the client's subcontractors, before, during and after the requested risk assessment has been conducted.
d) The risk assessment conducted by Nature & Business Alliance Africa (Pty) Ltd and the related findings are based on the circumstances, external factors and conditions that prevailed at the time when the study was conducted.
e) The risk assessment, related reports and all recommendations must not be interpreted as automatic safeguards against an incident that could lead to damage, injury or death and Nature & Business Alliance Africa (Pty) Ltd does not accept liability for such damage, injury or death.
f) Nature & Business Alliance Africa (Pty) Ltd retain copyright of this report. No part of the report may be copied or reproduced in any format without written approval from the author. If any part of the report is to be used for other work by another party, clear reference must be made to Nature & Business Alliance Africa (Pty) Ltd as the owner and copyright holder of the report.
g) It is declared that Nature & Business Alliance Africa (Pty) Ltd did not allow any form of external influencing of this assessment results, conclusions and recommendations, including undue time constraints imposed on the author, bribery, incentives offered to personnel and alterations made to this report. The submission of any draft report to the client does not grant the client the opportunity or the right to alter the findings, conclusions or recommendations in its favour in any way, without sound substantiation.
h) Nature & Business Alliance Africa (Pty) Ltd and Alfonso Niemand (the author) in particular, declare that the organization and its personnel are not related to the client or to its employees or contractors for this assignment. It is declared that the risk assessment report and the findings are unbiased and was not influenced by any commercial, financial or other pressures imposed on the organization or the author.
i) All information disclosed to us by the client or its contractors, are treated as confidential. The information contained in this study report will also be treated as confidential and will not be disclosed by the author to any party other than the client.
j) This report is valid for a period of 5 years, in accordance with the Major Hazard Installation Regulations, 2001.

6. Methodologies used:

a) Causal analysis and international failure data (BEVI and AIChE) were applied to determine the frequency of an event (fault) that could eventually lead to a major incident.
b) An event-tree analysis method was applied to determine the potential major incidents that could be the end result of the event, with its frequency. The logic is explained as follows:



c) The frequency of occurrence of a major incident was calculated, based on analysis of international historical data for similar incidents. Similar data does not exist for South African industry.
d) The toxicity, flammability and explosivity potential of liquid and gas releases were evaluated by means of internationally accepted mathematical modeling techniques [1, 2, 3 and 18].
e) Toxic releases were modeled by means of the ALOHA mathematical dispersion model [3] of the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) of the USA.
f) Heat radiation flux caused by a fire was simulated by means of the equations proposed by *Mudan* and *Groce* [1, p243].
g) The overpressure blast effects of vapour cloud explosions and solid explosions were simulated by means of the trinitrotoluene (TNT) equivalency methods described by *Baker et al, Decker, Lees* and *Stull* [1, p174].
h) Meteorological tendencies at the site were taken into consideration.
i) Individual and societal risks were assessed, based on the frequencies of major incidents, minimum safety distances and the predicted number of potential fatalities.
j) The occurrence and effect of a boiling liquid expanding vapour explosion (BLEVE) was modeled based on work done by the Centre for Chemical Process Safety of the American Institute of Chemical Engineers.
k) The frequency of occurrence of a major incident was calculated based on analysis of international historical data for similar incidents in Europe and the USA. Similar data does not exist for South African industry.

2 Descriptions

a) <u>Company's main activities and products</u>

Easigas has existing LPG bulk storage tanks and cylinder filling facilities at Eveready Road, Sidwell, Port Elizabeth. They propose to expand the operations by the installation of a further 400 000-liters LPG bulk storage tank.

b) <u>Non-technical process description</u>

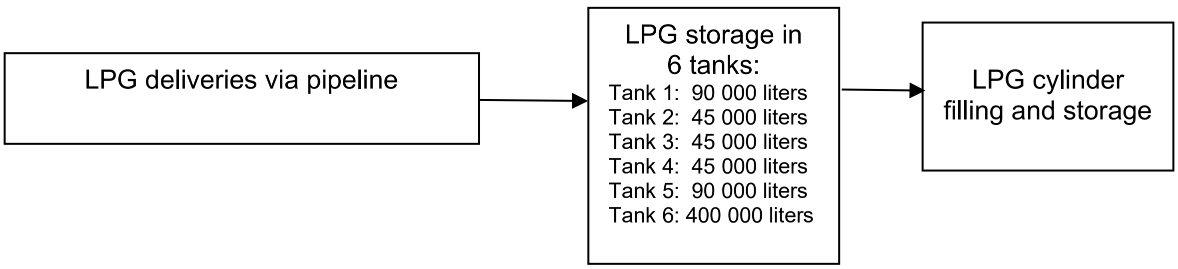


Figure 2.1: Conceptual process description

Table 2.1: Hazardous material inventory

T1	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	LPG tank storage tanks	1075 68476-85-7	2.1	Tank 1: 90 000 liters Tank 2: 45 000 liters Tank 3: 45 000 liters Tank 4: 45 000 liters Tank 5: 90 000 liters Tank 6 (new): 400 000 liters All tanks 7 barg	-	135 000 liters per week	90 000-liters 49 500-kg
2	LPG road tanker	1075 68476-85-7	2.1	45 000 liters 7 barg	-	135 000 liters per week	45 000 liters 24 750 kg
3	LPG cylinders	1075 68476-85-7	2.1	10 000 cylinders in total 9/19/48-kg range	-	4 000 cylinders per week	48-kg

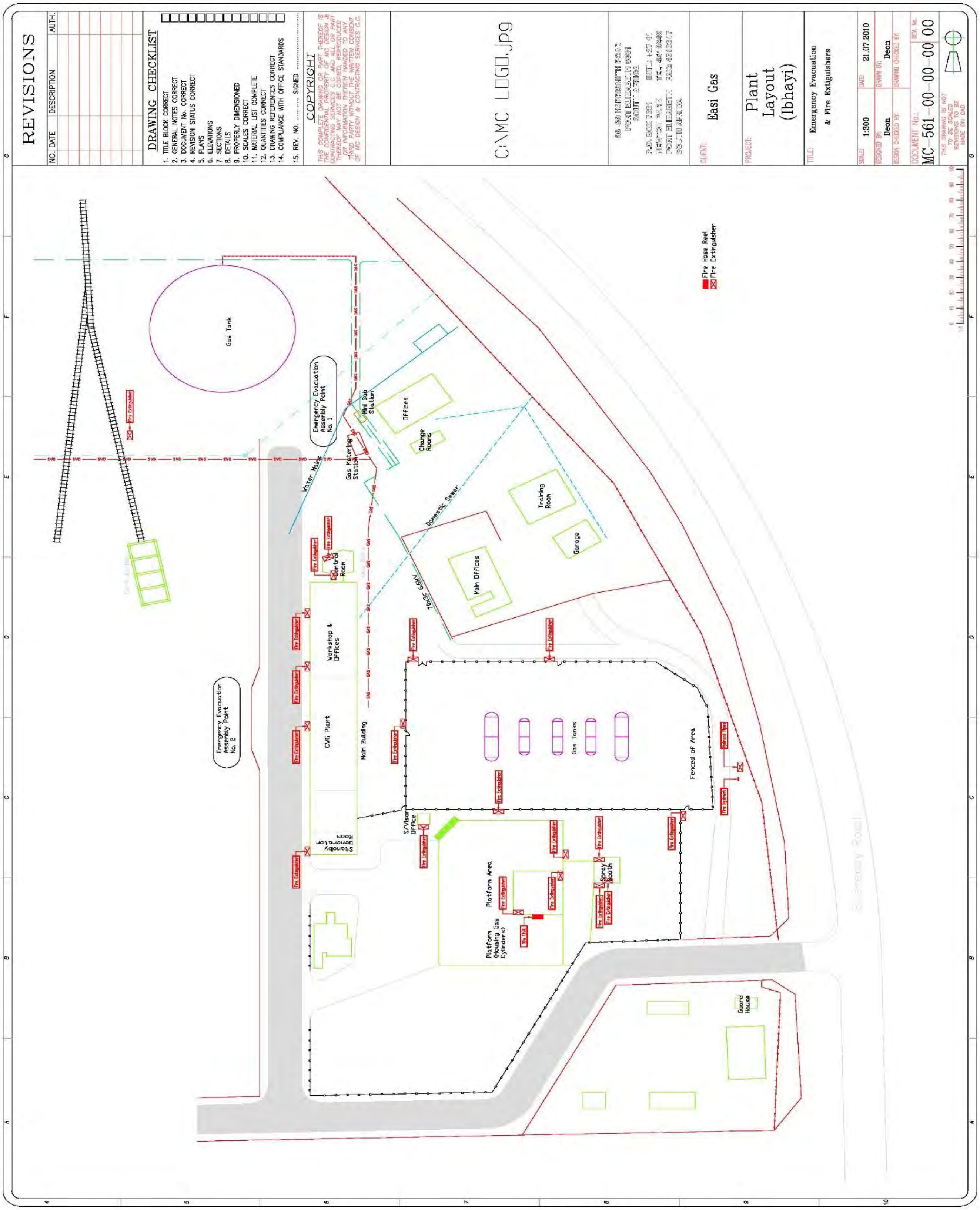


Figure 2.1: Site layout plan

Figure 2.2: Aerial view of the site

c) <u>Details of neighbouring facilities including other hazardous installations in the vicinity, sources of additional risk (for example, flight paths, natural hazards) and vulnerable developments/sensitive receptors</u>

No	Adjacent facility	Distance from site, m	MHI status of neighbours
1	Eveready Batteries	130	Not MHI
2	N2 freeway	165	Not MHI
3	Traffic and Licensing Services Local Authority	385	Not MHI
4	Medium-density residential	345	Not MHI
5	High-density residential	520	Not MHI
6	Aqua Marine Container Depot	510	Not MHI

Figure 2.3: Aerial view of adjacent facilities

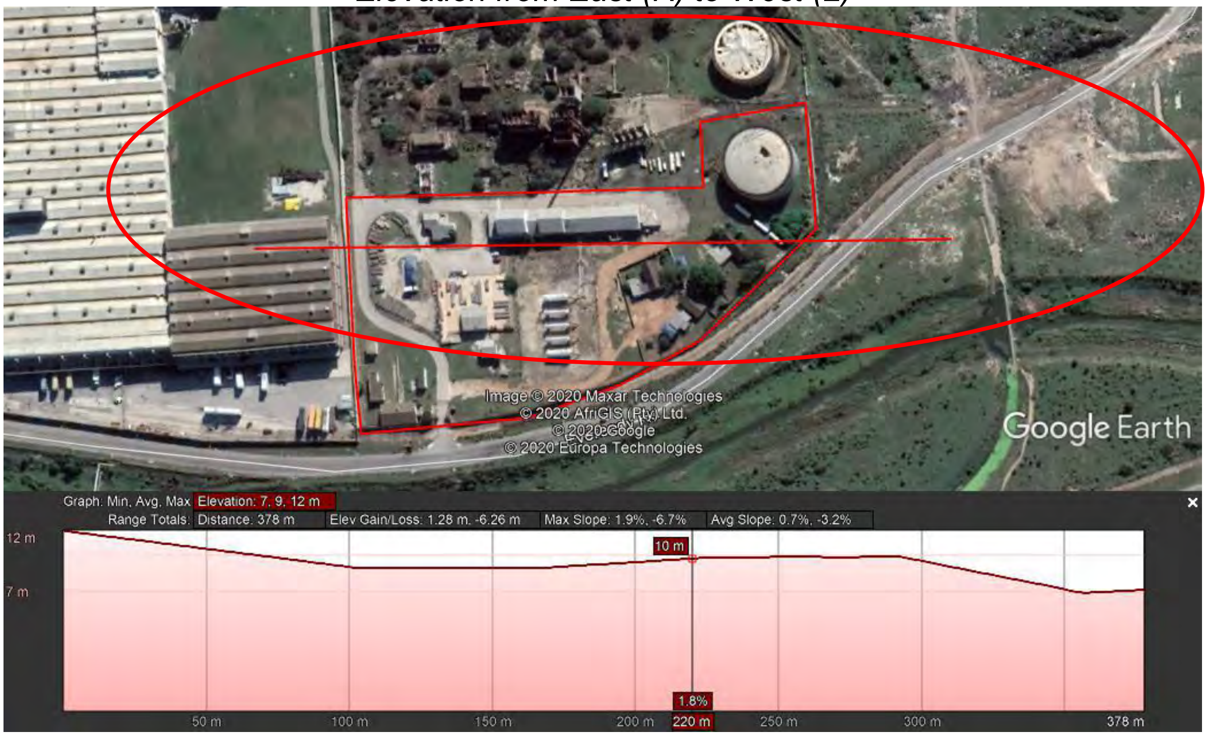
d) Relevant local meteorology

SA Weather station	Wind direction	Wind speed m/s	Wind calm %	Precipitation mm	Cloud cover %	Ambient temperature ^0C
P ort Elizabeth	SW	11	20	1 100	50	16-18

Lightning: 1 to 2 strikes per square kilometer (10^6 m^2) per year.

e) <u>Relevant topography of the area</u> (*red ovals indicate qualitatively where heavy gas and smoke may settle during wind-still times; not to scale)*

Elevation from East (R) to West (L)



Elevation from North (L) to South (R)

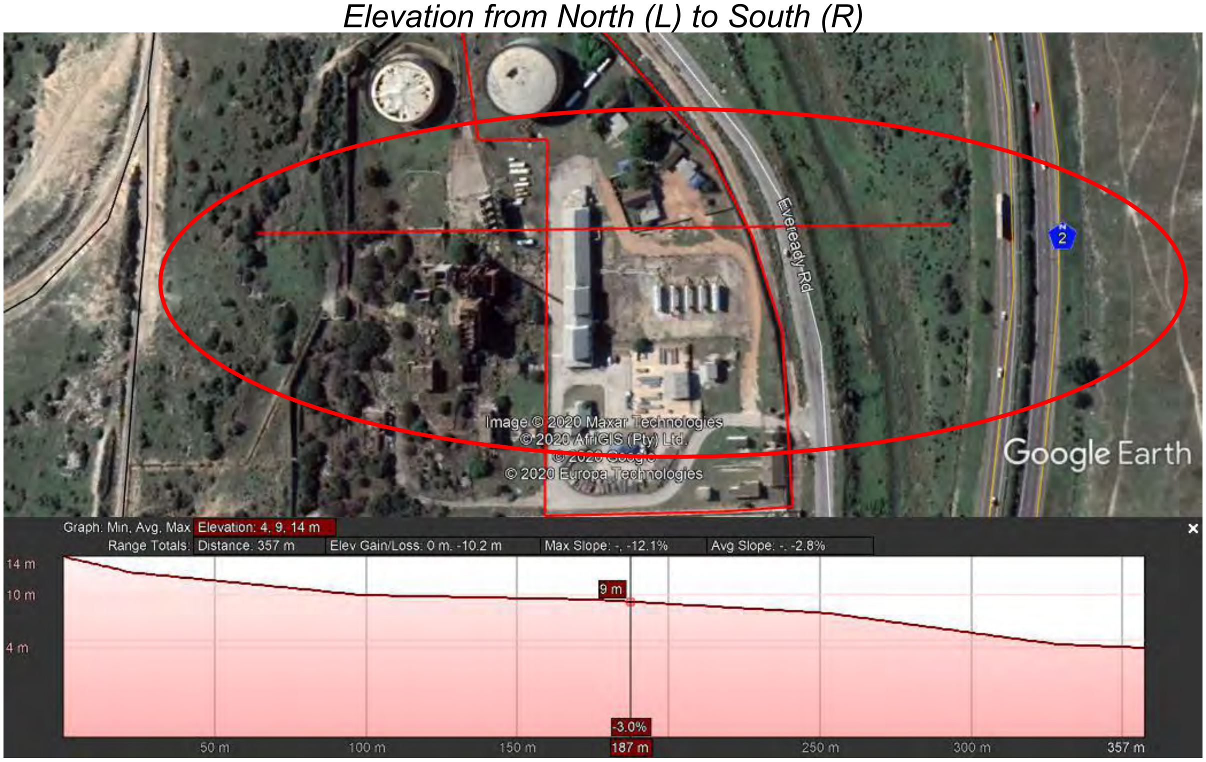


Figure 2.4: Topography of the site

3 Hazard identification

1. <u>Inventory of hazardous materials on site</u>: (Name, UN/CASRN number, inventories, through-put (or batches) and maximum release quantities, SANS 10228 category)

Table 3.1: Hazardous material inventory

T1	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	LPG tank storage tanks	1075 68476-85-7	2.1	Tank 1: 90 000 liters Tank 2: 45 000 liters Tank 3: 45 000 liters Tank 4: 45 000 liters Tank 5: 90 000 liters Tank 6 (new): 400 000 liters All tanks 7 barg	-	135 000 liters per week	90 000-liters 49 500-kg
2	LPG road tanker	1075 68476-85-7	2.1	45 000 liters 7 barg	-	135 000 liters per week	45 000 liters 24 750 kg
3	LPG cylinders	1075 68476-85-7	2.1	10 000 cylinders in total 9/19/48-kg range	-	4 000 cylinders per week	48-kg

2. <u>The relevant physical, chemical and toxicological characteristics of the materials, mixtures, reactions; both under normal and foreseeable abnormal conditions</u>

Table 3.2: Characteristics of the hazardous materials

Item	Name	Characteristics
1	LPG	• Jet fire • BLEVE • VCE

3. <u>Key reactions especially any exothermic reactions or reactive chemicals</u>

None.

4. <u>License restrictions (for example, flammables)</u>

LPG is notifiable to the local Emergency Services who must issue a certificate for it.

5. <u>Significant accidents and incidents that have occurred at the installation with lessons learned and measures implemented to prevent re-occurrence</u>

None recorded.

6. <u>Major accidents and incidents at related facilities or with related materials (case study)</u>

Refer to Appendix 2.

7. <u>Containment systems for analysis (major equipment considering control systems and blocking systems)</u>

    - Each LPG storage tank is equipped with an overpressure relief valve.
    - Each LPG storage tank is equipped with an emergency shut-off switch.
    - Each LPG storage tank is equipped with an independent emergency shut-off valve.
    - Each LPG tank is installed in a well-ventilated structure to prevent the accumulation of gas in case of a leak.
    - Emergency LPG shut-off valves are located outside the LPG storage area and at the filling platform.
    - Flammable materials such as wooden pallets are not stored near the LPG tanks.
    - All LPG cylinders are equipped with leakproof valves.
    - The LPG storage tanks are equipped with pneumatically actuated deluge systems.
    - The cylinder filling platform is equipped with a pneumatically actuated deluge system.

8. <u>Description of safety systems, equipment and devices used for prevention and mitigation of major incidents</u>

    - Each LPG storage tank is equipped with an overpressure relief valve.
    - Each LPG storage tank is equipped with an emergency shut-off switch.
    - Each LPG storage tank is equipped with an independent emergency shut-off valve.
    - Each LPG tank is installed in a well-ventilated structure to prevent the accumulation of gas in case of a leak.
    - Emergency LPG shut-off valves are located outside the LPG storage area and at the filling platform.
    - Flammable materials such as wooden pallets are not stored near the LPG tanks.
    - All LPG cylinders are equipped with leakproof valves.
    - The LPG storage tanks are equipped with pneumatically actuated deluge systems.
    - The cylinder filling platform is equipped with a pneumatically actuated deluge system.

4 Hazard analysis

a) Scenarios to be modelled for each containment system

The minimum scenarios to be identified and modelled are listed in Table 4.1 below, in accordance with SANS 1461:

Table 4.1: Mandatory minimum scenarios to be modelled

Equipment type	***Scenario***
A *Fixed storage or processing units classified as pressure vessels (for example, reactors, storage spheres) and pressurized transport units (for example, pressurized road tankers, cylinders)*	*1) Catastrophic rupture with instantaneous failure (including a boiling liquid expanding vapour explosion (BLEVE where applicable).* *2) Entire contents released in 10 min or large hole in the processing unit (a large hole is typically the size of the largest appurtenance on the processing unit).* *3) Small hole in vessel (leak typically 10 mm diameter).* *4) Pressure safety valve release (if applicable).*
B *Fixed storage or processing units at atmospheric pressure or lower (for example, tanks, blending vessels) and atmospheric transport units (for example, standard road tankers, intermediate bulk containers (IBCs)*	*1) Catastrophic rupture (with bund overtopping if necessary).* *2) Entire contents released in 10 min or large hole in the processing unit (a large hole is typically the size of the largest appurtenance on the processing unit).* *3) Small hole in vessel (leak typically 10 mm diameter).* *4) Overfilling (if applicable).*
C *Pipe, hose, arm (onsite pipelines)*	*1) Pipeline, hose, arm full bore rupture.* *2) Small hole in pipeline, hose, arm (typically a leak with effective diameter of 10 % to 50 % of the pipeline diameter).*
D *Pipe (cross country pipelines) (refer also to Clause 7 of this standard)*	*1) Pipeline full bore rupture.* *2) Small hole in pipeline (leak as in accordance with Clause 5).*
NOTE *If the scenarios given in this table are not in the risk assessment, justification for their exclusion should be provided in the assessment report.*	

The hazard scenarios applicable to this site are as follows:

Table 4.2: Hazard scenarios analysed in this assessment

1	BLEVE on LPG tank; 37.5 kW/m2	Thermal
2	BLEVE on LPG tank; 12.5 kW/m2	Thermal
3	VCE from full LPG tank; 5 psi	Overpressure
4	VCE from full LPG tank; 2 psi	Overpressure
5	Jet fire on LPG tank; 50 mm hole; 37.5 kW/m2	Thermal
6	Jet fire on LPG tank; 50 mm hole; 12.5 kW/m2	Thermal
7	Jet fire on LPG tank; 10 mm hole; 37.5 kW/m2	Thermal
8	Jet fire on LPG tank; 10 mm hole; 12.5 kW/m2	Thermal
9	BLEVE on LPG road tanker; 37.5 kW/m2	Thermal
10	BLEVE on LPG road tanker; 12.5 kW/m2	Thermal
11	VCE from full LPG road tanker; 5 psi	Overpressure
12	VCE from full LPG road tanker; 2 psi	Overpressure
13	Jet fire on LPG road tanker; 50 mm hole; 37.5 kW/m2	Thermal
14	Jet fire on LPG road tanker; 50 mm hole; 12.5 kW/m2	Thermal
15	Jet fire on LPG road tanker; 10 mm hole; 37.5 kW/m2	Thermal
16	Jet fire on LPG road tanker; 10 mm hole; 12.5 kW/m2	Thermal
17	BLEVE on 48-kg LPG cylinder; 37,5 kW/m2	Thermal
18	BLEVE on 48-kg LPG cylinder; 12,5 kW/m2	Thermal
19	VCE from full 48-kg LPG cylinder; 5 psi	Overpressure
20	VCE from full 48-kg LPG cylinder; 2 psi	Overpressure
21	Jet fire from 48-kg LPG cylinder; 50-mm hole; 5 psi	Thermal
22	Jet fire from 48-kg LPG cylinder; 50-mm hole; 2 psi	Thermal
23	Jet fire from 48-kg LPG cylinder; 10-mm hole; 5 psi	Thermal
24	Jet fire from 48-kg LPG cylinder; 10-mm hole; 2 psi	Thermal

b) <u>Description of specific postulated causes for the various major hazard scenarios or groups of scenarios</u>

- <u>LPG storage tank</u>
    - Mechanical damage to the tank or pipe work.
    - Workers not trained in the operation of the tank, pump, valves, and filler pipe.
    - Poor maintenance of the tank such as corrosion protection, flange integrity, valve integrity, pump and seal and pipe integrity.
    - Degradation of the tank from internal and external corrosion and negligence with regard to tanker inspections.
    - Human error with regard to maintenance or operation.
    - Operation of equipment beyond design parameters such as overfilling of the tank.

- <u>LPG road tanker</u>
    - Mechanical damage to the tanker or pipe work.

- Workers not trained in the operation of the delivery tanker, pump, valves and filler pipe.
- Poor maintenance of the tanker such as corrosion protection, flange integrity, valve integrity, pump and seal and pipe integrity.
- Degradation of the tanker from internal and external corrosion and negligence with regard to tanker inspections.
- Human error with regard to maintenance or operation.
- Operation of equipment beyond design parameters such as overfilling of the road tanker at the supply depot.
- Road tanker collisions on site with other vehicles or stationary objects.

- LPG cylinders

  - Mechanical damage to the cylinder.
  - Workers not trained in the operation of the cylinders, pump, valves, and filler pipe.
  - Poor maintenance of the cylinders such as corrosion protection, valve integrity, and seal integrity.
  - Degradation of the cylinder from internal and external corrosion and negligence with regard to inspections.
  - Human error with regard to maintenance or operation.
  - Operation of equipment beyond design parameters such as overfilling of the cylinder.

5 Consequence analysis

Table 5.1: Hazardous material inventory

1. Indication of scenarios for consequence analysis and those included in the calculation of risk

Table 5.2: Consequence scenarios that were modelled

1	BLEVE on LPG tank; 37.5 kW/m2	Thermal
2	BLEVE on LPG tank; 12.5 kW/m2	Thermal
3	VCE from full LPG tank; 5 psi	Overpressure
4	VCE from full LPG tank; 2 psi	Overpressure
5	Jet fire on LPG tank; 50 mm hole; 37.5 kW/m2	Thermal
6	Jet fire on LPG tank; 50 mm hole; 12.5 kW/m2	Thermal
7	Jet fire on LPG tank; 10 mm hole; 37.5 kW/m2	Thermal
8	Jet fire on LPG tank; 10 mm hole; 12.5 kW/m2	Thermal
9	BLEVE on LPG road tanker; 37.5 kW/m2	Thermal
10	BLEVE on LPG road tanker; 12.5 kW/m2	Thermal
11	VCE from full LPG road tanker; 5 psi	Overpressure
12	VCE from full LPG road tanker; 2 psi	Overpressure
13	Jet fire on LPG road tanker; 50 mm hole; 37.5 kW/m2	Thermal
14	Jet fire on LPG road tanker; 50 mm hole; 12.5 kW/m2	Thermal
15	Jet fire on LPG road tanker; 10 mm hole; 37.5 kW/m2	Thermal
16	Jet fire on LPG road tanker; 10 mm hole; 12.5 kW/m2	Thermal
17	BLEVE on 48-kg LPG cylinder; 37,5 kW/m2	Thermal
18	BLEVE on 48-kg LPG cylinder; 12,5 kW/m2	Thermal
19	VCE from full 48-kg LPG cylinder; 5 psi	Overpressure
20	VCE from full 48-kg LPG cylinder; 2 psi	Overpressure
21	Jet fire from 48-kg LPG cylinder; 50-mm hole; 5 psi	Thermal
22	Jet fire from 48-kg LPG cylinder; 50-mm hole; 2 psi	Thermal
23	Jet fire from 48-kg LPG cylinder; 10-mm hole; 5 psi	Thermal
24	Jet fire from 48-kg LPG cylinder; 10-mm hole; 2 psi	Thermal

2. Consequences modelled

a) BLEVE on LPG tank; 37.5 kW/m2; 400 000 liters

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.27: BLEVE Thermal Flux

Input Data:			
Density of liquid gas	0,55	kg/l	
Initial flammable mass:	220000	kg	> 30,000
Water partial pressure in air:	2810	Pascal	
Radiation Fraction, R	0,3		
Distance from fireball center on ground:	276	m	
Heat of Combustion of fuel:	50368	kJ/kg	
Volume of liquid gas	400000	liters	

Calculated Results:		
Maximum fireball diameter:	350,1	m
Fireball combustion duration:	20,2	s
Center height of fireball:	262,6	m
Initial ground level hemisphere diameter:	455,2	m
Surface emitted flux:	427,5	kW/m**2
Path length:	205,9	
Transmissivity:	0,612	

	Horizontal	Vertical	
View Factor:	0,15	0,15	
Received flux:	38,08	40,02	kW/m**2

b) BLEVE on LPG tank; 12.5 kW/m2; 400 000 liters

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.27: BLEVE Thermal Flux

Input Data:			
Density of liquid gas	0,55	kg/l	
Initial flammable mass:	220000	kg	> 30,000
Water partial pressure in air:	2810	Pascal	
Radiation Fraction, R	0,3		
Distance from fireball center on ground:	470	m	
Heat of Combustion of fuel:	50368	kJ/kg	
Volume of liquid gas	400000	liters	

Calculated Results:		
Maximum fireball diameter:	350,1	m
Fireball combustion duration:	20,2	s
Center height of fireball:	262,6	m
Initial ground level hemisphere diameter:	455,2	m
Surface emitted flux:	427,5	kW/m**2
Path length:	363,3	
Transmissivity:	0,581	

	Horizontal	Vertical	
View Factor:	0,05	0,09	
Received flux:	12,82	22,95	kW/m**2

Final Copy – Authorised for Submission to Authorities

c) VCE from full LPG tank; 5 psi; 400 000 liters

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0,03	%
Mass of gas	220000	kg
Higher heating value of gas	50368	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	400000	liters
Equivalent TNT mass	71459	kg
Density of liquid:	0,55	kg/l

Input Data:

TNT Mass:	71459	kg
Distance from blast:	235	m

Calculated Results:

Scaled distance, z:	5,6630	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,80251	
Overpressure:	34,92	kPa
	5,066109	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0,13452	
Impulse:	52,97365	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0,92808	
Duration:	3,966511	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,835156	
Arrival time:	9,949	ms

d) VCE from full LPG tank; 2 psi; 400 000 liters

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0,03	%
Mass of gas	220000	kg
Higher heating value of gas	50368	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	400000	liters
Equivalent TNT mass	71459	kg
Density of liquid:	0,55	kg/l

Input Data:

TNT Mass:	71459	kg
Distance from blast:	430	m

Calculated Results:

Scaled distance, z:	10,3621	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1,156841	
Overpressure:	14,10	kPa
	2,045991	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,497074	
Impulse:	29,96564	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0,01926	
Duration:	4,842946	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1,196703	
Arrival time:	22,631	ms

e) Jet fire on LPG tank; 50 mm hole; 37.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	9	m
Hole diameter:	50	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	0,001963	m**2
Gas discharge rate:	3,886	kg/s
L/d ratio for flame:	126,1	
Flame height:	6,30	m
Location of flame centre above ground:	3,65	
Radiation path length:	9,71	m
Point source view factor:	0,000844	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,848	

Flux at receptor location:	42,02	kW/m**2

f) Jet fire on LPG tank; 50 mm hole; 12.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	17	m
Hole diameter:	50	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	0,001963	m**2
Gas discharge rate:	3,886	kg/s
L/d ratio for flame:	126,1	
Flame height:	6,30	m
Location of flame centre above ground:	3,65	
Radiation path length:	17,39	m
Point source view factor:	0,000263	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,805	

Flux at receptor location:	12,44	kW/m**2

g) Jet fire on LPG tank; 10 mm hole; 37.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:

Distance from flame:	2	m
Hole diameter:	10	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:

Area of hole:	7,85E-05	m**2
Gas discharge rate:	0,155	kg/s
L/d ratio for flame:	126,1	
Flame height:	1,26	m
Location of flame centre above ground:	1,13	
Radiation path length:	2,30	m
Point source view factor:	0,015079	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,966	

Flux at receptor location:	34,21	kW/m**2

h) Jet fire on LPG tank; 10 mm hole; 12.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	4	m
Hole diameter:	10	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	7,85E-05	m**2
Gas discharge rate:	0,155	kg/s
L/d ratio for flame:	126,1	
Flame height:	1,26	m
Location of flame centre above ground:	1,13	
Radiation path length:	4,16	m
Point source view factor:	0,004606	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,916	

Flux at receptor location:	9,91	kW/m**2

Final Copy – Authorised for Submission to Authorities

i) BLEVE on LPG road tanker; 37.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.27: BLEVE Thermal Flux

Input Data:

Initial flammable mass:	45000	Liters	
Initial flammable mass:	24750	kg	<30 000
Water partial pressure in air:	2810	Pascal	
Radiation Fraction, R	0,3		
Distance from fireball centre on ground:	115	m	
Heat of Combustion of fuel:	50368	kJ/kg	
Density of liquid:	0,55	kg/l	

Calculated Results:

Maximum fireball diameter:	169,0	m
Fireball combustion duration:	13,1	s
Centre height of fireball:	126,8	m
Initial ground level hemisphere diameter:	219,7	m
Surface emitted flux:	317,9	kW/m**2
Path length:	86,6	
Transmissivity:	0,662	
Surface area of emitter	151746,1	m2

	Horizontal	Vertical	
View Factor:	0,18	0,16	
Received flux:	37,98	34,45	kW/m**2

j) BLEVE on LPG road tanker; 12.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.27: BLEVE Thermal Flux

Input Data:

Initial flammable mass:	45000	Liters	
Initial flammable mass:	24750	kg	<30 000
Water partial pressure in air:	2810	Pascal	
Radiation Fraction, R	0,3		
Distance from fireball centre on ground:	208	m	
Heat of Combustion of fuel:	50368	kJ/kg	
Density of liquid:	0,55	kg/l	

Calculated Results:

Maximum fireball diameter:	169,0	m
Fireball combustion duration:	13,1	s
Centre height of fireball:	126,8	m
Initial ground level hemisphere diameter:	219,7	m
Surface emitted flux:	317,9	kW/m**2
Path length:	159,1	
Transmissivity:	0,626	
Surface area of emitter	151746,1	m2

	Horizontal	Vertical	
View Factor:	0,06	0,10	
Received flux:	12,47	20,47	kW/m**2

k) VCE from full LPG road tanker; 5 psi

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0,03	%
Mass of gas	24750	kg
Higher heating value of gas	50368	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	45000	liters
Equivalent TNT mass	8039	kg
Density of liquid:	0,55	kg/l

Input Data:

TNT Mass:	8039	kg
Distance from blast:	114	m

Calculated Results:

Scaled distance, z:	5,6907	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,805372	
Overpressure:	34,64	kPa
	5,025148	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0,12942	
Impulse:	52,73929	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0,92074	
Duration:	3,973444	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,838076	
Arrival time:	10,021	ms

I) VCE from full LPG road tanker; 2 psi

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0,03	%
Mass of gas	24750	kg
Higher heating value of gas	50368	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:	45000	liters
Equivalent TNT mass	8039	kg
Density of liquid:	0,55	kg/l

Input Data:

TNT Mass:	8039	kg
Distance from blast:	208	m

Calculated Results:

Scaled distance, z:	10,3831	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1,158026	
Overpressure:	14,06	kPa
	2,040362	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,499186	
Impulse:	29,90722	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0,01622	
Duration:	4,846109	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1,197911	
Arrival time:	22,689	ms

m) Jet fire on LPG road tanker; 50 mm hole; 37.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:

Distance from flame:	9	m
Hole diameter:	50	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:

Area of hole:	0,001963	m**2
Gas discharge rate:	3,886	kg/s
L/d ratio for flame:	126,1	
Flame height:	6,30	m
Location of flame centre above ground:	3,65	
Radiation path length:	9,71	m
Point source view factor:	0,000844	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,848	

Flux at receptor location:	42,02	kW/m**2

n) Jet fire on LPG road tanker; 50 mm hole; 12.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:

Distance from flame:	17	m
Hole diameter:	50	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:

Area of hole:	0,001963	m**2
Gas discharge rate:	3,886	kg/s
L/d ratio for flame:	126,1	
Flame height:	6,30	m
Location of flame centre above ground:	3,65	
Radiation path length:	17,39	m
Point source view factor:	0,000263	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,805	

Flux at receptor location:	12,44	kW/m**2

o) Jet fire on LPG road tanker; 10 mm hole; 37.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	2	m
Hole diameter:	10	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	7,85E-05	m**2
Gas discharge rate:	0,155	kg/s
L/d ratio for flame:	126,1	
Flame height:	1,26	m
Location of flame centre above ground:	1,13	
Radiation path length:	2,30	m
Point source view factor:	0,015079	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,966	

Flux at receptor location:	34,21	kW/m**2

p) Jet fire on LPG road tanker; 10 mm hole; 12.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	4	m
Hole diameter:	10	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	7,85E-05	m**2
Gas discharge rate:	0,155	kg/s
L/d ratio for flame:	126,1	
Flame height:	1,26	m
Location of flame centre above ground:	1,13	
Radiation path length:	4,16	m
Point source view factor:	0,004606	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,916	

Flux at receptor location:	9,91	kW/m**2

q) BLEVE on 48-kg LPG cylinder; 37,5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.27: BLEVE Thermal Flux

Input Data:

Initial flammable mass:		Liters	
Initial flammable mass:	48	kg	<30 000
Water partial pressure in air:	2810	Pascal	
Radiation Fraction, R	0,3		
Distance from fireball centre on ground:	16	m	
Heat of Combustion of fuel:	50368	kJ/kg	
Density of liquid:	0,55	kg/l	

Calculated Results:

Maximum fireball diameter:	21,1	m
Fireball combustion duration:	1,6	s
Centre height of fireball:	15,8	m
Initial ground level hemisphere diameter:	27,4	m
Surface emitted flux:	317,9	kW/m**2
Path length:	12,0	
Transmissivity:	0,791	
Surface area of emitter	2359,907	m2

	Horizontal	Vertical	
View Factor:	0,15	0,16	
Received flux:	38,79	39,25	kW/m**2

r) BLEVE on 48-kg LPG cylinder; 12,5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.27: BLEVE Thermal Flux

Input Data:

Initial flammable mass:		Liters	
Initial flammable mass:	48	kg	<30 000
Water partial pressure in air:	2810	Pascal	
Radiation Fraction, R	0,3		
Distance from fireball centre on ground:	28	m	
Heat of Combustion of fuel:	50368	kJ/kg	
Density of liquid:	0,55	kg/l	

Calculated Results:

Maximum fireball diameter:	21,1	m
Fireball combustion duration:	1,6	s
Centre height of fireball:	15,8	m
Initial ground level hemisphere diameter:	27,4	m
Surface emitted flux:	317,9	kW/m**2
Path length:	21,6	
Transmissivity:	0,750	
Surface area of emitter	2359,907	m2

	Horizontal	Vertical	
View Factor:	0,05	0,09	
Received flux:	12,59	22,29	kW/m**2

s) VCE from full 48-kg LPG cylinder; 5 psi

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0,03	%
Mass of gas	48	kg
Higher heating value of gas	50368	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:		liters
Equivalent TNT mass	16	kg
Density of liquid:	0,55	kg/l

Input Data:

TNT Mass:	16	kg
Distance from blast:	15	m

Calculated Results:

Scaled distance, z:	6,0043	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,836832	
Overpressure:	31,71	kPa
	4,600684	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	-0,07334	
Impulse:	50,21978	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0,84005	
Duration:	4,049174	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,870177	
Arrival time:	10,842	ms

t) VCE from full 48-kg LPG cylinder; 2 psi

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Explosion overpressure yield	0,03	%
Mass of gas	48	kg
Higher heating value of gas	50368	kJ/kg
Higher heating value of TNT	4652	kJ/kg
Liquid volume of gas:		liters
Equivalent TNT mass	16	kg
Density of liquid:	0,55	kg/l

Input Data:

TNT Mass:	16	kg
Distance from blast:	26	m

Calculated Results:

Scaled distance, z:	10,4075	m/kg**(1/3)

Overpressure Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1,159405	
Overpressure:	14,02	kPa
	2,033832	psig
Impulse Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	0,501644	
Impulse:	29,83936	Pa s
Duration Calculation:	(only valid for z > 0.178 and z < 40)	
a+b*log(z):	-0,01268	
Duration:	4,849794	ms
Arrival Time Calculation:	(only valid for z > 0.0674 and z < 40)	
a+b*log(z):	1,199319	
Arrival time:	22,756	ms

u) Jet fire from 48-kg LPG cylinder; 50-mm hole; 37.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	9	m
Hole diameter:	50	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	0,001963	m**2
Gas discharge rate:	3,886	kg/s
L/d ratio for flame:	126,1	
Flame height:	6,30	m
Location of flame centre above ground:	3,65	
Radiation path length:	9,71	m
Point source view factor:	0,000844	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,848	

Flux at receptor location:	42,02	kW/m**2

v) Jet fire from 48-kg LPG cylinder; 50-mm hole; 12.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	17	m
Hole diameter:	50	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	0,001963	m**2
Gas discharge rate:	3,886	kg/s
L/d ratio for flame:	126,1	
Flame height:	6,30	m
Location of flame centre above ground:	3,65	
Radiation path length:	17,39	m
Point source view factor:	0,000263	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,805	

Flux at receptor location:	12,44	kW/m**2

w) Jet fire from 48-kg LPG cylinder; 10-mm hole; 37.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	2	m
Hole diameter:	10	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	7,85E-05	m**2
Gas discharge rate:	0,155	kg/s
L/d ratio for flame:	126,1	
Flame height:	1,26	m
Location of flame centre above ground:	1,13	
Radiation path length:	2,30	m
Point source view factor:	0,015079	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,966	

Flux at receptor location:	34,21	kW/m**2

Final Copy – Authorised for Submission to Authorities

x) Jet fire from 48-kg LPG cylinder; 10-mm hole; 12.5 kW/m2

Data transfer from iPad to report	*Checked*
Data transfer from report to software	*Checked*

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	4	m
Hole diameter:	10	mm
Leak height above ground:	0,5	m
Gas pressure:	7	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	50368	kJ/kg
Molecular weight of gas:	44	
Flame temperature:	2200	K
Discharge coefficient for hole:	1	
Ambient pressure:	101325	Pa
Fuel mole fraction at stoichiometric:	0,095	
Moles of reactant per mole of product:	1	
Molecular weight of air:	29	
Fraction of total energy converted:	0,3	

Calculated Results:		
Area of hole:	7,85E-05	m**2
Gas discharge rate:	0,155	kg/s
L/d ratio for flame:	126,1	
Flame height:	1,26	m
Location of flame centre above ground:	1,13	
Radiation path length:	4,16	m
Point source view factor:	0,004606	m**2
Water vapor partial pressure:	1580	Pa
Atmospheric transmissivity:	0,916	

Flux at receptor location:	9,91	kW/m**2

Final Copy – Authorised for Submission to Authorities

2. <u>Relevant key process data for each major hazard scenario</u>

Refer to the raw data in Annexure 1 and the model inputs below.

3. <u>Probit functions for the estimation of the number of fatalities</u>

Cross-correlation 2.35: Thermal Flux Estimate

Input Data:

Exposure time:	10	seconds
Percent Fatalities:	50	%

Calculated Results:

Thermal Flux Estimate for:

Significant injury threshold:		21.56	kW/m**2
Percent Fatalities:	1	38.13	kW/m**2
	50	85.22	kW/m**2
	100	131.54	kW/m**2

Cross-correlation 2.32: Dose-Response Correlation via Probits Overpressure

Input Data: Equation 2.3.7 Page 269

1 psi = 6903,8 N/m**2

Percentage Affected	Probit	Peak Overpressure (N/m**2)	Peak Overpressure psi	N/m**2 LN(Overpressure)	Calculated Probit	Table for interpolation by EXCEL:				Calculated Percentage
1	2.67	13807	2.00	9.53	2.66	2.65	2.7	0.94	1.07	0.97
10	3.72	19300	2.80	9.87	3.34	3.30	3.35	4.46	4.95	4.84
50	5.00	34490	5.00	10.45	4.52	4.50	4.55	30.85	32.64	31.41
90	6.28	84300	12.23	11.34	6.33	6.30	6.35	90.32	91.15	90.76

6 Frequency analysis

1) Postulated cause-event analysis

Hazardous material
Flammable liquids
Flammable gases
Explosive liquid vapours
Explosive gases
Toxic gases

Causal Factor	Probability
Routine task on schedule	0.064
Routine task on demand	0.008
Special task on schedule	0.037
Ad hoc, improvisation	0.015
Other	0.019
Paced by system dynamics	0.006
Paced by programme or orders	0.003
Self-paced	0.119
Spontaneous error in undisturbed task	0.067
Change in condition of familiar task	0.019
Operator distracted in task, preoccupied	0.007
Unfamiliar task	0.016
Monitoring and inspection	0.002
Supervisory control	0.009
Manual operation and control	0.012
Inventory control	0.022
Test and calibration	0.034
Repair and modification	0.043
Administrative and recording	0.003
Management and staff planning	0.009
Specified act not performed	0.074
Positive effect of wrong act	0.047
Extraneous effect	0.011
Sneak path	0.009
Effect not immediately reversible	0.021
Effect not immediately observable	0.098
Absent-mindedness	0.002
Familiar association	0.004
Capability exceeded	0.001
Low alertness	0.007
Manual variability and lack of precision	0.007
Topographic and spatial orientation inadequate	0.007
Familiar routine interference	0.000
Omission of functionally isolated act	0.040
Omission of administrative act	0.009
Other omissions	0.006
Mistake, interchange among alternative possibilities	0.008
Expect and assume rather than observe	0.007
System knowledge insufficient	0.001
Side-effects of process not adequately considered	0.011
Latent causal condition or relations not adequately considered	0.014
Reference data recalled wrongly	0.001
Sabotage	0.001
Poor maintenance	0.012
Corrosion/material defect/operating spec exceeded/mechanical damage/container overfilled/no training/natural hazard/drive to increase production/poor construction/wrong product/tank contamination/chemical incompatibility/ignition source	0.110

Event

Loss of containment

Human Error	Probability
Task condition	
Routine task on schedule	0.064
Routine task on demand	0.008
Special task on schedule	0.037
Ad hoc, improvisation	0.015
Other	0.019
Task control	
Paced by system dynamics	0.006
Paced by programme or orders	0.003
Self-paced	0.119
Other	0.015
Error situation	
Spontaneous error in undisturbed task	0.067
Change in condition of familiar task	0.019
Operator distracted in task, preoccupied	0.007
Unfamiliar task	0.016
Other	0.034
Task	
Monitoring and inspection	0.002
Supervisory control	0.009
Manual operation and control	0.012
Inventory control	0.022
Test and calibration	0.034
Repair and modification	0.043
Administrative and recording	0.003
Management and staff planning	0.009
Other	0.009
Effect from	
Specified act not performed	0.074 max
Positive effect of wrong act	0.047
Extraneous effect	0.011
Sneak path	0.009
Other	0.004
Potential for recovery	
Effect not immediately reversible	0.021
Effect not immediately observable	0.098
Other	0.024
Error categories	
Absent-mindedness	0.002

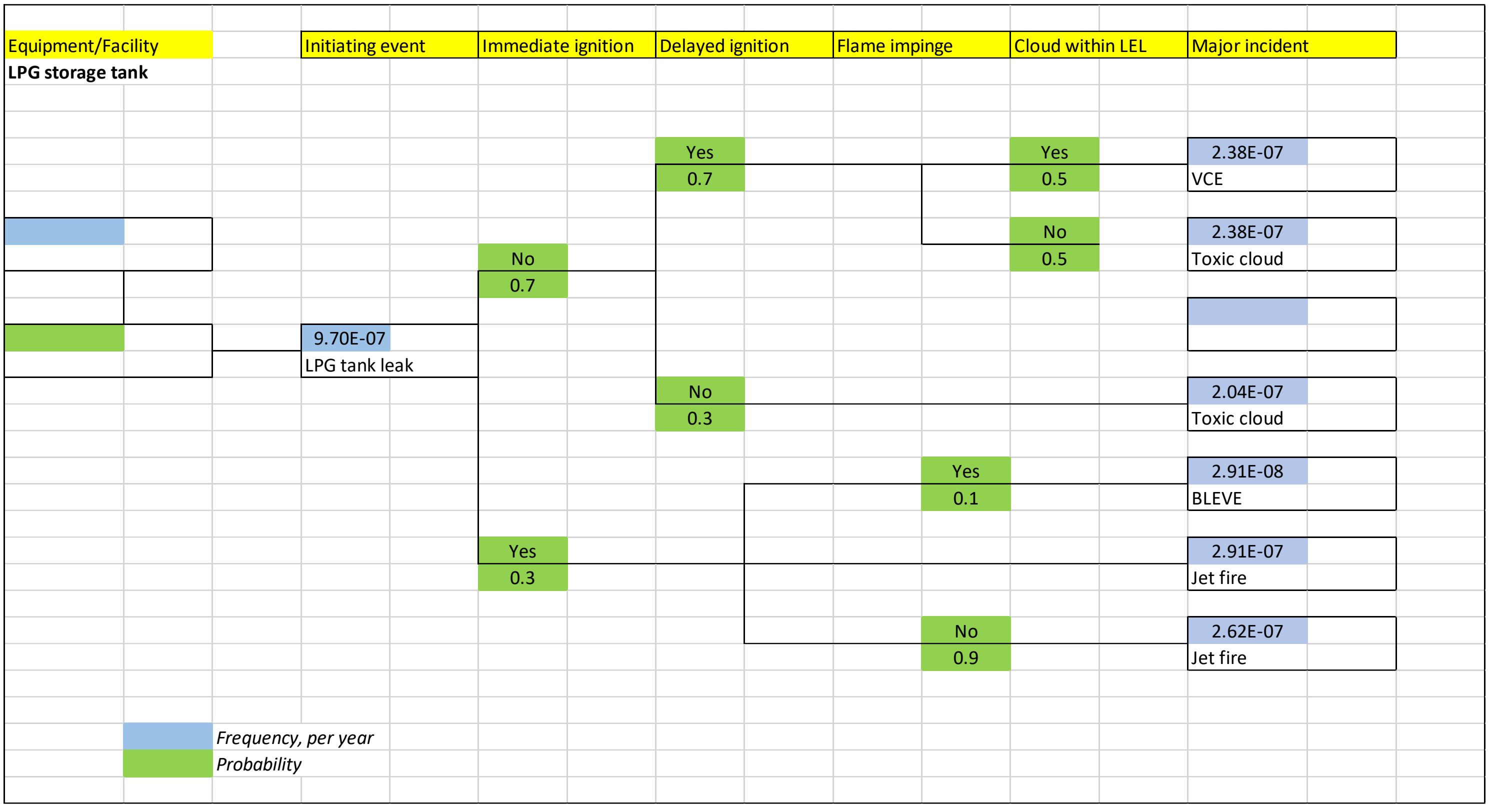
Familiar association	0.004
Capability exceeded	0.001
Low alertness	0.007
Manual variability and lack of precision	0.007
Topographic and spatial orientation inadequate	0.007
Familiar routine interference	0.000
Omission of functionally isolated act	0.040
Omission of administrative act	0.009
Other omissions	0.006
Mistake, interchange among alternative possibilities	0.008
Expect and assume rather than observe	0.007
System knowledge insufficient	0.001
Side-effects of process not adequately considered	0.011
Latent causal condition or relations not adequately considered	0.014
Reference data recalled wrongly	0.001
Sabotage	0.001
Other	0.012

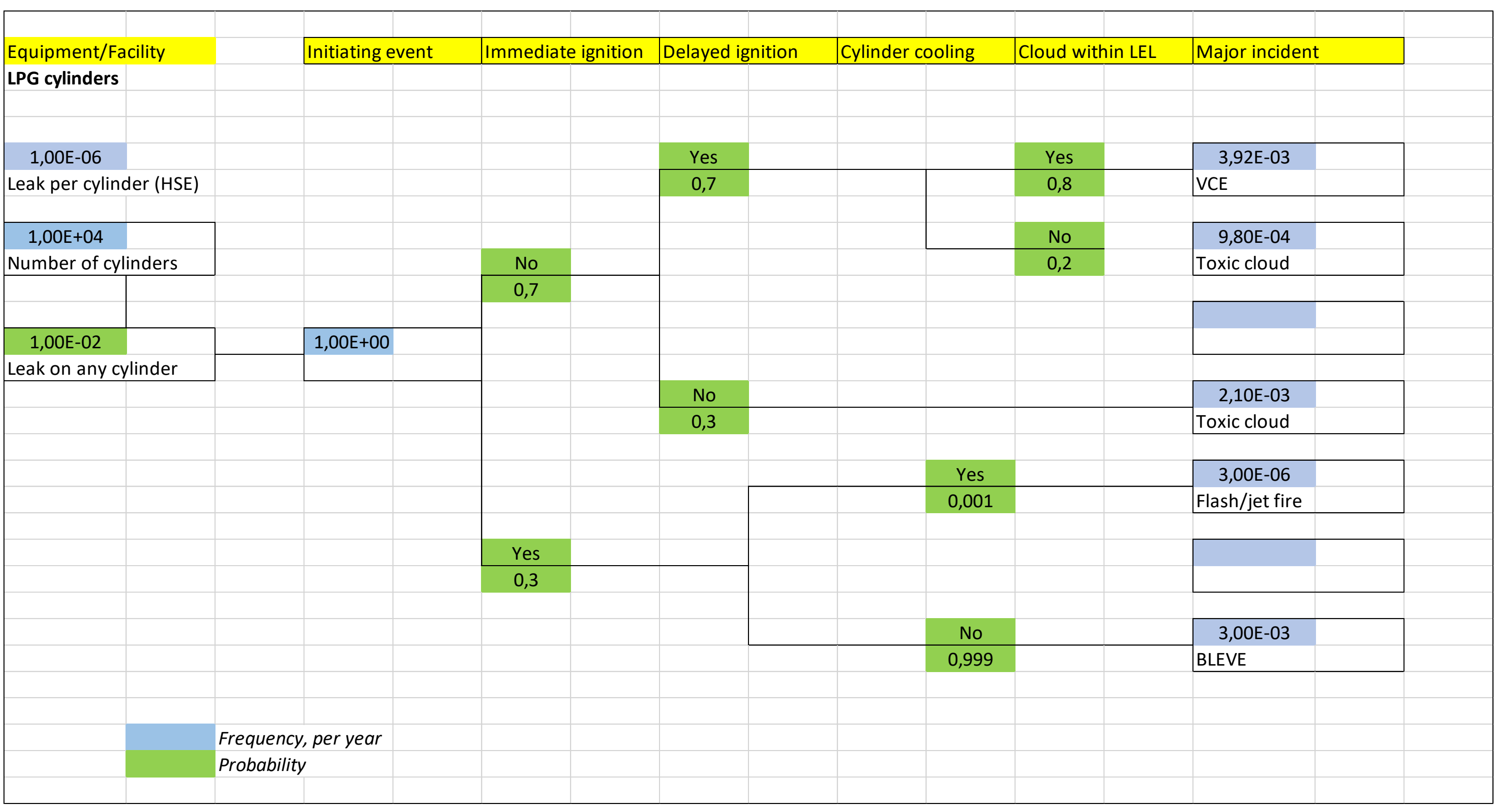
Failure data used – equipment and systems

Table 6.1: Failure data from BEVI

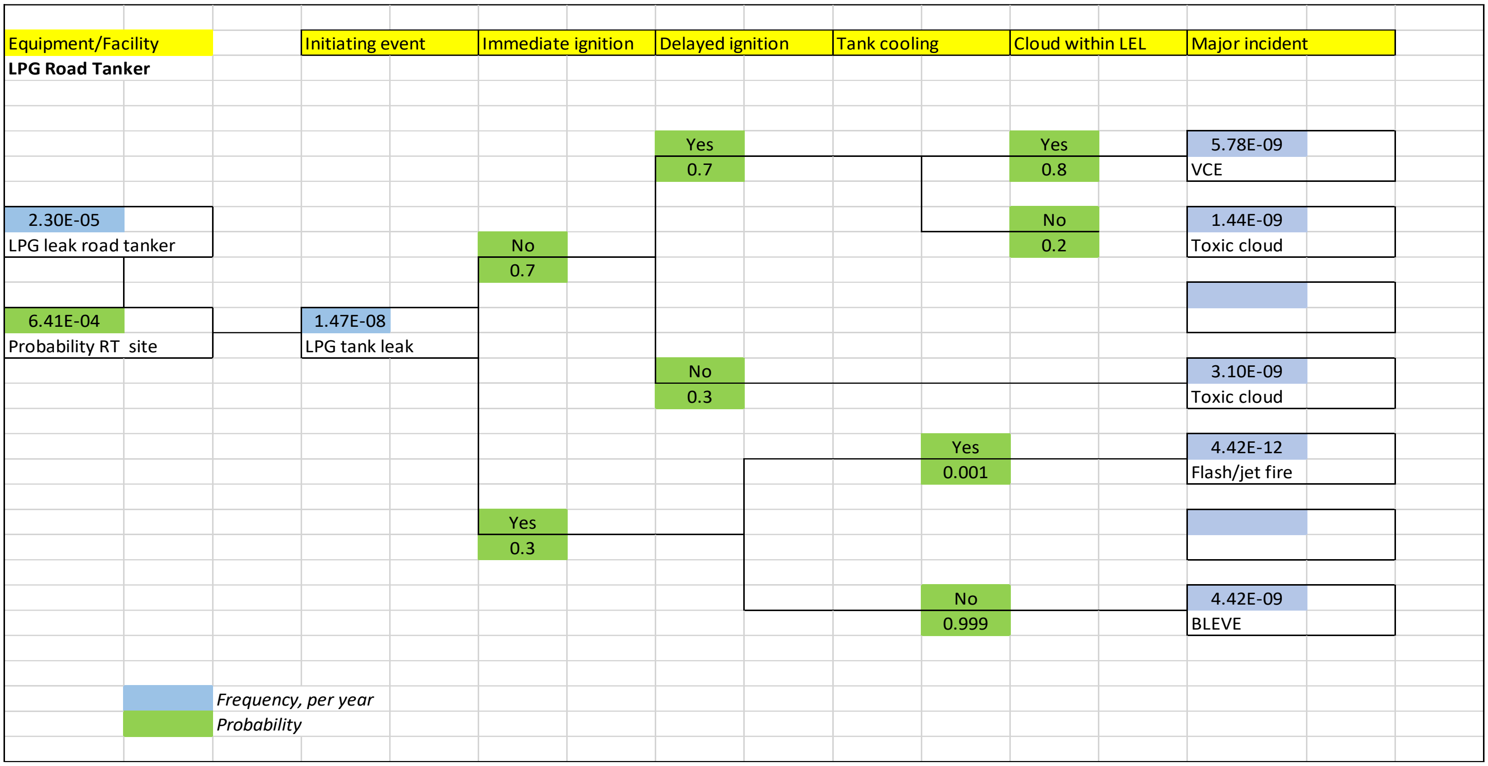
Installation component	Failure frequency, per year
Manual valve	1.0 E-4
Remotely controlled shut-off valve	3.0 E-2
Automatic shut-off valve	1.0 E-2
Excess flow valve	1.3 E-2
Flammable warehouse fire	8.8 E-4
Underground LPG tank, instantaneous release	5.0 E-7
Underground storage tank for toxic materials	5.0 E-7
Underground pipeline, rupture	5.0 E-7
Underground pipeline, 20-mm hole	1.5 E-6
Aboveground pipeline, <75 mm diameter, rupture	1.0 E-6
Aboveground pipeline, 75-150 mm diameter, rupture	3.0 E-7
Aboveground pipeline, >150 mm diameter, rupture	1.0 E-7
Aboveground pipeline, <75 mm diameter, 50-mm hole	5.0 E-6
Aboveground pipeline, 75-150 mm diameter, 50-mm hole	2.0 E-6
Aboveground pipeline, >150 mm diameter, 50-mm hole	5.0 E-7
Reciprocating pumps and compressors	4.4 E-3
Heat exchangers	1.0 E-3
Gas road tankers (pressurized; LPG) full release	5.0 E-7
Road tankers with flammable liquid at atmospheric pressure, full release	4.5 E-9
LPG cylinders, catastrophic (HSE)	2N where N = total number of cylinders on site
LPG storage tank aboveground	9.7 E-7

2) Information to determine the final frequency of each failure scenario included in the calculation of risk





Final Copy – Authorised for Submission to Authorities


Equipment/Facility
LPG Road Tanker
Initiating event
Immediate ignition
Delayed ignition
Tank cooling
Cloud within LEL
Major incident
2.30E-05
LPG leak road tanker
6.41E-04
Probability RT site
1.47E-08
LPG tank leak
No
0.7
Yes
0.3
Yes
0.7
No
0.3
Yes
0.8
No
0.2
Yes
0.001
No
0.999
5.78E-09
VCE
1.44E-09
Toxic cloud
3.10E-09
Toxic cloud
4.42E-12
Flash/jet fire
4.42E-09
BLEVE
Frequency, per year
Probability

7. Risk calculations

Location specific societal and individual risk levels:

Colour Code
1 × 10-3 d/p/y – blue
1 × 10-4 d/p/y – red
1 × 10-5 d/p/y – orange
1 × 10-6 d/p/y – yellow
1 or 3 × 10-7d/p/y – green

Table 7.1: Summary of risks

Public population density	588	Persons/km2	Statistics SA 2011 Census
Public population density	0,000588	Persons/m2	
Workers on site	6	Workers total, including contractors, peak	
Surface area of site	27200	m2	
Worker density on site:	0,000221	Workers/m2	
Fraction of site within max safe radius	100%		

Scenario No	Major incident	Consequence	Frequency per yr	Impact radius m	Average N outside site (Public)	Fatalities N	Radius m	Individual risk contours	
								Freq, per yr	Risk, d/p/yr
1	BLEVE on LPG tank; 37.5 kW/m2; 400 000 liters	Thermal	2,91E-08	276	645	6,5	470	2,91E-08	2,91E-08
2	BLEVE on LPG tank; 12.5 kW/m2; 400 000 liters	Thermal	2,91E-08	470	1872	18,7	430	2,38E-07	2,67E-07
3	VCE from full LPG tank; 5 psi	Overpressure	2,38E-07	235	468	4,7	276	2,91E-08	2,96E-07
4	VCE from full LPG tank; 2 psi	Overpressure	2,38E-07	430	1567	15,7	235	2,38E-07	5,34E-07
5	Jet fire on LPG tank; 50 mm hole; 37.5 kW/m2	Thermal	2,62E-07	9	1	0,0	208	4,42E-09	5,39E-07
6	Jet fire on LPG tank; 50 mm hole; 12.5 kW/m2	Thermal	2,62E-07	17	2	0,0	208	5,78E-09	5,44E-07
7	Jet fire on LPG tank; 10 mm hole; 37.5 kW/m2	Thermal	2,62E-07	2	0	0,0	115	4,42E-09	5,49E-07
8	Jet fire on LPG tank; 10 mm hole; 12.5 kW/m2	Thermal	2,62E-07	4	0	0,0	114	5,78E-09	5,55E-07
9	BLEVE on LPG road tanker; 37.5 kW/m2	Thermal	4,42E-09	115	112	1,1	28	3,00E-03	3,00E-03
10	BLEVE on LPG road tanker; 12.5 kW/m2	Thermal	4,42E-09	208	367	3,7	26	3,92E-03	6,92E-03

11	VCE from full LPG road tanker; 5 psi	Overpressure	5,78E-09	114	110	1,1	17	2,62E-07	6,92E-03
12	VCE from full LPG road tanker; 2 psi	Overpressure	5,78E-09	208	367	3,7	17	4,42E-12	6,92E-03
13	Jet fire on LPG road tanker; 50 mm hole; 37.5 kW/m2	Thermal	4,42E-12	9	1	0,0	17	3,00E-06	6,92E-03
14	Jet fire on LPG road tanker; 50 mm hole; 12.5 kW/m2	Thermal	4,42E-12	17	2	0,0	16	3,00E-03	9,92E-03
15	Jet fire on LPG road tanker; 10 mm hole; 37.5 kW/m2	Thermal	4,42E-12	2	0	0,0	15	3,92E-03	1,38E-02
16	Jet fire on LPG road tanker; 10 mm hole; 12.5 kW/m2	Thermal	4,42E-12	4	0	0,0	9	2,62E-07	1,38E-02
17	BLEVE on 48-kg LPG cylinder; 37,5 kW/m2	Thermal	3,00E-03	16	2	0,0	9	4,42E-12	1,38E-02
18	BLEVE on 48-kg LPG cylinder; 12,5 kW/m2	Thermal	3,00E-03	28	7	0,1	9	3,00E-06	1,38E-02
19	VCE from full 48-kg LPG cylinder; 5 psi	Overpressure	3,92E-03	15	2	0,0	4	2,62E-07	1,38E-02
20	VCE from full 48-kg LPG cylinder; 2 psi	Overpressure	3,92E-03	26	6	0,1	4	4,42E-12	1,38E-02
21	Jet fire from 48-kg LPG cylinder; 50-mm hole; 5 psi	Thermal	3,00E-06	9	1	0,0	4	3,00E-06	1,39E-02
22	Jet fire from 48-kg LPG cylinder; 50-mm hole; 2 psi	Thermal	3,00E-06	17	2	0,0	2	2,62E-07	1,39E-02
23	Jet fire from 48-kg LPG cylinder; 10-mm hole; 5 psi	Thermal	3,00E-06	2	0	0,0	2	4,42E-12	1,39E-02
24	Jet fire from 48-kg LPG cylinder; 10-mm hole; 2 psi	Thermal	3,00E-06	4	0	0,0	2	3,00E-06	1,39E-02
	Individual risk, d/p/yr		**1,39E-02**						

1. <u>Risk levels and ranking at key locations</u>

The risk rankings for the site are as follows:

- First priority: BLEVE on LPG road tanker.
- Second priority: BLEVE on LPG storage tank.

2. <u>Societal risks- F-N curve (including on-site populations)</u>

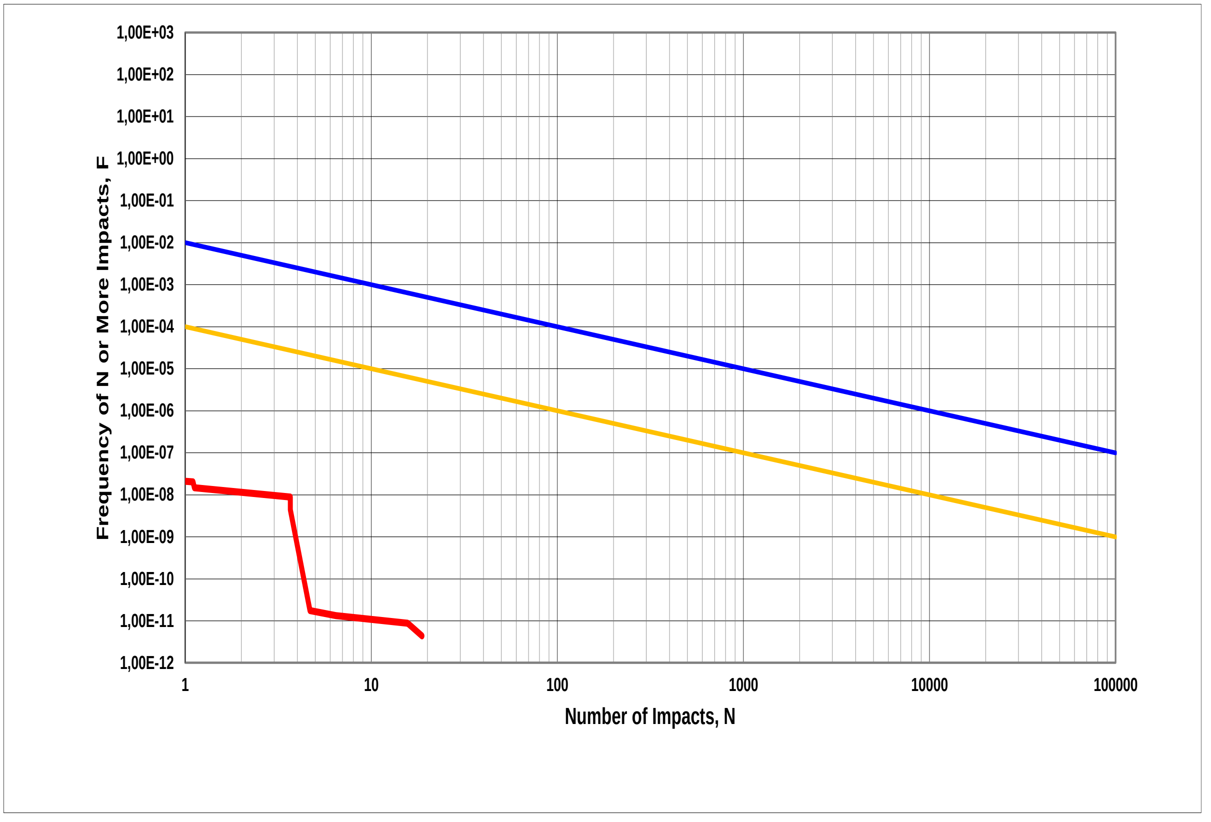


Figure 7.1: FN Curve for societal risk

Site graph

Intolerably high line

Tolerable with ALARP between blue and orange lines

Acceptably low line

3. Individual risk transect

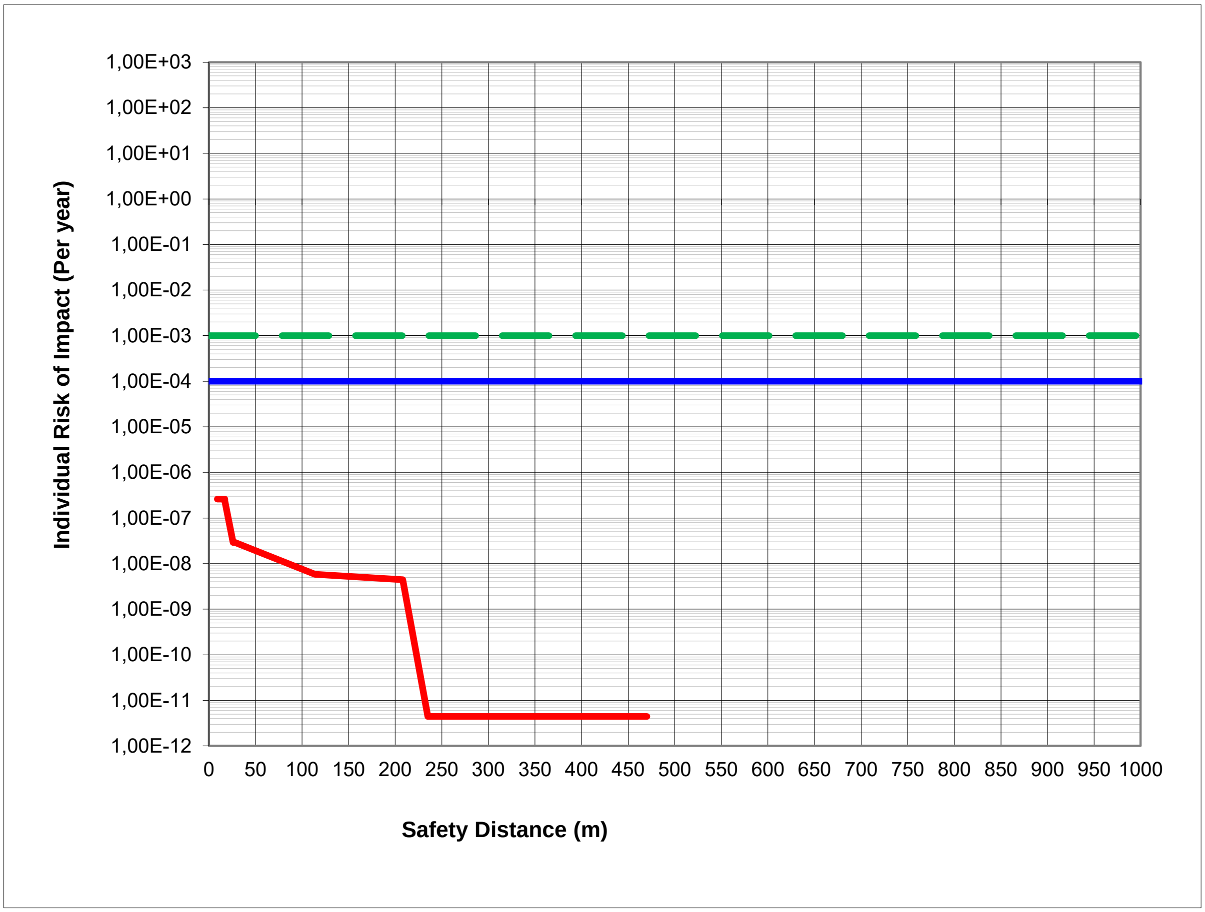


Figure 7.2: Individual risk transect

Site graph

Tolerable for public

Tolerable for employees

4. Individual risk contours

Figure 7.2: Individual risk contours

Colour Code

1 × 10-3 d/p/y – **blue**
1 × 10-4 d/p/y – **red**
1 × 10-5 d/p/y – **orange**
1 × 10-6 d/p/y – **yellow**
1 or 3 × 10-7d/p/y – **green**

8 Risk judgement

1. The risk associated with the operations on this site are judged as follows:

   a) The cumulative individual safety risks for the site is 1.39 E-2 d/p/yr.
   b) Individual risk at the site is higher than tolerable for the public (1.0 E-4 d/p/yr) and for employees (1.0 E-3 d/p/yr) on site.
   c) The individual risk transect indicates that the risks are lower than the norm for employees and the public.
   d) Societal safety risks on this site are acceptably low.

2. The LPG tank installation on the premises comprises an MHI, because a major incident on site would impact on members of the public outside the boundaries of the site e.g. a BLEVE or VCE on the LPG storage tanks or LPG delivery road tanker, respectively.
3. The LPG delivery road tanker comprises an MHI while it is parked on the premises of Easigas. However, this risk is lower than when the road tanker drives in streets as a result of possible collisions with vehicles. Refer to Appendix 8 for societal and individual risk criteria.

5. <u>Domino effects</u>

The following domino effects have been identified for this site:

Trigger	Impact receptor
6. Shrapnel from BLEVE on LPG tank	LPG road tanker
7. Shrapnel from BLEVE on LPG road tanker	LPG storage tank
8. Shrapnel from BLEVE on an LPG cylinder	LPG road tanker LPG storage tank

9 Risk treatment

1. Risk reduction options including recommended preventative and mitigative measures

   a) The national Chief Inspector of the Department of Employment and Labour must be notified about the status of the proposed LPG installation.
   b) The provincial Chief Inspector of the Department of Employment and Labour must be notified about the status of the proposed LPG installation.
   c) The Fire Department of Nelson Mandela Bay Municipality must be notified about the status of the proposed LPG installation.
   d) An advertisement must be published in a local community newspaper, as follows:

NOTIFICATION OF
MAJOR HAZARD INSTALLATION
EASIGAS, SIDWELL

Notice is hereby given in accordance with Section 3(b) of the Major Hazard Installation Regulations R.692 of 30 July 2001 that an approved inspection authority conducted a major hazard installation risk assessment review on the LPG facilities of Easigas at Eveready Road, Sidwell, Port Elizabeth. The risk assessment report can be obtained in electronic format from the following address:

Nature & Business Alliance Africa (Pty) Ltd
Tel 011-958 2132
E-mail: alfonso@yebo.co.za

Interested and affected parties have 60 days from the date of publication of this advertisement to submit comments on the major hazard installation to the Head of the Emergency Services of Nelson Mandela Bay Municipality or to the Provincial Chief Inspector of the Department of Employment and Labour in Gauteng.

   e) A permanent warning sign must be installed at the entrance to the site, as follows:

BEWARE

MAJOR HAZARD INSTALLATION

f) Ensure that no flammable or explosive liquid or gas is stored in the redundant municipal gas storage tank next to the proposed new 400 000-liter LPG tank.
g) The emergency management plan must be updated when personnel changes or contact details occurs, in accordance with the guidelines given in this report.
h) Operating procedures for the site must be kept up to date to include preventative measures against the uncontrolled release of the following hazardous substances:

- LPG from the delivery road tanker.
- LPG from the storage tank.
- LPG from the cylinder filling platform.

i) The outcome of the risk assessment must be brought to the attention of all the employees at the site.
j) A Maintenance Plan must be compiled and kept up to date for all the hazardous equipment used on the facility. The Plan must contain at least the following:
    - List of all equipment and facilities on the facility.
    - Maintenance frequency.
    - Particulars of maintenance activities that must be performed on the listed equipment.
    - Responsible person.

k) All hazardous equipment and facilities on the facility must be inspected on a regular basis by means of an Inspection Register. The Register must contain at least the following:
    - List of all equipment and facilities on the facility.
    - Equipment items that must be inspected.
    - Facilities that must be inspected.
    - Areas that must be inspected.
    - Inspection findings.
    - Responsible person who carried out the inspection.

l) All authorised operators must be trained in the application of the operating procedures applicable to their jobs.
m) All operating personnel at the facility must be made aware and kept aware of the dangers involving LPG.
n) The facility must remain under safety and security access control for 24 hours per day. The security guard must Nelson Mandela Bay Municipalitymust comply with the following requirements:
    - The guard must be trained in the potential major incidents that could occur at the site as well as the emergency procedure that must be followed.
    - The guard must be linked via SMS or cellular phone with a responsible standby person at the site.
    - The guard must be able to contact the local Fire Department immediately.

o) The Emergency Evacuation Procedure aimed at workers and visitors must be updated at least annually in collaboration with the emergency services of Nelson Mandela Bay Municipality.
p) The LPG delivery road tanker must not reverse on site.
q) The LPG road tanker must be inspected when it comes onto the site, for possible overheated tyres, smell of heated rubber, LPG leaks or other defects that can place the site at risk.
r) The Emergency Management Plan and Emergency Evacuation Procedure must be tested at least once every 12 months by means of mock emergencies. The emergency services of Nelson Mandela Bay Municipality must be invited to participate in these tests.
s) Customer and staff parking bays must be located in an area where public vehicles will not cause obstruction to emergency vehicles.
t) Prior to any construction work on site, the local office of the Department of Employment and Labour must be notified in writing, in accordance with the Construction Regulations of the Department of Employment and Labour.
u) No modifications may be made to the facilities on site unless an MHI risk assessment has been done beforehand.
v) Train all staff in emergency preparedness for an LPG leak, in collaboration with the fire department of Nelson Mandela Bay Municipality.
w) The highest risks at the site are quite manageable, namely a BLEVE on the LPG storage tanks or on the delivery road tanker.
x) Ensure that the nameplates on all LPG storage tanks are clearly visible and legible.
y) Test the deluge systems at the road tanker loading bays at least monthly to ensure that it is in good working order and effective.
z) The site CCTV surveillance system must be inspected regularly to ensure its good functional operation and all employees in the control room must be trained in the use of the system.
aa) Ensure that the windsock on site remains in a good functional state.
bb) The LPG detection and alarm system at the site must be inspected and tested regularly to ensure that it remains in a good working order.

2. <u>Conclusions on ALARP risk mitigation measures</u>

It is recommended that ALARP mitigation measures are applied at this site, as outlined above in this report. The risk criteria in comparison with the site assessment are given in Table 9.1 below.

Table 9.1: Summary of site assessment against risk criteria as per the FN and IR graphs

Frequency, deaths/person/year		**Site assessment**
Public		
Intolerable	>1.0 E-4	
Tolerable	1.0 E-4 to 1.0 E-6	
Broadly acceptable	<1.0 E-6	X
Employees		
Intolerable	>1.0 E-3	
Tolerable	1.0 E-3 to 1.0 E-5	
Broadly acceptable	<1.0 E-5	X
Graph of ALARP		
Intolerable		
Tolerable with mitigation (ALARP)		
Acceptably low		X

3. Domino effects

The following domino effects have been identified for this site:

Table 9.2: Potential domino effects

Trigger	Impact receptor
9. Shrapnel from BLEVE on LPG tank	LPG storage tank LPG road tanker
10. Shrapnel from BLEVE on LPG road tanker	LPG storage tank

10 Land use planning

1. Restricted development distance

The site is located in a predominantly industrial area, which have partly been developed.

2. Plot of three land-use planning zones on a map of the area

Figure 9.1: Land-use planning zones

Key
Red: Inner zone > 10 chances of a major incident per million per annum (1.0 E-5 per year).

Orange: Middle zone > 1 chance of a major incident per million per annum (1.0 E-6 per year).

Yellow: Outer zone > 0.3 chances of a major incident per million per annum (3.0 E-7 per year).

3. <u>Highlighting of possible land-use planning conflicts for new installations</u>

   a) There are no development conflicts for this site at the time of the risk assessment.
   b) If new development around the site is planned, the local authority must take the land-use planning zones in Figure 9.1 into consideration.

11 Conclusions

1. A total of 24 hazard scenarios have been analysed in this risk assessment.
2. The Occupational Health and Safety Act (Act 85 of 1993) defines a major hazard installation as "*an installation-*
    - *where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily; or*
    - *where any substance is produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident*".

   The Explanatory Notes on the Major Hazard Installation Regulations issued in April 2005 by the Chief Directorate of Occupational Health and Safety of the Department of Employment and Labour explains the following:

   "*What is important here is to know that there are two reasons that can determine when an installation is a major hazard installation (MHI). The first reason is when there is more than the prescribed quantity of a substance. The quantities and type of substances are prescribed in the General Machinery Regulation 8 and its Schedule A, on notifiable substances. The second reason is where substances are produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident. The important issue is the potential of an incident and not whether the incident is a major incident or not. The potential will be determined by the risk assessment.*

   A major incident means an occurrence of catastrophic proportions, resulting from the use of plant or machinery, or from activities at a workplace.
   It is impossible to put a specific value to "catastrophic" because it will always differ from person to person and from place to place. However, when the outcome of a risk assessment indicates that there is a possibility that the public will be involved in an incident, then the incident can be seen as catastrophic".

3. The facility is classified as a major hazard installation, because a major incident at the site will impact members of the public outside the boundaries of the premises.
4. There are no development conflicts for this site.
5. To the best knowledge of the risk assessor there are no major hazard installation within reach of the worst-case major incident that can occur at this site.
6. If new development around the site is planned, the local authority must take the land-use planning zones in Figure 9.1 into consideration.

12 Emergency response data

1. The emergency response plan of the site is enclosed in Appendix 4.
2. Evaluation of the suitability of the onsite emergency response plan in terms of the risk assessment results.

A General Requirements	Is it contained in the Plan?
The Plan must have a date of compilation	Yes
A clear indication must be given when and how the Plan will be revised.	Yes
Various categories of emergency situations must be defined.	Yes
The Plan must consider all potential natural or man-made emergencies that could disrupt the operation of the MHI facility.	Yes
The Plan must consider all potential internal sources of emergencies that could disrupt the operation of the MHI facility.	Yes
The Plan must consider the impact of all internal and external emergencies on the operation of the MHI facility.	Yes
Response actions must be tailored to the specific MHI facility.	Yes
The Plan must contain a list of key personnel with their responsibilities and contact information.	Yes
The Plan must contain a list of local emergency responders with their contact information.	Yes
The Plan must contain the names, titles, departments and contact numbers of individuals who can be contacted for additional information or an explanation of duties and responsibilities applicable to the Plan.	Yes
The Plan must outline how rescue operations will be performed.	Yes
The Plan must outline how medical assistance will be provided.	Yes
The Plan must state how and where personal information on employees can be obtained in an emergency.	Yes
The Plan must state how affected members of the public will be contacted, who the contact persons are and their contact numbers.	Yes
B Evacuation Procedure	
The Plan must identify the conditions under which an evacuation of people would be necessary.	Yes
The procedure must make provision for the evacuation of employees on site as well as affected members of the public.	Yes
The Plan must outline a clear chain of command and designate a specific person with a standby authorized to order an evacuation or operational shutdown.	Yes
The Plan must address the types of actions expected from different employees for the various categories of emergencies.	Yes
The Plan must identify who will stay behind to shut down critical operations during an evacuation.	Yes
The Plan must show specific evacuation routes for employees and these must be posted at the MHI facility where they are easily accessible to all employees.	Yes
The Plan must show specific evacuation routes for members of the public and these must be easily accessible to the public.	Yes

The Plan must prescribe procedures for assisting people during an evacuation, people with disabilities or those who cannot speak English or read.	Yes
The Plan must show one or more assembly areas where employees will gather.	Yes
The Plan must include a method of accounting for all employees.	Yes
The Plan must explain how visitors will be assisted and accounted for during an evacuation.	Yes
C Reporting of an Emergency Condition	
The Plan must outline the method of reporting fires and other emergencies to the local emergency services.	Yes
The Plan must outline the method of alerting employees, including disabled employees, to evacuate from the MHI site or to take other action.	Yes
D Employee Training and Drills	
The Plan must state how and when employees will be trained with regard to the types of emergencies that may occur, their responsibilities and the actions that they must take.	Yes
The Plan must state how and when retraining of employees will take place.	Yes
The Plan must state how often drills will take place. These drills must involve all employees at the MHI site as well as affected members of the public.	Yes
E Management of the News Media	
The Plan must indicate the person whose responsibility it will be to provide information about the emergency to the news media.	Yes
The Plan must state clear channels for the approval of media releases to journalists.	Yes

13 Proof of competency

Alfonso Niemand is the author of this report.

In terms of the ISO/IEC-17020 standards he has been appointed as Technical Manager of Nature & Business Alliance Africa (Pty) Ltd.

Alfonso holds the following qualifications:

- *Baccalaureus Scientiae (BSc), University of South Africa.*
- *Master's Degree in Business Leadership (MBL), University of South Africa.*
- *PhD, University of the Free State.*
- *Certificate course in the Integration of Safety, Health, Environmental, Risk and Quality Management Systems, University of Potchefstroom, South Africa.*
- *Certificate course in Environmental Management, University of Pretoria, South Africa.*
- *Certificate courses as Safety and Health Representative, Occupational Health and Safety Services and Advantage ACT.*
- *Certificate course in Health and Safety Incident Investigation, Advantage ACT.*
- *Training in Aloha and Cameo software applications for risk incident consequence modelling, University of California, Davis Campus, USA.*

Alfonso Niemand holds the following memberships:

- *International Association for Impact Assessment (IAIA).*
- *South African Right of Way Association (SARWA).*
- *South African Association for Professional Managers (SAAPM, registration 9/2/99)*
- *South African Council for Natural Scientific Professions (SACNASP, registration 200026/04).*
- *SA Institute of Occupational Safety and Health (SAIOSH).*
- *Disaster Management Institute of South Africa (DMISA).*
- *Southern Africa Society for Disaster Reduction (SASDiR).*
- *International Society for Integrated Disaster Risk Management (IDRiM).*

Alfonso Niemand has 40 years' experience in the petrochemical and construction industries in South Africa. He worked with the Environmental Protection Agency of the United States in 1981 for the environmental, safety and health mapping of an oil-from-coal facility in South Africa.

South African National Accreditation System

CERTIFICATE OF ACCREDITATION

In terms of section 22(2)(b) of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006), read with sections 23(1), (2) and (3) of the said Act, I hereby certify that: -

NATURE & BUSINESS ALLIANCE AFRICA (PTY) LTD
Co. Reg. No.: 2003/020335/07
ROODEPOORT

Accreditation Number: **MHI0004**

is a South African National Accreditation System Accredited Inspection Body to undertake **TYPE A** inspection provided that all SANAS conditions and requirements are complied with

This certificate is valid as per the scope as stated in the accompanying scope of accreditation, Annexure "A", bearing the above accreditation number for

THE ASSESSMENT OF RISK ON MAJOR HAZARD INSTALLATIONS

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17020:2012 AND SANS 1461:2018

The accreditation demonstrates technical competency for a defined scope and the operation of a management system

While this certificate remains valid, the Accredited Facility named above is authorised to use the relevant SANAS accreditation symbol to issue facility reports and/or certificates

Mr T Baleni
Acting Chief Executive Officer

Effective Date: 08 August 2021
Certificate Expires: 07 August 2025

This certificate does not on its own confer authority to act as an Approved Inspection Authority as contemplated in the Major Hazard Installation Regulations. Approval to inspect within the regulatory domain is granted by the Department of Employment and Labour.

ANNEXURE A

SCOPE OF ACCREDITATION

Accreditation Number: MHI0004

TYPE A

Permanent Address: Nature & Business Alliance Africa (Pty) Ltd 13 Sedona Complex 386 Flora Haase Street Amorosa Roodepoort 1735 Tel: (011) 958-2132 Cell: 083 225-4426 E-mail: alfonso@yebo.co.za	**Postal Address:** P O Box 1753 Strubens Valley 1735 Issue No.: 13 Date of issue: 08 August 2021 Expiry date: 07 August 2025

Nominated Representative: Dr A Niemand **Quality Manager:** Dr A Niemand	**Technical Manager:** Dr A Niemand	**Technical Signatory:** Dr A Niemand

Field of Inspection	Service Rendered	Codes and Regulations
Regulatory: The supply of services as an Inspection Authority for Major Hazard Risk Installation as defined in the Major Hazard Risk Installation Regulations, Government Notice No. R 692 of 30 July 2001	Major Hazard Installation Risk Assessments for the following material categories: 1) Explosive chemicals 2) Gases: i) Flammable Gases ii) Non-flammable, non-toxic gases (asphyxiants) iii) Toxic gases 3) Flammable liquids 4) Flammable solids, substances liable to spontaneous combustion, substances that on contact with water release flammable gases 5) Oxidizing substances and organic peroxides 6) Toxic liquids and solids	MHI regulation par. **5 (5) (b)** i) Frequency/Probability Analysis ii) Consequence Modelling iii) Hazard Identification and Analysis iv) Emergency planning reviews SANS 31000 SANS 31010 Guidelines for Chemical Process Quantitative Risk Analysis of the Centre for Chemical Process Safety (CCPS), American Institute of Chemical Engineers Areal Locations of Hazardous Atmospheres (ALOHA) Computer Programme developed by the US Environmental Protection Agency (EPA), US National Oceanic and Atmospheric Administration (NOAA), US Chemical Emergency Preparedness and Prevention Office (CEPPO) and US Hazardous Materials Response Division (HMRD)

Original date of accreditation: 08 August 2005

Page 1 of 1

ISSUED BY THE SOUTH AFRICAN NATIONAL ACCREDITATION SYSTEM

Accreditation Manager

SACNASP

South African Council for Natural Scientific Professions

herewith certifies that

Alfonso Niemand

Registration Number: 002914

is a registered scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)
in the following fields(s) of practice (Schedule 1 of the Act)

Environmental Science (Professional Natural Scientist)

Effective **25 November 2004** Expires **31 March 2022**

Chairperson

Chief Executive Officer

To verify this certificate scan this code

14 References and bibliography

HSE, UK. *Failure Rate and Event Data for use within Risk Assessments.* 2 February 2019.

USA National Oceanic and Atmospheric Administration (NOAA*). CAMEO Chemical Database, Version 2.7.1.*

American Institute of Chemical Engineers. Center for Chemical Process Safety. *Guidelines for Chemical Process Quantitative Risk Analysis.* Second Edition. 2000.

US Environmental Protection Agency. US National Oceanic and Atmospheric Administration. US Chemical Emergency Preparedness and Prevention Office. US Hazardous Materials Response Division. *Computer-aided Management of Emergency Operations* used in conjunction with the *Areal Locations of Hazardous Atmospheres (ALOHA) User Manual Volume 1 and 2.* March 2004.

US Arizona Emergency Response Commission. *Cameo Companion Procedure for the Management of Hazardous Situations.* October 2004.

Sam Mannan. Lee's Loss Prevention in the Process Industries. Hazard Identification, Assessment and Control. Volume 1. Third Edition. 2005.

Sam Mannan. Lee's Loss Prevention in the Process Industries. Hazard Identification, Assessment and Control. Volume 2. Third Edition. 2004.

Sam Mannan. Lee's Loss Prevention in the Process Industries. Hazard Identification, Assessment and Control. Volume 3. Third Edition. 2004.

Robert H Perry and Cecil H Chilton. *Chemical Engineer's Handbook.* Fifth Edition. 1973.

A C Valsamakis, R W Vivian and G S du Toit. *Risk Management.* Second Edition. 1999.

J D Andrews and T R Moss. *Reliability and Risk Assessment.* Second Edition. 2002.

Dennis P Nolan. *Handbook of Fire and Explosion Protection Engineering Principles for Oil, Gas, Chemical and related Facilities.* Noyes Publications. 1996.

CRC Press. *Handbook of Chemistry and Physics.* 61st Edition. 1980.

RSA Occupational Health and Safety Act (Act No 85 of 1993).

RSA Major Hazard Installation Regulations R.692 of 30 July 2001.

RSA Development Facilitation Act (Act No 67 of 1995).

UK Health and Safety Executive. *Risk Criteria for Land-use Planning in the Vicinity of Major Industrial Hazards.* 1989.
RSA Weather Service. A C Kruger. *Climate of South Africa: Surface Winds. Publication No WS-43.* 2002.

RSA Weather Bureau. Climate of South Africa. Climate Statistics up to 1984. Publication WB-40.

RSA Weather Bureau. Climate of South Africa Part 8. General Survey. Publication WB-28.

UK Health and Safety Executive. *Lines of Defense / Layers of Protection Analysis in the COMAH (Control of Major Accident Hazards regulations of 1999) Context.* 1999.

The Concise Oxford Dictionary. 1983.

UK Health and Safety Executive. *Reducing Risks, Protecting People.* 2001.

D van Zyl. *South African Weather and Atmospheric Phenomena.* Briza Publications. 2003.

Statistics South Africa. Data sets for the RSA census survey in 2011.

Foresight Publications. *Emergency Response Guidebook of Southern Africa. A guidebook for first responders during the initial phase of a dangerous goods incident.* Compiled from the latest USA Department of Transport Emergency Response Guidebook (Annex A of SANS 10232-3) and modified to fully comply with Southern African requirements. 2006.

USA Environmental Protection Agency. *RMP Comp software programme for the calculation of overpressure safety distances.* 2006.

USA National Oceanic and Atmospheric Administration. Cameo Chemical Database. 2019.

University of Natal. Department of Agricultural Engineering. *South African Atlas of Agrohydrology and Climatology*. 1997.

South African Weather Service. *Climate of South Africa. Surface Winds*. 2002.

15 Appendices

Appendix 1: Raw data

Easigas Port Elizabeth MHI Survey 20 July 2020
Eveready Road
Sidwell; Port Elizabeth
Lisa Taljaard
Rudi van der Westhuizen

Site layout plan with new installation added
Emergency plan awaited

Inventory:
Five bulk tanks: four LPG and one unstenched butane; referred to LPG in this risk assessment
Tank 1: no capacity on nameplate, volume is 90 000 liters
Tank 2: 10 000 imp gallons 45 000 liters
Tank 3: 10 000 imp gallons
Tank 4: 10 000 imp gallons
Tank 5: butane, 90 000 liters
Three drums of Scentinel A, 200 liters each from Chevron, stenching agent for use at harbour, only stored here on site; negligible risk.
Tank 6 (new): 400 000 liters LPG
All tanks 7 barg pressure.

Number of filling scales: three
Number of pumps: 2
Number of cylinders on site, max for winter, 9/14/19/48 kg: 10 000
Number of deliveries per week: 3
Water supply: municipal or own reservoir? Municipal
Deluge on tanker offloading bay

Water deluge at tanks? Yes, all five tanks
Water deluge at filling platform? Yes, covering all three scales
Lpg detectors at filling platform?
Tanker does not reverse
Sidwell Fire Station Tel 041-5085600; email : scswell@mandelametro.gov.za; G Gelderbloem is station commander.
Residence opposite five LPG tanks, 100 meters
Number of workers 6
Lpg isolation valves: at each scale, at each pump, at each tank, thirteen in total
Electrical switch cut-off
Pipe from tanks to filling platform: 50 mm
CCTV monitoring to control room
Wind sock

A Niemand
AIA

T1	Name	UN No CAS No	SANS 10228 Class	Inventory	Bund surface area, m^2	Throughput	Release quantity
1	LPG tank storage tanks	1075 68476-85-7	2.1	Tank 1: 90 000 liters Tank 2: 45 000 liters Tank 3: 45 000 liters Tank 4: 45 000 liters Tank 5: 90 000 liters Tank 6 (new): 400 000 liters All tanks 7 barg	-	135 000 liters per week	90 000-liters 49 500-kg
2	LPG road tanker	1075 68476-85-7	2.1	45 000 liters 7 barg	-	135 000 liters per week	45 000 liters 24 750 kg
3	LPG cylinders	1075 68476-85-7	2.1	10 000 cylinders in total 9/19/48-kg range	-	4 000 cylinders per week	48-kg

Appendix 2: Case studies

LPG Tank Truck road accident and subsequent BLEVE

7. Driver of the said LPG Bulk TT immediately advised nearby houses and shops to vacate stating

that fire can take place any movement. Local residents alerted State Electricity Board who put off the grid power supply immediately. The LPG continued to leak for about 20 minutes and huge LPG vapour cloud formed at the sites. Subsequently, the LPG vapour cloud caught fire – source of ignition is yet to be established. Thereafter, 3 explosions took place consecutively. BLEVE conditions existed and BLEVE probably took place. The front dish end of the bullet with 1/3 rd of the cylindrical shell of the bullet flew away

almost 400 mtrs. in a green field. The rest of the Bullet plates were rendered flat. With these three explosions, the rear wheel and the front wheel of the LPG Bulk TT also flew away in different directions of the road. All the nearby houses and shops were damaged due to fire and explosion. On the date of investigation, 20 people were reported to have died and 17 people were still admitted with burn injury in hospitals. People who were inside the house were saved but those who came out from the house and running along the wind direction got burnt badly. Fire Brigade reached the spot but could not approach the vehicle before the explosion took place. The driver was arrested by police at a later date. The tank lorry was not accompanied by helper at the time of accident.

8. As per available record, driver was having valid license duly indorsed by RTO for carrying hazardous good however the validity of hazardous goods of the driving license was expired. As per concerned OMC record, the empty TT entered the loading location along with the driver & helper but the LPG Bulk TT was found to be running without helper on road when the incident took place.

9. As per available record of loading OMC, the said driver loaded the same TT three times ex ex-the loading location prior to this accident but he was going with the said TT to the concerned stretch of road for the first time. As per the check list issued by the involved OMCs, validity of endorsement in the driving license for carrying hazardous goods was valid but the copy of the document provided to the investigation team indicated that the same expired long back.

Action by the Investigation team covered the following:-

1. Survey of the stretch of road travelled by LPG Bulk TT.
2. Visit to the accident spot, interaction with the eye witnesses, collection of photographs and analysis of the tank truck conditions.
3. Interaction with RTO officials (enroute from loading location to the accident spot) & TT crew members of other bulk LPG Tank lorry (available enroute).

LPG Tank Truck road accident and subsequent BLEVE

4. Interaction of the officials of the loading location, collection of documents and study of prevailing system followed by the OMCs concerned for Bulk TT Loading assistance.

5. Root cause analysis and framing recommendations remedial measure

10. Root cause of the accident:-

1. Historically the place where the accident took place is an accident prone Zone. No speed limit is defined while approaching to that spot from either side of the road. No caution board, divider signal, curve signal, speed barrier are provided on the either side of the road. No pedestrian zebra crossing signal is painted on the road. While approaching from loading location side, this was the first divider put on the road without any signal.

2. Restriction on TT movement in Highway during day time imposed by local State Govt imposed fatigue related hardship/inconvenience on the drivers forcing them to drive only during night time.

3. Although loading location routinely ensured presence of both TT crew members during TT loading within the location premises but there was little or no control on ensuring presence of both the members for TT on road.

4. LPG tank lorry valve manifold got damaged due to high impact resulting in uncontrolled leakage of LPG.

Recommendation:-

1. Proper signage's to be displayed on the both side of the highway cautioning driver and pedestrian about the traffic rule and road conditions. A physical Speed barrier / rumble strip needs to be provided before such accident prone zones.

2. OMC to represent for review of the current restriction imposed by the state government and relaxation to be made for movement of POL & LPG tank trucks on the highway during day time to minimize night driving fatigue to the driver.

3. Law enforcing agency of the state government should implement MV Act in true sprit without any deviation ensuring 2 member crew in heavy vehicles at all the time as stipulated in the explosive license issued to the TT.

4. OMC to device a mechanism to put in control measures to implement transport tender conditions w.r.t safety conditions even outside the terminal while on transit and strict action should be taken in case of violation.

LPG Tank Truck road accident and subsequent BLEVE

5. Design changes in the manifold of LPG Tank lorry to ensure:

    a. Adequate protection to the manifold to ensure that in case of accident minimum damage to the manifold / valves takes place thus preventing the leakage during such emergency.

    b. In-case of major damage to the manifold - suitable design changes in the Excess Flow Check Valve (EFCV) to prevent uncontrolled leak to the external. This may also include the review in material of construction of the EFCV to increase its strength and avoid its consequent damage which at present is brass – a weak link between the LPG valves and the Tank Truck shell.

    c. Industry to implement of VTS and AVS on all LPG TTs in line with such features in POL TTs.

    d. Online driver safety records along with personal details like driving license, validity, hazardous validity, address, Telephone No. to be maintained by OMC for easy identification.

See also valuable information on BLEVEs for firefighters at:

https://www.firerescue1.com/firefighter-training/articles/what-firefighters-need-to-know-about-bleves-EwLDAJRkauiIfaDR/

J Indian Acad Forensic Med, 31(1)

Case Report

Fatal LPG cylinder blast accident – a case report

Tabin Millo[*], M. Sunay[**] & A.K Jaiswal[***]

Abstract

Accidental explosions[1] in the home are not uncommon which may be associated with gas leaks, the storage of explosive material such as propane. LP Gas cylinders are very commonly used in the household as a cooking gas and also as fuel in motor vehicles. In spite of safety guidelines accidents occur which are fatal. Due to the release of high pressure LP gas the blast effect becomes destructive and fatal. We report here a case of two deaths due to fatal LPG cylinder blast, which came for autopsy to AIIMS Mortuary.

Key words: *Liquified petroleum gas, blast, propane, butane.*

Introduction

LPG or LP Gas is the abbreviation of Liquefied Petroleum Gas. This group of products includes saturated hydrocarbons – propane (C_3H_8) and butane (C_4H_{10}), which can be stored and transported separately or as a mixture. They exist as gases at normal room temperature and atmospheric pressure. It is called Liquefied petroleum gas because these gases liquefy under moderate pressure. They liquefy at moderate pressure readily vaporizing upon release of pressure. It is this property that permits transportation of a storage of LP Gas in concentrated liquid form.

LPG comes from two sources. It can be obtained from the refining of crude oil. When produced this way it is generally in pressurized form. LPG is also extracted from natural gas or crude oil stream coming from underground reservoirs. 60% of LPG in the world today is produced this way whereas 40% of LPG is extracted from refining of crude oil.

The commercialized product referred to as "propane" and "butane" consists very largely of these saturated hydrocarbons, but during the process of extraction/production certain allowable unsaturated hydrocarbons like ethylene, propylene, butylenes etc. may be included in the mixture along with pure propane and butane. The presence of these in moderate amounts would not affect LPG in terms of combustion but may affect other properties slightly (such as corrosiveness or gas formation).

Case history

On 17.10.07 two cases were brought for postmortem in AIIMS Mortuary, Deptt. of Forensic Medicine and Toxicology. The inquest paper revealed that the deceased were couples who were found dead in the their kitchen room in their residence in Defence colony, South Delhi. The neighbours heard a loud blast sound at about 7.30 pm on 16.10.07. When they rushed to the house they found the husband and the wife lying in the floor with the pool of blood. They rushed them to the AIIMS emergency but they were declared dead on arrival. The scene of accident in the kitchen showed blood spattered in the floor, wall and even in the roof. There was a LPG cylinder kept on the side in standing position with the knob open. The room was well ventilated.

The external examination of the body of the husband showed a well-built body, brownish complexion, 5 feet 6 inch tall with 75 kg weight. The rigor mortis was well developed in all the four limbs and the postmortem lividity seen on the backside and the dependent parts of the body. There was singeing of hair in the eyebrows and

****Corresponding author** -Assistant Professor
e-mail: tabinmillo@yahoo.co.in
**Junior Resident,
***Chemist, Dept. of Forensic Medicine and Toxicology, AIIMS, Ansari Nagar, New Delhi - 29 .

scalp. There was multiple burn injury (I and II degree) over the face, neck, anterior chest wall, left upper limb, anterior abdomen, and left anterior thigh. There was a lacerated wound of size 7x4 cm, muscle deep with charred margins in the postero-medial aspect of left arm. There was another lacerated wound of size 4x6 cm, muscle deep with charring of underlying muscle. The left hand was amputed at left wrist joint with charring of the skin and soft tissues. There was rupture of the anterior abdominal wall with a gap of 60x40 cm with charred margins and the visceral organs exposed. On internal examination the lower respiratory tract showed blood stained froth. There were subpleural haemorrhagic patches on both lungs. The heart surface showed multiple contusions of size about 1x1 to 2x2 cm. The stomach showed semi digested food mixed with blood about 100 ml. The left kidney showed laceration of size 4x2 cm on the anterior surface of the middle third region.

The external examination of the wife's body showed a well built 45 yrs old, brown complexion, 5 feet one inch tall, weighing 60 kg. The rigor mortis was well developed in all the four limbs and postmortem lividity present in backside of abdomen and the dependent parts. The body showed multiple contused abrasions and lacerated wounds (skin to muscle deep) varying in size from 8x5 cm to 1x 0.5 cm present over the face, anterior chest, anterior abdomen and anterior aspect of both upper and lower limbs. On internal examination there was multiple contusions over the surface of the stomach, small intestine and mesentry. The stomach contained one litre of blood stained fluid mixed with semi-digested food. The left kidney showed laceration of size 4x1x0.5 cm in the anterior surface of the lower pole with the surrounding haemotoma. There was no visible pathological lesion in both the case.

The cause of death in both the case was given as shock due to blast injuries sustained by the accidental LPG cylinder blast.

Discussion

In the victims of explosion we can see various types of injuries like blunt impact injuries (bruises, abrasions, lacerations, incised wound usually occurring over the bony prominences where the skin is less mobile, penetrating injuries, burns and fractures. In both the above cases we find the mixture of these injuries. The pattern, distribution, consequences and medical management of explosion injuries varies greatly with the nature [8, 9, 10] of the explosive material. The explosive blast injuries can be divided into four main categories[1] and the nature and extent of injuries depends upon the blast wave energy of the explosion. The primary blast injuries result directly from the sudden changes in enviromental pressure caused by the blast wave. Disintegration or disruptions of tissues tend to occur when the tissues are in close proximity to the explosive device. The flying debris striking the victim causes the secondary blast injuries. Most bodies, unless in extreme proximity to the centre of the explosion, remain relatively intact. One of the characteristic features of bomb blast is body stippling with the the injury triad of bruising, abrasions and lacerations. The tertiary blast injuries are caused by victim impacted against stationary object e.g, injuries by collapsing collapsing buildings. Babar et al [4] showed in their study on ocular trauma that 20% of the ocular trauma was caused by gas cylinder and automobile battery explosives. The injuries in these two cases were mainly of primary impact due to the blast waves caused by the LPG cylinder blast. The body of the husband showed abrasions, contusions, lacerations, burn injuries, fracture of left wrist joint bones with amputation and lacerations of visceral organs. The majority of the injuries were present on the front side and above the waist area. The scene showed blood spattered over the wall and the roof and the cylinder standing below with open knob. This suggest that both the victim must be standing close to the cylinder and the husband must have handled the cylinder with his left hand. The injury severity is more in the husband suggesting that he must have in more proximity to the cylinder. The bloodstain in the roof suggests the upward direction of the blast wave. The cylinder appears to have defective valve in the knob which has caused the leak and the subsequent explosion.

Common properties of LPG [3]

It is colorless and cannot be seen.

- It is odorless. Hence LPG is odorized by adding an odorant prior to supply to the user, to aid the detection of any leaks.
- It is slightly heavier than air and hence if there is a leak it flows to lower lying areas.
- In liquid form, its density is half that of water and hence it floats initially before it is vaporized.
- It is non-toxic but can cause asphyxiation in very high concentrations in air.

LPG expands upon release and 1 liter of liquid will form approximately 250 liters of vapor. LPG is used as a fuel for domestic (cooking), industrial, horticultural, agricultural, heating and drying processes. LPG can be used as an automotive fuel or as a propellant for aerosols in addition to other specialist applications. LPG can also be used to provide lighting through the use of pressure lanterns while butane and propane are different chemical compounds, their properties are similar enough be useful in mixtures. Butane and propane are both saturated hydrocarbons. They do not react with other. Butane is less volatile and boils at 0.6 degree C. Propane is more volatile and boils at degree C. Both products are liquids at atmospheric pressure when cooled to temperatures lower their boiling points. Vaporization is rapid at temperatures above the boiling points. The calor (heat) values of both are almost equal. Both are thus mixed together to attain the vapor pressure that is required by the end user and depending on the ambient conditions. If the ambient temperature is very low propane is preferred to achieve higher vapor pressure at the given temperature. The advantages of LPG are as follows:

- Because of its relatively fewer components, it is easy to achieve the correct fuel to air ratio that allows the complete combustion of the product. This gives LPG its clean burning characteristics.
- Both propane and butane are easily liquefied and stored in pressure containers. The properties make the fuel highly portable, and hence, can be easily transported in cylinder or tanks to end-users.
- LPG is a good substitute for petrol in spark ignition engines. Its clean burning properties,a properly tuned engine, give reduced exhaust emissions, extended lubricant and spare plug life.
- As a replacement for aerosol propellants and refrigerants, LPG provides alternatives fluorocarbons, which are known to cause deterioration of the earth's ozone layer.

Mechanism of cylinder of cylinder blast [3]

LPG is a flammable gas. It is the most commonly used cooking gas in every homes. It is generally contained in iron gas cylinders and delivered to homes by the authorized dealers. The average weight of the cylinder is 14.2 kg. The flammable limit value of LPG is between 1.8% to 9.5% volume of gas in gas/air mixture. The flammability range for LPG is considerably lower and narrower than that for other commonly used gaseous fuels. The small percentage concentration at the lower limit, however, means that even small leaks can create explosive atmosphere. It is colourless which means that it's presence by sight cannot serve as warning signals for the impending potential fire hazards whenever there is a leakage. It is distinctively odorized to give warning in case of leakage. The odourant contents is about 1/5th of the LFL i.e., (0.36%). In other words, it can be smelt long before it becomes dangerous enough to catch fire.

Its vapour density is 1.8 to 2.0 at 25°C. LPG in gaseous state is nearly twice heavier than air. Any leakage of LPG, therefore will tend to collect in low lying areas such as drains. This should be borne in mind when dispersing LPG leaks. The liquid to gas expansion ratio is 1:250 at atmospheric temperature. It means 1 volume of liquid on expansion generates 250 volume of gaseous LPG. The leakage of liquid LPG is, therefore very dangerous. The liquid density of LPG is 0.525 to 0.580 at 15°C which is lighter than water. Therefore in case of leakage LPG could be carried by flowing water. This factor should be borne in mind when using fire water hose streams for fire control purposes. The latent heat of vapourization value for LPG is 88 Kcal/kg at 20°C at 1 atm pressure.

Hence, the latent heat of vaporization is very high for LPG. Thus, LPG takes large quantity of heat, when it vaporizes. On vaporization, LPG's requirement for latent heat gives rise to the cold burn resulting from liquid contact with naked flesh. This results in several local chilling and damage to the tissues.

The LPG has high calorific value of 11000 Kcal/kg. The poor visibility of the ignitable mixture and high burning velocity that can injure instantly anyone coming into contact with it, on account of high caloric value of LPG.

Most of the LPG explosion accidents are due to the vapour cloud explosion (VCE) event. It starts with the leakage of LPG either due to damage of the connecting tube or defective valve sealing the cylinder. The wind plays a significant role in its dispension. The immediate ignition of this LPG will cause fire balls followed by the delayed ignition which cases vapour cloud explosion causing severe damages.

The boiling liquid expanding vapour explosion (BLEVE) occurs where there is a major container failure, which contained liquid above its boiling point. A BLEVE is generally followed by a fireball, which rises due to the buoyancy effect of hot gases. The burning liquid droplets fall down like rainfall. The BLEVE of an LPG vessel occurs when it gets engulfed in fire as in case of a pool fire at ground level.

LPG gets overheated resulting in pressure build-up. The pressure in vapour space increases, PSV starts leaking and a flame appears at PSV discharge nozzle. The vessel portion is contact with liquid LPG remains cool while those in contact with vapour LPG get overheated. The steel gets softened due to reduced UTS. Thinned vessel wall ruptures due to enhanced internal pressure. The overheated LPG mass gets ejected, catches fire and rises as a fireball followed by blast.

Common causes of LPG accidents

Liquefied petroleum gas is a flammable gas, which has the potential to create blast accidents. Therefore it is important that the properties and safe handling of LPG are understood and applied in the domestic and commercial/industrial situations.[3]

- Liquefied petroleum gas is stored under pressure. The gas will leak from any joint connection, which is not sealed properly.
- Liquefied petroleum gas is heavier than air. Any significant leak will move downward and stay on the ground. LPG will accumulate in any low-lying area such as depressions in the ground, drains or pits.
- Since LPG is stored in two phases, liquid and gaseous, there is potential for either liquid leak or a gas leak.
    - If the liquefied petroleum gas leak is a gas leak it may not be seen (because LPG is colourless), except where the leak is of sufficient size to be seen shimmering in the air.
    - When a liquid liquefied petroleum gas leak occurs, the gas release will be as a patch of ice around the area of the leak, or as a jet of white liquid. This white appearance is due to the cooling effect created by the rapid expansion the LPG liquid into a gas. The condensing atmospheric moisture makes them visible.
    - In concentrated amounts and in uncontrolled conditions, liquefied petroleum gas has the potential to create a fire or an explosion.

As per the various investigation conducted by OISD, it found the following common causes for the LPG related accidents.[3]

i) Overfilled/liquid full cylinders, which are highly dangerous.
ii) Forgetting to switch off the regulator when not in use.
iii) Damaged O-ring of the PR knob.
iv) Leak of LPG from damaged rubber lube.
v) Incorrect way of fixing the regulator causing damage and leak of LPG.

Safety precautions[3]

Choose an LPG supplier who can provide you with well-maintained LPG cylinders after-sales support.

- Always close the cylinder or tank valves after use.
- Use a child-safe regulator on the LPG cylinder for domestic use.
- Ensure that your LPG supplier provides a supply of LPG that is odorized to allow smell and detect leaking LPG.
- Always use LPG appliances, and other gas equipment that is approved for use, and meets all local safety standards.
- Check for gas leaks on a regular basis.
- Always use LPG rubber tubes that have an ISI mark.
- Always close the LPG cylinder or tanks valves after use.
- Never check for gas leaks using a lit match. Always use a solution of soapy water to look for bubbles coming from around valves and pipe joints. These bubbles indicate gas leak.
- Replace the LPG cylinder hose on a regular basis, and replace any damaged hose with a new hose.
- Stand the cylinder upright and make sure that any hose connection between the cylinder and the appliance does not come into contact with or near the gas burner.
- If you smell or find a gas leak:[5,7]
    - ♣ Turn off the gas supply valve from the cylinder of the tank.
    - ♣ If possible turn off the appliance.
    - ♣ Turn off or remove any other source of ignition.
    - ♣ Ventilate the room by opening doors and windows.
    - ♣ Inform your gas supplier immediately.
    - ♣ Leave the house or apartment, and advise your neighbours.
    - ♣ If you think that there is a danger of a fire, call the Fire Service.

Conclusion

Deaths and injuries from the effect of explosive devices and the explosive substances can occur in a variety of circumstances. And LPG cylinder[6] is one the common cause of domestic blast accidents. The primary role of the medical investigation of explosives is to document the injuries and collect evidence that will assist with the investigation of the nature and source of the explosion. It is also important to educate the public about the safety precautions in handling the LPG cylinders and enforce strict guidelines for standards and precautions to be followed by the Suppliers.

References

1. **Alexander Beveridge.** Forensic Investigation of Explosions. 1st Edn, Taylors Francis, London, 1998; 453-476.
2. Soveneir- National symposium on awareness and mitigation of exposure to domestic and industrial chemicals, organised by Natonal Disaster Management Authority, Govt. of India and Notional Poison Information Centre, AIIMS, Delhi, on August 30-31th 2007.
3. http://www.e-lpg.com/lp-gas.asp assesed on 1.1.2008.
4. **Babar TF, Khan MN, Jan SU, Shah SA, Zaman M and Khan MD**. Frequency and causes of bilateral ocular trauma. *J Coll Physician Surg Pak* .2007; 17 (11):679-82.
5. **Rani M, Gupta A, Dikshit PC, Aggrawal A, Setia P and Dhankar V**. Accidental death resulting from acetylene cylinder implosion. *Am J Forensic Med Pathol*. 2005;26(2):170-73.
6. **Chandulal R.** Accidental death due to explosion of gas cylinder. *Med Sci Law*. 1974;14(1):51-52.
7. **Flinch JS**. A report on a possible hazard of gas cylinder tanks. *Anesthesiology*. 1970;33(4):467.
8. **Baject J, Gang RK and Laria AR.** Post Gulf war explosive injuries in liberated kuwait. *Injury : Int J Care Injured.* 1993; 24 : 517-20.
9. **Boffard GJ and MacFarelane C**. Urban bomb blast injuries: patterns of injury and treatment. *Surgery Annal*. 1993: 25 : 29-47.
10. **Hull JB, Bowyer GW, Cooper GJ and Crane J.** Pattern of injury in those dying from taumatic amputation caused by bomb blast. *British J Surg.* 1994; 81: 1132-5.

Appendix 3: Schedule A of the General Machinery Regulations of 1988

United Nations Organisation Identification Number	Substance	Notifiable Quantity in Tonnage
1001	Acetylene (dissolved)	2
1005	Ammonia (anhydrous, liquified and solutions containing over 50% ammonia)	20
1010	Butadiene	25
1031	Carbon disulphide	20
1017	Chlorine	10
1154	Diethylamine	20
1155	Diethyl Ether	20
1033	Dimethyl Ether	20
1032	Dimethylamine (anhydrous)	20
1220	Dimethylamine (solution)	20
1035	Ethane (compressed)	15
1961	Ethane (refrigerated liquid)	15
1962	Ethylene (compressed)	15
1038	Ethylene (refrigerated liquid)	15
1036	Ethylamine	25
1040	Ethylene oxide	5
1050	Hydrogen Chloride (anhydrous)	10
1051	Hydrogen Cyanide (anhydrous)	10
1052	Hydrogen Fluoride (anhydrous)	10
1969	ISO-Butane	25
1055	ISO-Butylene (Isobutene)	25
1075	LPG (Liquid Petroleum Gas)	25
1971	Methane (compressed)	15
1011	n-Butane	25
1012	n-Butylene (Butene)	25
1076	Phosgene	2
1978	Propane	25
1077	Propylene	25
1079	Sulphur Dioxide (liquified)	15
1829	Sulphur Trioxide (liquified)	15
1083	Trimethylamine (anhydrous)	25
1086	Vinyl Chloride	25

Appendix 4: Site Emergency Response Plan

EASIGAS	EMERGENCY RESPONSE PLAN	Ref ERP-PED Version : *2.1*
	PE Depot	15/08/2019

LPG SITE
Port Elizabeth Depot

Emergency Response Plan

Eveready Road, Sidwell, Port Elizabeth, 6001

Phone : 041 451 1775

Hard copy N°: 001

The content of this Emergency Response Plan is based on Rubis Guideline for the preparation of a LPG site ERP. The setup of the organisation for emergency response and the systems of communication described here below are compliant with the requirements of current local legislation and relevant authorities.

	NAME	POSITION	DATE	SIGNATURE
Prepared by (custodian):	Rudi vdWesthuizen (RW)	Depot Manager (DM)		
Reviewed by :	Bulali Mdontsane (EH)	National Depot Manager (NDM)		
Approved by :	Welcome Bila(WB)	Operations Manager (OM)		

This document is restricted for internal use only. Neither the whole nor any part of this document may be disclosed to any third party without the prior written consent of the National Depot Manager.

Page 1/20

AMENDMENTS :

Date	Version N°	Description of amendment	Amended by
01/08/2019	ERP001	Comprehensive review of the Emergency Response Plan	RW
30/04/2020	ERP 002	Update change of Operations Manager	BM

Distribution list:

Controlled hard copies of this document have been sent to positions on this list. The list is maintained by the custodian. Further updates and revisions will be sent only to positions on the list. Recipients who require extra copies must make a request to the custodian to join the list and receive a controlled hard copy. All authorised hard copies of this document must have the signatures of the review and approval authorities.

Hard copy N°	Recipient
1	Depot Manager
2	HSEQ Department
3	Disaster & Emergency Management Services
4	Nelson Mandela Metro Municipality

Uncontrolled document if not downloaded from EASIGAS / Common drive, recipient having no access to EASINET must engage the Depot Manager to get the last version of the document. Documents are recorded on J-Drive/Operations/HSE/2019EMERGENCY RESPONSE PLAN.

CONTENTS

Annexures

- Alarm message to Fire Brigade
- Site Specific Emergency contact details list
- Instructions for Security guards in case of Emergency
- EASIGAS Emergency contact details list*
- Reflex -card LPG Fire*
- Reflex card - Not ignited leak*
- Reflex card – Alarm out of working hours*

** Document on common ERP document folder (to be printed and add at the end of this document for each printout)*

1. PRESENTATION OF THE SITE

1.1. DESCRIPTION OF THE SITE

Bulk Facility:

- Bulk storage total capacity:
  - 168 535KG or 315 m3

- Description of bulk facility:
  - 2 x 90m3 LPG Storage Tanks on plinths
  - 3 x 45m3 LPG Storage Tanks on plinths

Product stored: LPG mix (50% to 70% propane)

Bulk throughput:

- Annual: 1500 tons
- Low month: 95 tons
- Peak month: 170 tons

Cylinder storage:

- storage of EASIGAS Vapour outlet cylinders capacity: 5 kg, 9 kg,14 kg, 19 kg and 48 kg.
- storage of EASIGAS Forklift (liquid outlet) cylinder: 14 kg and 19 kg.
- storage of EASIGAS double valve (vapour and liquid outlets) cylinder: 48 kg.

Storage of other company's cylinders with similar capacities. 2000
Average qty of empty cylinders on site: 8500
Average qty of full cylinders on site: 1500

Max storage capacity allowed by fire license:

- bulk: 143 200 kg
- packed: Not stated
- Total: Not stated

Activities on site:

- Storage of bulk LPG
- Storage of packed LPG
- LPG cylinders filling
- Bulk truck offloading (1 Road bay)
- Bulk truck loading (1 Road bay)
- Packed truck loading and dispatching
- Cylinder decanting
- Cylinder re-valving and painting

Staff:

- Administrative: 2
- Permanent workers on site (driver is excluded): 7
- Additional Temp staff during peak season: 1

Security:

- Company: RPU & Stallion
- Working hours: 24/7
- Closing hours: Business Hrs: 07H00 – 16H00

After Hrs: 16H01 – 06H59

1.2. LOCATION MAP

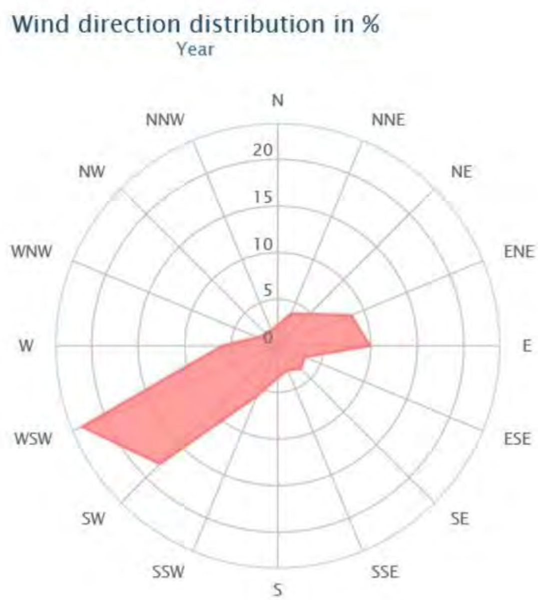
Geographical coordinates:

33°54’46.70”S
25°35’48.34”E

1.3. SITE SURROUNDINGS

Adjacent Facilities
Eveready Complex – Lithium Ion Battery manufacturer – Distance 110m

1.4. Compass card



1.5. RESOURCES AVAILABLE

1.5.1. *Firefighting equipment*

Water reserve: *information on type and number of storage tanks, connection to public network and other industrial sites, replenishment capacity including supply by fire brigade …*

Main Supply – Municipal Water (*supply pressure at* ***500-600 kPa***)

- Supplies Platform and Tank Farm Sprinkler System and Road and rail bays
- Supplies Fire Hydrants

Water pumping and network: *provide information on water pumps type and number, their nominal flow rate at designed pressure, their autonomy if not electrical, their procedure for start-up…For the water network describe type e.g. pressurized with automatic valves on pumps, full with all valves open at start-up of pumps,others…No water pumps*
Fix firefighting equipment *provide list by type of equipment (water spray lines, water cannons, water curtains, hydrants…) and by location (LPG storage tanks, LPG pumps, bulk transfer points, cylinder filling building, cylinder storage area…)*

- Hydrant 1 – Main Gate to the right
- Hydrant 2 – Behind control room
- Hydrant 3 – At Workshop door
- RTC – fixed water cannons x2
- Hose reel to the right of filling scales
- Hose reel on the control room side of road tanker bay.

Mobile firefighting equipment: *provide list of equipment and their storage location in the site*

1. Fire extinguishers: *provide list of fire extinguishers and their number by type i.e. CO2, powder, water…)*

2. Filling Platform
   - 2 x 9kg DCP – Left of filling scales
   - 2 x 9kg DCP – Right of filling scales
   - 2 x 9kg DCP – On either side of coldworks station
3. LPG Bulk Tanks
   - 2 x 9kg DCP – At tanker bay
   - 2 x 9kg DCP – Building side of tanker bay
   - 2 x 9kg DCP – Northern entrance to tank farm
   - 2 x 9kg DCP – Western entrance to tank farm
4. Main office building:
   - 3 x 9kg DCP – Along northern wall
   - 1 x 5kg DCP – Upstairs office door
   - 1 x 5kg DCP - Kitchen
   - 4 x 9kg DCP – Mixer room
   - 4 x 9kg DCP – Booster room
   - 1 x 9kg DCP – Control room
   - 1 x 2.5kg DCP – Control room kitchen

5. Sales Building
   - 1 x 9kg CO2 – Reception entrance
   - 1 x 5 kg DCP – Kitchen entrance
6. Training Building:
   - 1 x 5 kg CO2 – Main room
7. Storage building:
   - 6 x 9 kg DCP – outside entrance

1.5.2. Medical assistance

Provide information on equipment available such as first aid kits, emergency blankets, dedicated room for treatment, first aid trained staff…

First Aid Kit:	*1 kept in the Storage Room (next to DA office)* *1 x Kept on filling platform*
First Aider	*Luyanda Qawe (filler)* *Sam Mgala (filler)* *Richard Makana (filler)* *Mfuneko Fuzile (truck assistant)* *Bulelani Jama (driver)* *Heinrich Malgas (driver)*
First Aid Room:	*Spare office next to kitchen in main building.*

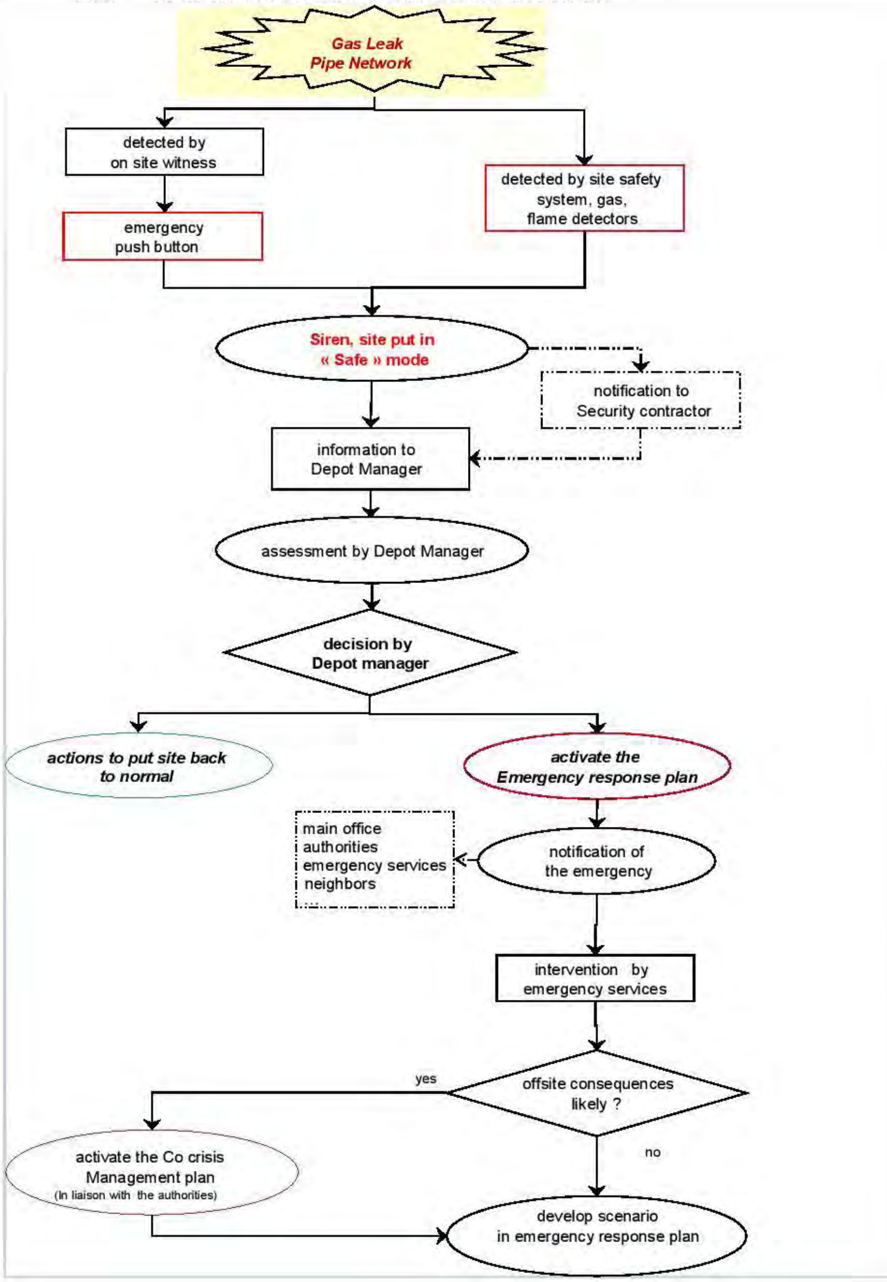
1.5.3. Other specific resources

Provide information on other resources not available on site that might be necessary such as lifting equipment, civil works, transport … with contact names and numbers including outside working hours.
Refer to contact list

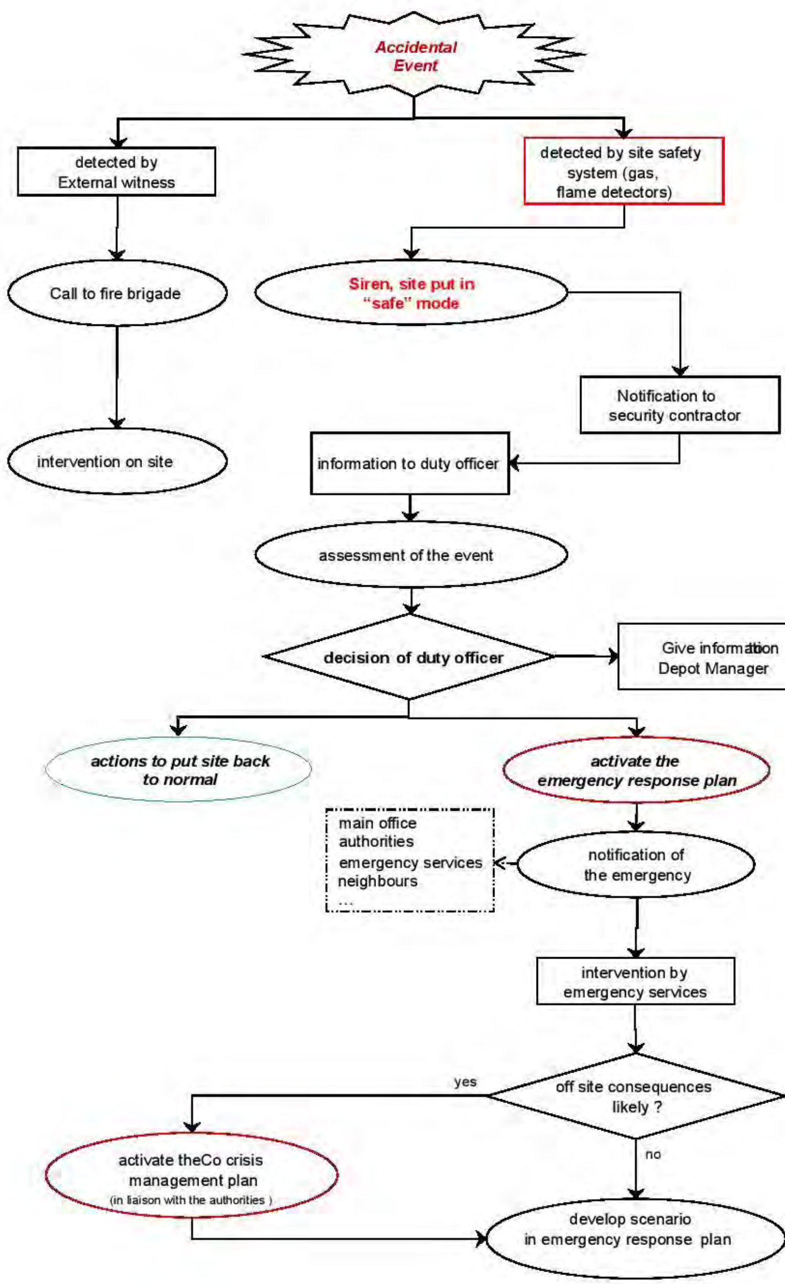
Updated list of Technical Contracto

2. ALARM

2.1. SEQUENCE OF ALARM DURING WORKING HOURS



2.2. SEQUENCE OF ALARM OUTSIDE WORKING HOURS



3. Emergency organisation

3.1. Roles / functions and staff available

The different functions in the Emergency Response Plan and the corresponding staff in the organisation are shown in the matrix below. Depending on the circumstances of the event and the staff available one member of staff can oversee the different functions.

		Site staffing at the time of the event					
		During working hours				Out of working hours	
Controller		DEM	DEA	DEO	DEAC	DEM	DEAC
Location		*ECR*	*ECR*	*Site*	*Master point*	*Remotely and ECR*	*Site*
List of roles / functions to be implemented	DM	**X (1)**				**X(1)**	
	DA	X (2)	X(1)			X(2)	
	Field operations supervisor		X(2)				
	Senior filler / Team Leader / Site Technician	X		X(1)			
	Security	X			X		X

Final Copy – Authorised for Submission to Authorities

3.2. EMERGENCY CONTROL ROOM (ECR)

Provide information on location of the ECR and conditions for access during and outside work hours.

ECR for PE depot is in the control room.

Provide information on the list of facilities and equipment permanently available.
See example of content in the appendix 3 of the guide.

Site layout drawings to highlight firefighting equipment , emergency buttons and LPG lines and valves made available in the control room.

3.2.1. *Drawings*

The Depot Manager must ensure that the last version of the following drawings in A1 or A0 printout format be continuously available in the ECR.

1. GENERAL SITE LAYOUT DRAWING
2. LPG piping network (PID and/or PFS) *
3. Firefighting water piping network*
4. Mobile firefighting equipment (drawing with position of equipment)
5. Emergency buttons, gas and fire detectors (drawing)

Note that some of those drawings can be merged together.
* those drawings must be continuously displayed in the ECR

3.2.2. *Arrangement and fittings*

- Site Camera Vision
- *Siren Safety Mode Control* **
- *ESD and Water Control Systems* **
- Basic First Aid Equipment**

3.3. EVACUATION OF PEOPLE

Describe the procedure for the evacuation of people in case of an emergency, i.e.:

- *Assembly Point: Assembly point 1 at exit to Filling yard. Assembly point 2 next to control room as demarcated.*
- *Meeting point for the emergency team: ECR/Control Room*
- *Communication of the command to evacuate – Activation of ESD (sprinkler system) or Siren*
- *Personnel in charge of assisting staff, third parties, contractors, in the evacuation: Fire Marshalls and Security Staff*
- *Accounting for people at assembling point – Security Staff on duty by entry and exit Logbook, Fire Marshall/SHE Rep to assist in verifying complete evacuation of all staff members and contractors on site.*
- *Other – . In case of office building fire – The Fire Marshall to ascertain that all doors and windows are closed to limit exposure to spreading of fire.*

4. ROLES AND RESPONSIBILITIES

4.1. DEPOT EMERGENCY MANAGER (DEM)

4.1.1. ***During Working hours***

- Use the relevant Reflex Card to records events and decisions
- receive or make the initial assessment of the event and use the relevant Reflex Card
- direct the shutting down of depot and evacuation of non-essential workers to assembly areas
- decide to activate the ERP, to call for external assistance,
- go to the ECC and ensure that the key personnel are mobilised
- prepare the alarm message and communicate (call) the fire brigade service
- supervise the onsite intervention based on Reflex Card guidelines
- review and assess developments, as appropriate, to help predict the most likely development of the incident and to activate the crisis plan
- ensure that casualties are receiving adequate attention and, if appropriate, arrange for additional assistance.

4.1.2. ***Out of the working hours***

- Call the fire brigade
- Use the relevant Reflex Card to records events and decisions
- Prepare the alarm message
- Alarm message can only be collected by Site Supervisor/ Site Manager
- Call the fire brigade and the site managers.
- The site manager to Inform the NDM, OM, HSSE.
- The security (remote monitoring) contractor to call the organisations below to answer delivery of alarm message and to repeat it.


Function form SMC.docx

4.1.3. ***After the arrival of the emergency services :***

- liaise with the chief officer of the fire brigade :
  - inform on event and current situation,
  - provide advice on response strategy based on Reflex Card guidelines
  - assess the need to activate the Disaster plan based on Reflex Card guidelines
- review and assess developments to help predict further actions

4.1.4. ***End of emergency:***

- decide of the end of emergency in liaison with emergency services

- ensure communication to all parties
- ensure that full consideration is given to the preservation of evidence (call cards records, CCTV records..)
- control the rehabilitation of affected areas after the emergency (note that the resuming of the activity can only be carry out after EASIGAS Managing Director authorization)

4.2. DEPOT EMERGENCY ASSISTANT (DEA)

During working hours only

- Assist DEM
- Communicate alert (phone call) to relevant parties (head office / neighbours / local authorities) on DEM request
- "Welcome" the fire brigade on arrival
- Ensure that injured people are "treated" (first aiders) and ER24 has been called in this case

4.3. DEPOT EMERGENCY OPERATOR (DEO)

During working hours only (no 24/7 personal on site)

- Perform event confirmation
- When feasible
    - Ensure that all relevant protection systems are working (sprinkler, booster pump.)
    - Install additional protection advised by DEM

4.4. DEPOT EMERGENCY ACCESS CONTROLLER (DEAC)

- In charge to count/confirm staff upon emergency
- In charge to control site access
- Inform DEM as soon as fire brigade arrives at the gate

5. TRAINING AND TESTING

On all EASIGAS depots, the training of staff on emergency situations is defined, assessed and scheduled by the HSEQ Department in order to provide the relevant skills to the staff according to their assigned missions in case of Emergency.

In addition to training the following Emergency Response drills are organised based on a scenario every 3 months.
The Depot Manager must communicate his annual ERP drills to the local fire brigade and invite them for any drills.

Annual table Emergency management response review which must involve:

- DEM
- DEA
- DEO
- Fire brigade chief (as much as possible)
- EASIGAS Manager (Operations Manager or/and HSEQ Manager or/and National Depot manager)

This review will consist in:

- Lessons learns from previous drills
- Identify upgrade to be perform either on the ERP documents or on site (examples: equipment tagging, need of additional fire monitor systems)

RC01 GENERAL EASIGAS EMERGENC

RC02 Reflex Card. LPG fire .docx

RC03 Reflex Card LPG leak not ignited

RC04 Reflex card Non Workings hour

ALARM NOTFICATION CARD

From: Easigas(Pty)LTD – PE Depot Tel: 041 451 1775
Eveready Road, Sidwell
Port Elizabeth

Day :	Date :	time :

To : ....
....
....

Easigas (Pty) Ltd – PE Depot

We activate our emergency response plan

☐ this is an exercise ☐ this is NOT an exercise

TYPE OF EVENT	LOCATION	
☐ Gas leak (not ignited)	LPG storage tanks	☐
☐ Gas leak (ignited)	LPG pumps	☐
☐ Fire	LPG compressors	☐
☐ Explosion	Bulk truck transfer point	☐
☐ other:	Bulk truck	☐
	RTC transfer point	☐
INJURED :	RTC	☐
☐ Yes	Cylinder truck	☐
☐ No	Cylinder storage area	☐
Number:	Cylinder filling building	☐
	Piping	☐
	Building	☐

	EMERGENCY RESPONSE PLAN	Ref ERP-PED Version : 2.1
EASIGAS It's guaranteed	PE Depot	11/03/2019

Direction of wind : From.................... to .... ☐low ☐medium ☐ high (or speed ....)	N O E S	Access gate available : ☐ .... ☐ ....

ACTIONS ALREADY BEING TAKEN :

Notification to authorities	☐
Activation of ERP	☐
Evacuation of staff	☐
Response according to ERP	☐
Other (to be defined) :	☐

Write the name of the person answering the call...

- ***Ask to repeat the message-***
- ***Do not hang up first-***

SITE SPECIFIC CONTACT DETAILS

Site Main Controller (site manager or his delegate) : DM

ORDER	ORGANISATION	PHONE NUMBERS 1ST /2ND (BY SECURITY CONTRACTOR)
1	*Fire brigade – Local number*	041 585 1555
2	*Site manager (if not on site)Rudi vd Westhuizen*	083 567 3389
3	*Depot Administrator. Lisa Taljaard*	079 143 5102
4	*Provincial Ambulance*	10177
5	*Netcare 911*	082 911
6	*Guardmed*	041 373 6777
7	*Police*	10111
8	*RPU Security*	071 779 9964/ 041 409 1748
9	*Atlas Security*	041 401 2222
10	*Municipal water*	041 360 1330
11	*Municipal electricity*	041 374 4434
12	*Disaster Management*	041 501 3595
13	*Eveready Complex (neighbour)*	041 401 2500
14	*Gas Engineering Services (contractor)*	082 332 0287
15	*Fueltech (contractor)*	082 327 4030

SECURITY COMPANY- INSTRUCTION IN CASE OF EMERGENCY

During working hours

- Security Officer to proceed to head count at the Emergency Muster point regarding EASIGAS Staff, Visitor and contractor, customers (collections)
- Security Officer to report to the Depot Manager the result of head counts and who is missing
- Security Officer to control site access: nobody to go inside the site perimeter without DM authorization
- Security Officer to inform DM as soon as fire brigade arrives at the gate

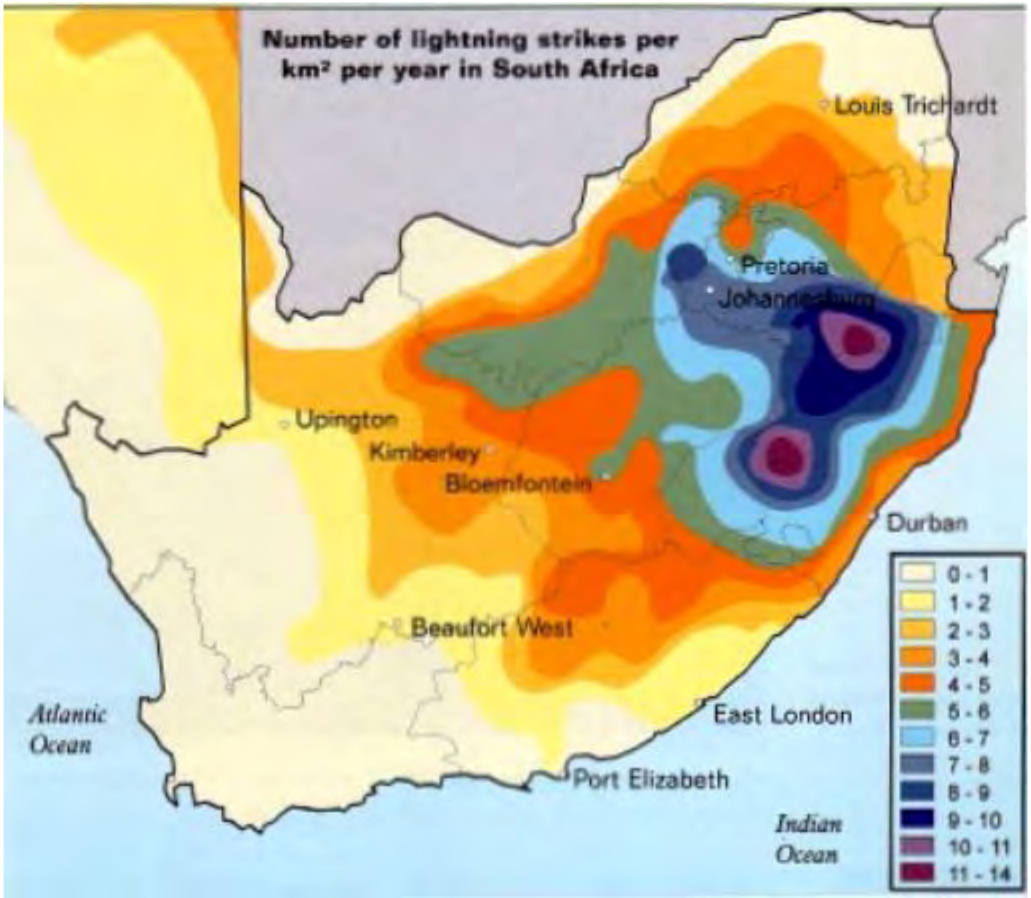
Out of working hours (Remote Site Monitoring system - RSM activated)

- Security officer to report any fire / leak watched to the RSM controller
- Or RSM controller report fire / leak directly by the RSM system
- RSM controller to contact fire department
- RSM shift supervisor to inform the Depot Manager
- Security Officer to Control site access: nobody to go inside the site perimeter without DM authorization (except fire brigade)

Appendix 5: Average meteorological conditions for South Africa

SA Weather station	Wind direction	Wind speed m/s	Wind calm %	Precipitation mm	Cloud cover %	Ambient temperature ^{0}C
A lexander Bay	S	11	28	<100	50	18-20
B ethlehem	E	10	15	700	10	14-16
B loemfontein	N	10	20	700	20	16-18
C alvinia	W	10	3	150	5	16-18
C ape Town	S	11	25	500	50	16-18
D e Aar	SE	11	3	150	5	14-16
D urban	NE	11	45	1 100	50	18-20
E ast London	SW	11	15	500	50	16-18
E rmelo	E	6	0.3	700	5	14-16
G eorge	SE	11	30	1 000	30	16-18
G raaff Reinet	S	11	12	300	5	16-18
J ohannesburg	N	8	40	500	5	16-18
K imberley	N	10	28	150	10	16-18
L adysmith	E	11	15	300	40	14-16
P olokwane	NE	11	39	500	10	18-20
P ort Elizabeth	SW	11	20	1 100	50	16-18
P retoria	NE	6	28	700	20	18-20
S truisbaai	E	11	3	500	50	16-18
U pington	SW	10	26	150	5	18-20
W elkom	NE	10	1	500	5	14-16

Lightning incidence



Appendix 6: Safety data sheet

Print

CAMEO Chemicals

Chemical Datasheet

LIQUEFIED PETROLEUM GAS

FLAMMABLE GAS 2

Chemical Identifiers

CAS Number	UN/NA Number	DOT Hazard Label	USCG CHRIS Code
68476-85-7	1075	Flammable Gas	LPG

NIOSH Pocket Guide	International Chem Safety Card
L.P.G.	none

NFPA 704

data unavailable

General Description

A mixture of butane, isobutane, propane, propylene, butylenes and other hydrocarbons of low molecular weight that is refined from petroleum. Maintained as a liquid under pressure. Leaking vessels can release either the liquid, which quickly vaporizes, or the gaseous mixture. The gas is heavier than air-- a flame can flash back to the source of the leak very easily. Under prolonged exposure to heat the containers may rupture violently and rocket. Used as a fuel, an aerosol propellant, in cigarette lighters, and to make other chemicals.

Hazards

Reactivity Alerts

- Highly Flammable

Air & Water Reactions

Highly flammable. No reaction with water.

Fire Hazard

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

EXTREMELY FLAMMABLE. Will be easily ignited by heat, sparks or flames. Will form explosive mixtures with air. Vapors from liquefied gas are initially heavier than air and spread along ground. CAUTION: Hydrogen (UN1049), Deuterium (UN1957), Hydrogen, refrigerated liquid (UN1966) and Methane (UN1971) are lighter than air and will rise. Hydrogen and Deuterium fires are difficult to detect since they burn with an invisible flame. Use an alternate method of detection (thermal camera, broom handle, etc.) Vapors may travel to source of ignition and flash back. Cylinders exposed to fire may vent and release flammable gas through pressure relief devices. Containers may explode when heated. Ruptured cylinders may rocket. (ERG, 2016)

Health Hazard

Concentrations in air greater than 10%; cause dizziness in a few minutes, 1% concentrations give the same symptom in 10 min. High concentrations cause asphyxiation. (USCG, 1999)

Reactivity Profile

Saturated aliphatic hydrocarbons, contained in LPG, may be incompatible with strong oxidizing agents like nitric acid. Charring may occur followed by ignition of unreacted hydrocarbon and other nearby combustibles. In other settings, mostly unreactive. Not affected by aqueous solutions of acids, alkalis, most oxidizing agents, and most reducing agents.

Belongs to the Following Reactive Group(s)

- Hydrocarbons, Aliphatic Saturated

Potentially Incompatible Absorbents

No information available.

Response Recommendations

Isolation and Evacuation

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

As an immediate precautionary measure, isolate spill or leak area for at least 100 meters (330 feet) in all directions.

LARGE SPILL: Consider initial downwind evacuation for at least 800 meters (1/2 mile).

FIRE: If tank, rail car or tank truck is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions. In fires involving Liquefied Petroleum Gases (LPG) (UN1075); Butane, (UN1011); Butylene, (UN1012); Isobutylene, (UN1055); Propylene, (UN1077); Isobutane, (UN1969); and Propane, (UN1978), also refer to BLEVE - SAFETY PRECAUTIONS (ERG page 368). (ERG, 2016)

Firefighting

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED. CAUTION: Hydrogen (UN1049), Deuterium (UN1957) and Hydrogen, refrigerated liquid (UN1966) burn with an invisible flame. Hydrogen and Methane mixture, compressed (UN2034) may burn with an invisible flame.

SMALL FIRE: Dry chemical or CO2.

LARGE FIRE: Water spray or fog. Move containers from fire area if you can do it without risk.

FIRE INVOLVING TANKS: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Do not direct water at source of leak or safety devices; icing may occur. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn. (ERG, 2016)

Non-Fire Response

Excerpt from ERG Guide 115 [Gases - Flammable (Including Refrigerated Liquids)]:

ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. If possible, turn leaking containers so that gas escapes rather than liquid. Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material. Do not direct water at spill or source of leak. Prevent spreading of vapors through sewers, ventilation systems and confined areas. Isolate area until gas has dispersed. CAUTION: When in contact with refrigerated/cryogenic liquids, many materials become brittle and are likely to break without warning. (ERG, 2016)

Protective Clothing

Skin: Wear appropriate personal protective clothing to prevent skin from becoming frozen from contact with the liquid or from contact with vessels containing the liquid.

Eyes: Wear appropriate eye protection to prevent eye contact with the liquid that could result in burns or tissue damage from frostbite.

Wash skin: No recommendation is made specifying the need for washing the substance from the skin (either immediately or at the end of the work shift).

Remove: Work clothing that becomes wet should be immediately removed due to its flammability hazard(i.e. for liquids with flash point < 100°F)

Change: No recommendation is made specifying the need for the worker to change clothing after the work shift.

Provide: Quick drench facilities and/or eyewash fountains should be provided within the immediate work area for emergency use where there is any possibility of exposure to liquids that are extremely cold or rapidly evaporating. (NIOSH, 2016)

DuPont Tychem® Suit Fabrics

No information available.

First Aid

Eye: If this chemical in liquid form contacts the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

Skin: If this chemical in liquid form contacts the skin, immediately flush the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.

Breathing: If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible. (NIOSH, 2016)

Physical Properties

Chemical Formula: data unavailable

Flash Point: Propane: -156° F (cc); butane: -76° F (cc). (USCG, 1999)

Lower Explosive Limit (LEL): Propane: 2.2 %; butane: 1.8 % (USCG, 1999)

Upper Explosive Limit (UEL): Propane: 9.5 %; butane: 8.4 % (USCG, 1999)

Autoignition Temperature: Propane: 871° F; butane: 761° F (USCG, 1999)

Melting Point: data unavailable

Vapor Pressure: greater than 1 atm (NIOSH, 2016)

Vapor Density (Relative to Air): data unavailable

Specific Gravity: 0.51 to 0.58 at -58 ° F (USCG, 1999)

Boiling Point: greater than -40 ° F at 760 mm Hg (USCG, 1999)

Molecular Weight: greater than 44 (USCG, 1999)

Water Solubility: Insoluble (NIOSH, 2016)

Ionization Potential: 10.95 eV (NIOSH, 2016)

IDLH: 2000 ppm (NIOSH, 2016)

AEGLs (Acute Exposure Guideline Levels)

No AEGL information available.

ERPGs (Emergency Response Planning Guidelines)

No ERPG information available.

PACs (Protective Action Criteria)

Chemical	PAC-1	PAC-2	PAC-3
Liquified petroleum gas; (L.P.G.) (68476-85-7)	65000 ppm	230000 ppm	400000 ppm

(DOE, 2016)

Regulatory Information

EPA Consolidated List of Lists

No regulatory information available.

DHS Chemical Facility Anti-Terrorism Standards (CFATS)

No regulatory information available.

OSHA Process Safety Management (PSM) Standard List

No regulatory information available.

Alternate Chemical Names

- BOTTLED GAS
- BURSHANE
- COMPRESSED PETROLEUM GAS
- FUELS, LIQUEFIED PETROLEUM GAS
- L.P.G.
- LIQ. PETROLEUM GAS
- LIQUEFIED HYDROCARBON GAS
- LIQUEFIED PETROLEUM GAS
- LIQUEFIED PETROLEUM GASES
- LPG
- LPG (LIQUEFIED PETROLEUM GASES)
- PETROLEUM GASES, LIQUEFIED
- PETROLEUM PRODUCTS, LIQUEFIED GASES
- PROPANE-BUTANE-(PROPYLENE)
- PYROFAX

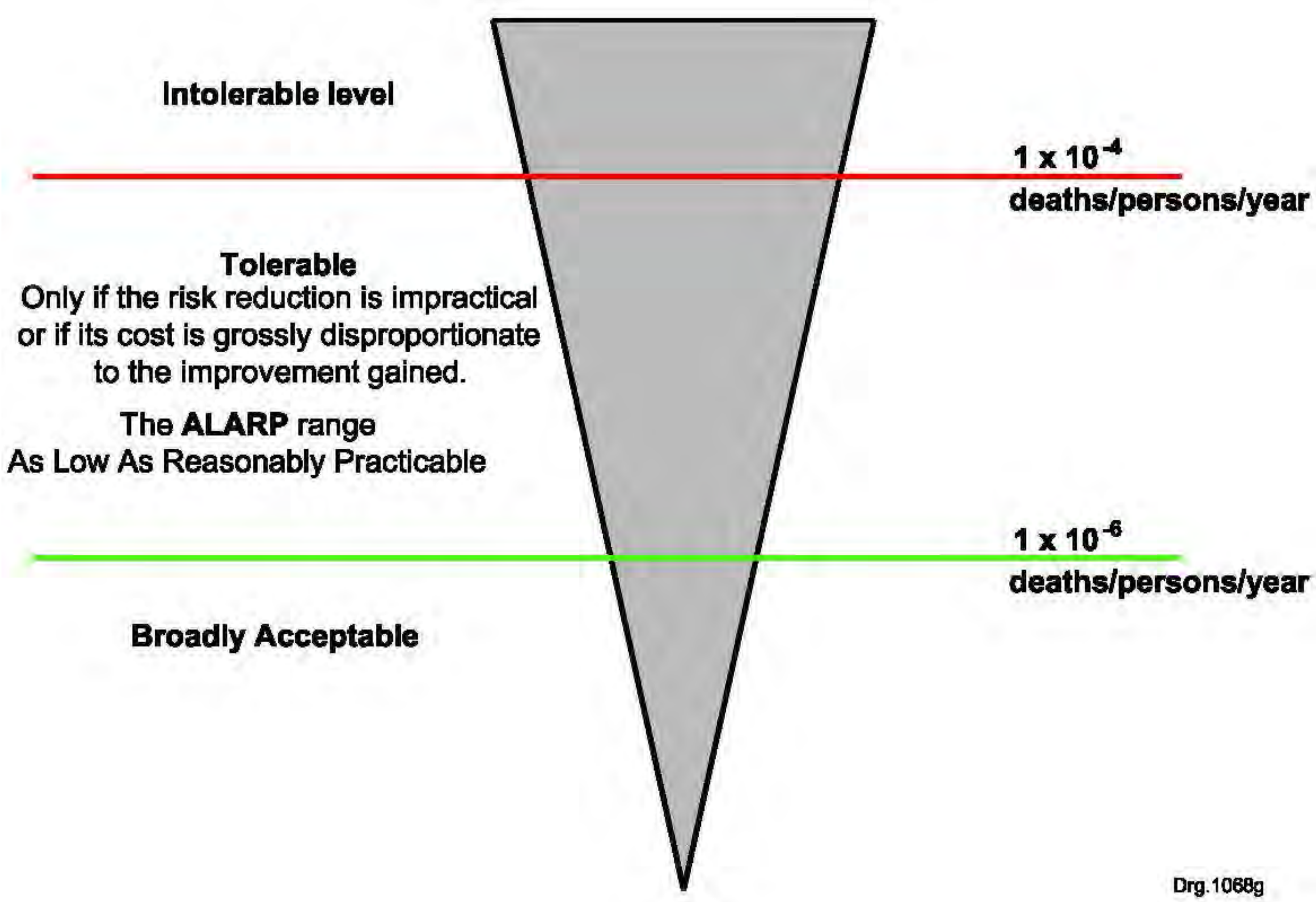
Appendix 7: Generic inspection protocol

Gas and liquid containment systems

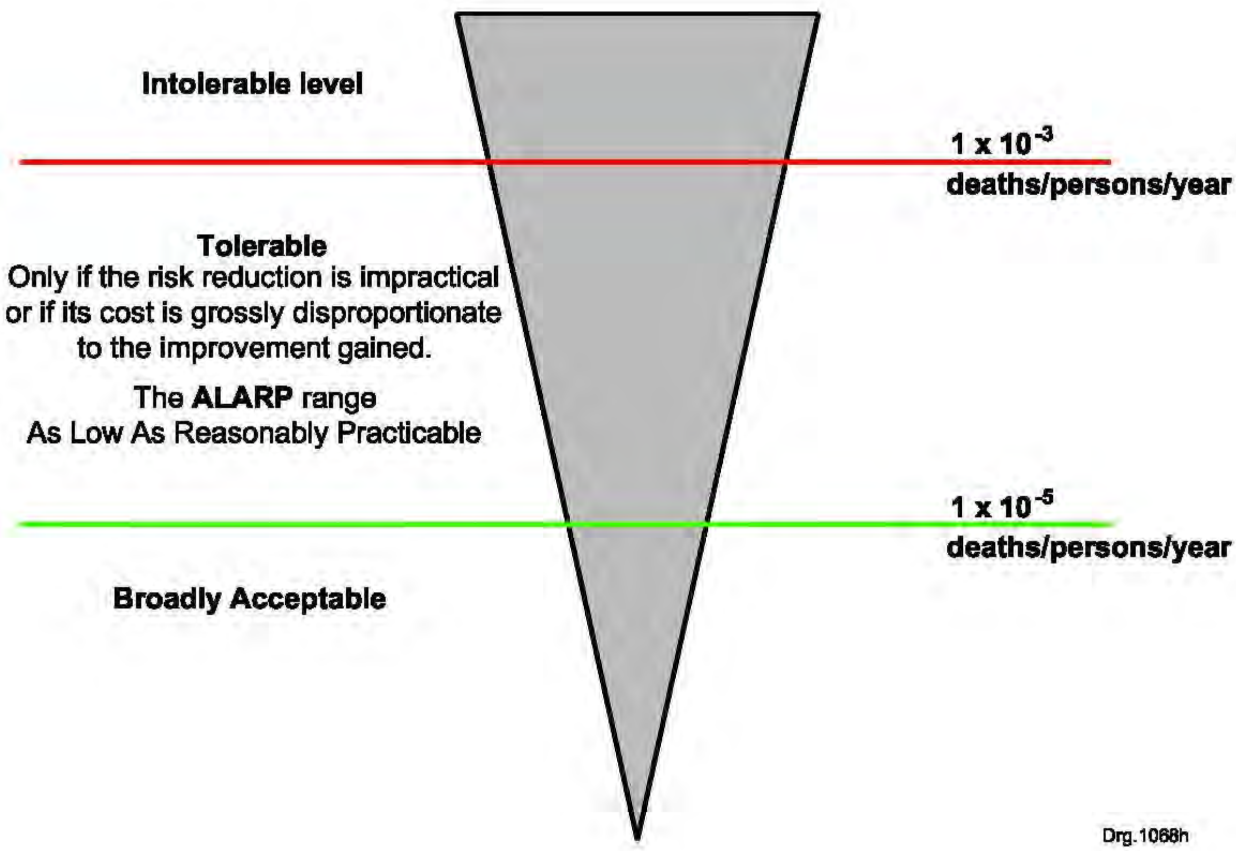
1. Pressure relief valve setting
2. Locality of emergency vent point to atmosphere
3. Flanges discharge side
4. Flanges intake side
5. Pipe nipples
6. Compressor oil drain points
7. Compressor lock-out procedure
8. Compressor shaft seals
9. Drive belts
10. Noticeable excessive vibration on compressor
11. Elbow connections on pipes
12. Valves on pipelines
13. Ammonia detectors
14. Detectors set point
15. Detectors testing
16. Audio alarm
17. Strobe alarm
18. Alarm linked to security office
19. Emergency contacts external
20. Emergency contacts internal
21. Windsock fitted
22. Windsock condition
23. Compressor mountings
24. Ammonia smell
25. Ventilation in engine room
26. Emergency switch for compressor shutdown
27. Length of reticulation piping
28. Pressure test certificates for receiver tank
29. Ammonia replenishment mode
30. Availability of self-contained breathing apparatus
31. Availability of full-face cartridge masks
32. Availability of resistant chemical suits
33. Emergency shower
34. Notice outside engine room with ammonia inventory
35. Availability of water source for ammonia vapour deluge
36. Classification of ammonia engine room: Zone 2
37. Flameproof and spark-proof electrical connections on compressors
38. Training of operators on engine room
39. Emergency training of staff
40. Identification of emergency assembly area
41. Identification of surrounding communities
42. Communication with neighbouring communities
43. Nameplate
44. Heat expansion relief valves on pipelines
45. Water drain valve

46. Intake flange
47. Outlet flange
48. Tank isolation valve
49. Tank isolation valve flanges
50. All Gaskets
51. Cylinder filling pump
52. Electrical connections
53. Area classification Zone 2
54. Tank mountings and plinth
55. Deluge system installed
56. Testing of deluge system
57. Scales
58. Filling platform LPG detectors
59. Flammables certificate
60. Road tanker connection
61. Road tanker filling coupling, dry
62. Road tanker no reverse
63. Isolation valves
64. Isolation valve flanges
65. Earth connections
66. Bund around liquid storage tanks
67. Bund drain valve
68. Tank leaks
69. Tank overfill protection.
70. Alarm systems.
71. Deluge systems.
72. Maintenance schedule.
73. Internal inspection registers.

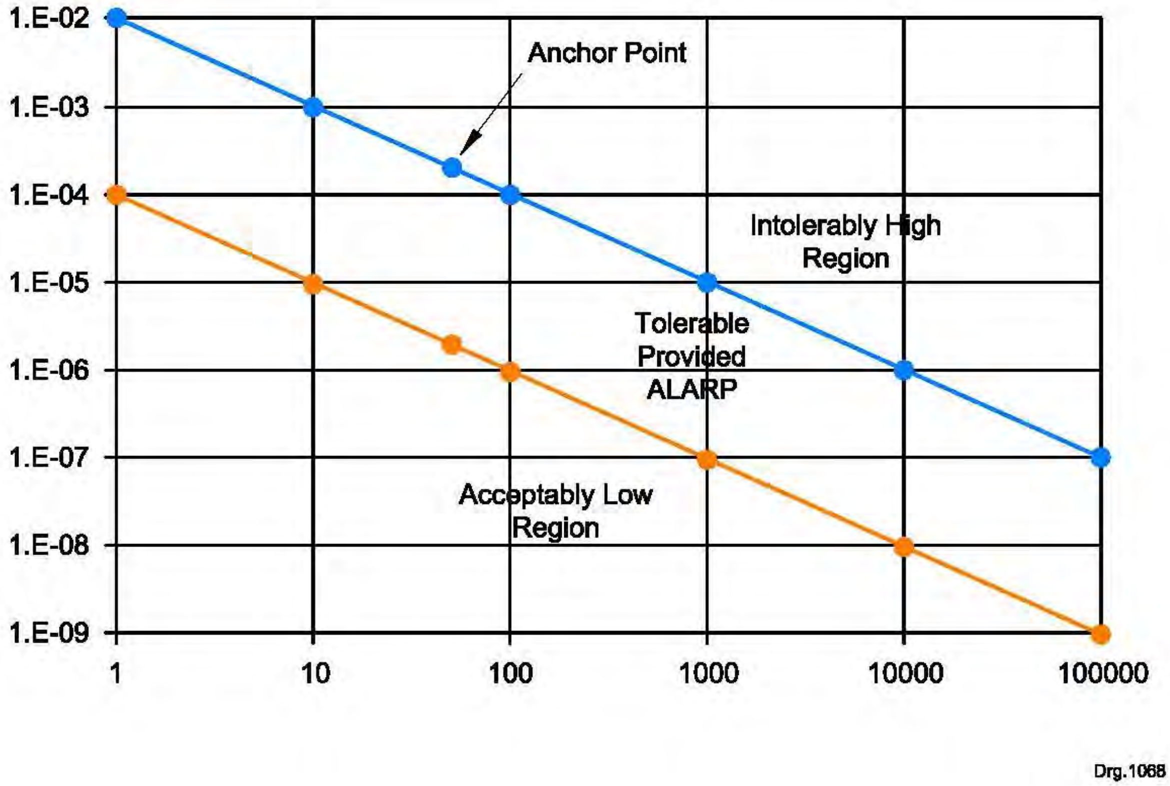
Appendix 8: Risk criteria



The public ALARP risk decision-making framework



The employee ALARP risk decision-making framework



Societal risk F-N criteria graph used in decision-making

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST IN TERMS OF REGULATIONS 12 AND 13 OF THE AMENDMENTS TO THE ENVIRONMENTAL IMPACT ASSESSMENT REGULATIONS, 2014 AS AMENDED.

	(For official use only)
File Reference Number:	
NEAS Reference Number:	
Date Received:	

Application for environmental authorization in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Amendments to the Environmental Impact Assessment Regulations, 2014. This form is valid as of 6 January 2021.

PROJECT TITLE

Proposed Increased Storage Capacity of the Easigas LPG Storage Facility in Sidwell, Gqeberha

SPECIALIST [1]			
Contact person:	Dr Alfonso Niemand		
Postal address:	20 Shiraz Street; Protea Heights; Brackenfell		
Postal code:	7560	Cell:	0832254426
Telephone:	0832254426	Fax:	None
E-mail:	alfonso@yebo.co.za		
Professional affiliation(s) (if any)	SANAS; SACNASP		

Project Consultant:	N/A		
Contact person:	N/A		
Postal address:	N/A		
Postal code:	N/A	Cell:	N/A

Telephone:	N/A	Fax:	N/A
E-mail:	N/A		N/A

4.2 The SPECIALIST

I, **ALFONSO NIEMAND** , declare that –

General declaration:

- I act as the independent Specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting environmental impact assessments, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in regulation **8** of the regulations when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will ensure that the comments of all interested and affected parties are considered and recorded in reports that are submitted to the competent authority in respect of the application, provided that comments that are made by interested and affected parties in respect of a final report that will be submitted to the competent authority may be attached to the report without further amendment to the report;
- I will keep a register of all interested and affected parties that participated in a public participation process; and
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not
- all the particulars furnished by me in this form are true and correct;
- will perform all other obligations as expected from an environmental assessment practitioner in terms of the Regulations; and
- I realise that a false declaration is an offence and is punishable in terms of section 24F of the Act.

Disclosure of Vested Interest (**delete whichever is not applicable**)

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Amendments to Environmental Impact Assessment Regulations, 2014 as amended.
- I have a vested interest in the proposed activity proceeding, such vested interest being:

NO VESTED INTEREST

Signature of the environmental assessment practitioner:

NATURE & BUSINESS ALLIANCE AFRICA PTY LTD

Name of company: SAPS

2021/11/19

Date:

Signature of the Commissioner of Oaths: CAPT S. MSI

Date: 2021/11/19

Designation: CAPTAIN

[1] Curriculum Vitae (CV) attached

Official stamp (below).

SUID AFRIKAANSE POLISIEDIENS
SAPS BRACKENFELL
2021 -11- 19
SAPS BRACKENFELL
SOUTH AFRICAN POLICE SERVICE

CURRICULUM VITAE OF ALFONSO NIEMAND

ID 5602075008084

1. CONTACT DETAILS

Dr Alfonso Niemand

13 Sedona Complex
Flora Haase Street
Amorosa
Roodepoort
1725

Cellular 083 225 4426
Landline 011-958 2132
Fax 086 502 4381
E-mail alfonso@yebo.co.za

2. PERSONAL DETAILS

Date of birth: 07 February 1956
Place of birth: Boksburg, South Africa
Citizenship: South Africa
Identity number: 5602075008084
Gender: Male

3. EDUCATIONAL QUALIFICATIONS

No	Qualification	Institution	Year
1.	PhD	University of the Free State	2016
2.	Vulnerability and Disaster Risk reduction	United Nations University and the University of the Free State	2014
3.	CAMEO Chemicals and ALOHA hazardous Material Computer Software	University of California	2014
4.	OR Tambo International Airport Airside Induction Training	Cargo Learning Academy	2007
5.	Occupational Health and Safety for Managers	Centre for Skills Advancement	2006
6.	Incident Investigation	Advantage ACT	2005
7.	Safety, Health, Environmental and Quality Induction Course	Advantage ACT	2005
8.	OHS Act and Regulations Occupational Health and Safety representative Course	OHASS Occupational Health and Safety Services	2003
9.	Environmental Management	University of Pretoria	2002
10.	SABS ISO 14001, SABS ISO 9000 and OHSAS 18001 Integration of environmental, quality and occupational health and safety management systems. ISO-17020 system implementation and auditing	Potchefstroom University (Northwest University) Internal	2002 2004
11.	Professional Communication	Navtel Educational and Communication Consultants	1995
12.	Masters' Degree in Business Leadership (MBL) Received the Best Group Award	University of South Africa	1991
13.	Baccalaureus Scientiae (BSc) Chemistry; Theoretical Physics	University of South Africa	1982

4. PROFESSIONAL AFFILIATIONS AND AWARDS

No	Membership	Institution	Year	Membership No
1.	Full member	Disaster Management Institute of South Africa (DIMISA)	2014	-
2.	Full member	Southern African Society for Disaster Risk Reduction (SASDIR)	2014	-
3.	Full member	International Society for Integrated Disaster Risk management (IDRIM)	2014	-
4.	Member	Health and Safety Executive (HSE) Infonet UK	2012	-
5.	Full member	SA Institute of Occupational Safety and Health (SAIOSH)	2011	0614
6.	Accredited major hazard installation risk assessor for explosive, flammable and toxic materials	SA National Accreditation System (SANAS)	2005	MHI-0004
7.	Registered Approved Inspection Authority for major hazard installation risk assessments	Department of Labour	2005	MHI-0002
8.	Certificated Natural Scientist	SA Council for Natural Scientific Professions (SACNASP)	2004	200026/04
9.	Right of Way member	SA Right of Way Association	2002	RW0145
10.	International Association for Impact Assessment member	International Association for Impact Assessment	2002	102910
11.	Professional Manager	Association of Professional Managers in South Africa	1999	-

5. PROFESSIONAL DEVELOPMENT

Present Studies		
Attended conference on Construction Regulations 2014, Pretoria	Department of Labour	2014
Attended conference on Construction regulations 2014, Bloemfontein	SA Institute of Occupational Safety and Health (SAIOSH)	2014
Presented a paper on international comparison of disaster risk legislation	Disaster Management Institute of South Africa (DIMISA); Durban; South Africa	2014
Presented a paper on disaster risk legislation	Southern African Society for Disaster Risk Reduction (SASDIR); Windhoek; Namibia	2014
Presented a paper on disaster risk legislation	International Society for Integrated Disaster Risk management (IDRIM); Western University; London Ontario; Canada	2014
Facilitate a national workshop on proposed disaster risk legislation for South Africa	Free State University; Bloemfontein; South Africa	2015

6. CAREER HISTORY / WORK EXPERIENCE

Period	Employer	Function
2000 - Present	Nature & Business Alliance Africa (Pty) Ltd, Consulting Firm South Africa Roodepoort Bloemfontein	Founder of the Company Managing Director, 19 years Occupational Health and Safety Management, 14 years Environmental Assessment Practitioner, 18 years Technical Manager for Major Hazard Installation (MHI) Risk Assessments, 12 years Approved Inspection Authority for MHI Risk Assessments, 12 years In-service training of Quality Manager: 12 years Internal audits on MHI risk assessments: 12 years
1979 -	Sasol Group of Companies	Laboratory Analyst, 2 years

2000	South Africa Sasolburg Johannesburg	Laboratory Manager, 1 year Research Chemist, 2 years Chemical process Consultant, 3 years Technical Sales Manager, 2 years Retail Manager, 2 years Occupational Health and Safety and Quality Management Change Agent, 4 years National Sales Manager, 1 year Strategic Planning Manager, 2 years Corporate Communication Manager, 3 years

7. PUBLICATIONS

Niemand, A., Jordaan, A.J. & Minnaar, H., 2015, 'Some international perspectives on legislation for the management of human-induced safety risks', *Jàmbá: Journal of Disaster Risk Studies* 7(2), Art. #170. http://dx.doi.org/10.4102/jamba.v7i2.170

rtificates of Accreditation and Registration

labour

Department:
Labour
REPUBLIC OF SOUTH AFRICA

National Department of Labour
Republic of South Africa

APPROVED INSPECTION AUTHORITY

Registered in accordance with the provisions of the Occupational Health and Safety Act, Act 85 of 1993, as amended and the Major Hazard Installation Regulations.

This is to certify that:

NATURE & BUSINESS ALLIANCE AFRICA (PTY) LTD

has been registered by the Department of Labour as an Approved Inspection Authority: Type A, to conduct Major Hazard Installation Risk Assessment, in terms of Regulation 5(5)(a), of the Major Hazard Installation Regulations.

CONDITIONS OF REGISTRATION:

- The AIA must at all time comply with the requirements of the Occupational Health and Safety Act, Act 85 of 1993, as amended.
- This registration certificate is not transferable.
- This registration will lapse if there is a name change of the AIA or change in ownership.

CHIEF INSPECTOR

Valid from: **08 August 2017**
Expires: **07 August 2021**
Certificate Number: **CI MHI 0002**

South African National Accreditation System

CERTIFICATE OF ACCREDITATION

In terms of section 22(2)(b) of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act 19 of 2006), read with sections 23(1), (2) and (3) of the said Act, I hereby certify that: -

NATURE & BUSINESS ALLIANCE AFRICA (PTY) LTD
Co. Reg. No.: 2003/020335/07
ROODEPOORT

Facility Accreditation Number: **MHI0004**

is a South African National Accreditation System Accredited Inspection Body to undertake **TYPE A** inspection provided that all SANAS conditions and requirements are complied with

This certificate is valid as per the scope as stated in the accompanying scope of accreditation, Annexure "A", bearing the above accreditation number for

THE ASSESSMENT OF RISK ON MAJOR HAZARD INSTALLATIONS

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17020:2012 AND SANS 1461:2018

The accreditation demonstrates technical competency for a defined scope and the operation of a management system

While this certificate remains valid, the Accredited Facility named above is authorised to use the relevant SANAS accreditation symbol to issue facility reports and/or certificates

Mr M Phaloane
Acting Chief Executive Officer

Effective Date: 11 June 2020
Certificate Expires: 07 August 2021

This certificate does not on its own confer authority to act as an Approved Inspection Authority as contemplated in the Major Hazard Installation Regulations. Approval to inspect within the regulatory domain is granted by the Department of Employment and Labour.

ANNEXURE A

SCOPE OF ACCREDITATION

Accreditation Number: MHI0004

TYPE A

Permanent Address: Nature & Business Alliance Africa (Pty) Ltd 13 Sedona Complex 386 Flora Haase Street Amorosa Roodepoort 1735 Tel: (011) 958-2132 Cell: 083 225 4426 E-mail: alfonso@yebo.co.za	**Postal Address:** P O Box 1753 Strubens Valley 1735 Issue No.: 11 Date of issue: 09 March 2020 Expiry date: 07 August 2021

Nominated Representative: Dr A Niemand **Quality Manager:** Dr A Niemand	**Technical Manager:** Dr A Niemand	**Technical Signatory:** Dr A Niemand

Field of Inspection	Service Rendered	Codes and Regulations
Regulatory: The supply of services as an Inspection Authority for Major Hazard Risk Installation as defined in the Major Hazard Risk Installation Regulations, Government Notice No. R 692 of 30 July 2001	Major Hazard Installation Risk Assessments for the following material categories: 1) Explosive chemicals 2) Gases: i) Flammable Gases ii) Non-flammable, non-toxic gases (asphyxiants) iii) Toxic gases 3) Flammable liquids 4) Flammable solids, substances liable to spontaneous combustion, substances that on contact with water release flammable gases 5) Oxidizing substances and organic peroxides 6) Toxic liquids and solids	MHI regulation par. **5 (5) (b)** i) Frequency/Probability Analysis ii) Consequence Modelling iii) Hazard Identification and Analysis iv) Emergency planning reviews SANS 31000 SANS 31010 Guidelines for Chemical Process Quantitative Risk Analysis of the Centre for Chemical Process Safety (CCPS), American Institute of Chemical Engineers Areal Locations of Hazardous Atmospheres (ALOHA) Computer Programme developed by the US Environmental Protection Agency (EPA), US National Oceanic and Atmospheric Administration (NOAA), US Chemical Emergency Preparedness and Prevention Office (CEPPO) and US Hazardous Materials Response Division (HMRD)

Original date of accreditation: 08 August 2005

Page 1 of 1

ISSUED BY THE SOUTH AFRICAN NATIONAL ACCREDITATION SYSTEM

Accreditation Manager

ANNEXURE A

SCOPE OF ACCREDITATION

Accreditation Number: MHI0004

TYPE A

Permanent Address: Nature & Business Alliance Africa (Pty) Ltd 13 Sedona Complex 386 Flora Haase Street Amorosa Roodepoort 1735 Tel: (011) 958-2132 Cell: 083 225 4426 E-mail: alfonso@yebo.co.za		**Postal Address:** P O Box 1753 Strubens Valley 1735 Issue No.: 12 Date of issue: 11 June 2020 Expiry date: 07 August 2021
Nominated Representative: Dr A Niemand **Quality Manager:** Dr A Niemand	**Technical Manager:** Dr A Niemand	**Technical Signatory:** Dr A Niemand
Field of Inspection	**Service Rendered**	**Codes and Regulations**
Regulatory: The supply of services as an Inspection Authority for Major Hazard Risk Installation as defined in the Major Hazard Risk Installation Regulations, Government Notice No. R 692 of 30 July 2001	Major Hazard Installation Risk Assessments for the following material categories: 1) Explosive chemicals 2) Gases: i) Flammable Gases ii) Non-flammable, non-toxic gases (asphyxiants) iii) Toxic gases 3) Flammable liquids 4) Flammable solids, substances liable to spontaneous combustion, substances that on contact with water release flammable gases 5) Oxidizing substances and organic peroxides 6) Toxic liquids and solids	MHI regulation par. **5 (5) (b)** i) Frequency/Probability Analysis ii) Consequence Modelling iii) Hazard Identification and Analysis iv) Emergency planning reviews SANS 31000 SANS 31010 Guidelines for Chemical Process Quantitative Risk Analysis of the Centre for Chemical Process Safety (CCPS), American Institute of Chemical Engineers Areal Locations of Hazardous Atmospheres (ALOHA) Computer Programme developed by the US Environmental Protection Agency (EPA), US National Oceanic and Atmospheric Administration (NOAA), US Chemical Emergency Preparedness and Prevention Office (CEPPO) and US Hazardous Materials Response Division (HMRD)

Original date of accreditation: 08 August 2005

Page 1 of 1

ISSUED BY THE SOUTH AFRICAN NATIONAL ACCREDITATION SYSTEM

Accreditation Manager

SACNASP

South African Council for Natural Scientific Professions

herewith certifies that

Alfonso Niemand

Registration Number: 002914

is a registered scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)
in the following fields(s) of practice (Schedule 1 of the Act)

Environmental Science (Professional Natural Scientist)

Effective **25 November 2004** Expires **31 March 2022**

Botha

Chairperson

Chief Executive Officer

To verify this certificate scan this code