

NOT CLASSIFIED AS A MAJOR HAZARD INSTALLATION

MAJOR HAZARD INSTALLATION RISK ASSESSMENT FOR VORTUM THERMAL POWER PLANT IN SALDANHA BAY FOR A PREFERRED AND ALTERNATIVE SITE



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An ISO/IEC-17020 Company Accredited by SANAS
as a Type A Major Hazard Risk Installation
Inspection Body N° MHI-0004

Government Approved Inspection Authority N°
MHI-0002 Registered by the Department of Labour



MHI-0004

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Contact particulars of the client

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Executive Summary

Vortum Energy (Pty) Ltd (Reg. No. 2013/088004/07) is proposing the establishment of an energy generation facility (thermal power plant) with associated infrastructure and structures on a portion (± 130 ha) of the Remaining Extent of the Farm Langeberg 188, Malmesbury RD (861ha), located in the Saldanha Bay Local Municipality, West Coast District Municipality, Western Cape Province. The project site is located 9 km North-East of the Port of Saldanha Bay, West of the regional road R27, in an area excluded from the provisions of the Subdivision of Agricultural Land Act (Act 70 of 1970) and already earmarked for Industrial Uses.

The proposed thermal power plant will be a Combined Cycle Gas Turbine (CCGT) power plant, to be fuelled with natural gas imported by means of one or more gas import facilities (e.g. LNG Import Terminal(s) and/or new gas pipeline(s)). The Department of Energy and Transnet are investigating the feasibility of new gas pipelines and LNG Import Terminals, in order to import natural gas from new offshore gas fields and/or from other countries (e.g. Mozambique). A public participation process in terms of the EIA Regulations (2014) is currently being conducted by Environmental Resources Management Southern Africa (Pty) Ltd for LNG Import facilities as well as a Floating Power Plant in Saldanha Bay. The securing of new energy sources, like natural gas, has become high priority for the Government, considering that the current energy production is not able to meet the increased energy demand of the country. This leads to frequent electricity shortage and fluctuations in supply ("load shedding"), detrimental to the economic development of South Africa.

Should natural gas not be available at the time of the commissioning of the Vortum Thermal Power Plant, the proposed facility will be fuelled with liquid fuel (diesel or other types of liquid fuels) until natural gas is available. Gas turbines can be fuelled either with natural gas or liquid fuel. Due to the current electricity shortage and the urgent need for new power generation units in the Country, the Vortum Thermal Power Plant will operate:

- as an Open Cycle Gas Turbine (OCGT) power plant as a first phase;
- in the second phase, with the "closure" of the open cycle (by means of steam turbine units added to the gas turbine units), as a Combined Cycle Gas Turbine (CCGT) power plant.

Vortum Energy (Pty) Ltd requested an independent assessment of the major hazard installation risks associated with its new power plant as required by Section 5 (1) of the Major Hazard Installation (MHI) Regulations. Nature & Business Alliance Africa (Pty) Ltd was appointed to perform the MHI risk assessment.

Liquid fuel (first phase) and gas (second phase) will be imported from the oil pier of the Port of Saldanha / planned location of the LNG Import and Re-gas Facility proposed by the Department of Energy by means of a pipeline approximately 12 km long.

The Vortum Thermal Power Plant will deliver energy to the Eskom Aurora main transmission substation via two 400 kV power lines (double circuit each) approximately 27 km long.

The health and safety risks associated with the thermal power plant were assessed for two sites:

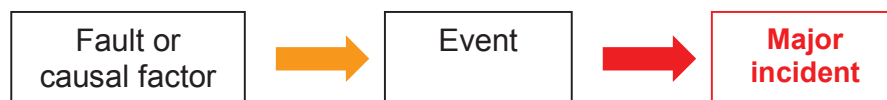
- The preferred site in the northwest corner of the farm.
- The alternative site in the southern part of the farm.

Hazardous material inventory for Phase 1:

Product	Quantity
1. Diesel (Phase 1)	1 931 tons per day Six aboveground storage tanks of 5 400 m ³ each 21 m diameter 17 m high Estimated bund area per tank is 2 970 m ²
2. Natural gas (Phase 2)	2 890 tons per day Pipeline fed

The following methodology was applied in this risk assessment:

- A fault-tree analysis method [1] was applied to determine the possible causes of an event (fault) that could eventually lead to a major incident. For this risk assessment, an event is defined as a chemical spill or gas leak that could result in a toxic release, an explosion or a fire on the premises of Vortum Energy (Pty) Ltd.
- An event-tree analysis method [1] was applied to determine the potential major incidents that could be the end result of the event. The logic is explained as follows:



- In this risk assessment, an **event** is defined as 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.
- A **major incident** is defined as 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.

- 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.
- 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].
- Toxic releases were modeled by means of the ALOHA mathematical dispersion model [3] of the Environmental Protection Agency of the USA.
- Heat radiation flux caused by a fire was simulated by means of the equations proposed by *Mudan and Groce* [1, p243].
- 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].
- Meteorological tendencies at the site were taken into consideration.
- Individual and societal risks were assessed, based on the frequencies of major incidents, minimum safety distances and the predicted number of potential fatalities.
- The occurrence and effect of a boiling liquid expanding vapour explosion (BLEVE) was modeled based on work done by the Center for Chemical Process Safety of the American Institute of Chemical Engineers.
- A **human impact** is defined as 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.
- **Baseline risk assessment** means a quantitative assessment of the safety risks associated with a particular major hazard installation, irrespective of the organisational mitigation measures implemented at the installation.
- **Residual risk assessment** means 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.
- 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.
- The norm for human impacts as developed by the Dutch Advisory Committee on Dangerous Substances was used in this risk assessment. Similar norms on human impacts do not exist for South Africa.
- The norm for major incident frequencies as developed by the UK Health and Safety Committee (HSE) was used in this risk assessment. Similar norms on frequencies do not exist for South Africa.

The following conclusions are drawn from this risk assessment:

1. The hazardous events that could occur at the Vortum Energy (Pty) Ltd facility in Saldanha Bay are as follows:
 - Diesel pool fire at the tank farm.
 - Natural gas jet fire.
 - Natural gas cloud explosion.
2. The safety risks at the Vortum Energy (Pty) Ltd Saldanha Bay facility are summarised in the table below.

Potential Major Incident	Possible Consequences	Estimated Frequency per year	Estimated safety distance, m	Estimated number of human impacts *
Scenario 1: Diesel storage tanks and pipe work for Phase 1				
Diesel leak	Pool fire in the bund of one storage tank	8.3 E-4	79	1
Diesel leak	Pool fire in all bunds	6.9 E-7	193	3
Diesel leak	<u>Toxic emissions from diesel pool fire in one bund</u> <ul style="list-style-type: none"> • Carbon monoxide • Carbon dioxide • Carbon particulates 	8.3 E-4	921 270 34	17 2 0
Scenario 2: Natural gas via pipeline for Phase 2				
Natural gas leak	Gas cloud explosion	3.2 E-3	110	1
Natural gas leak	Jet fire	1.0 E-3	14	0

* Based on a population density of 0.00005 persons per m² and an impact rate of 50%. In the case of toxic releases, one quadrant of the affected circle (25%) was taken into consideration to make provision for varying wind blow patterns.

3. The health and safety risks were assessed for two sites:
 - The preferred site in the northwest corner of the farm.
 - The alternative site in the southern part of the farm.
4. At both sites, the primary risk is the release of carbon monoxide from a diesel pool fire at the tank farm during Phase 1 of the project. This risk has the potential to affect people beyond the boundaries of the farm. However, the risk is manageable in the sense that people will have time to evacuate to a safe separation distance from the tank farm. The secondary risks at the preferred and alternative sites are due to a pool fire at one or more of the diesel storage tanks during Phase 1 of the project, or a natural gas cloud explosion during Phase 2. It is important to note that these risks are confined to the boundaries of the plant.
5. From a health and safety point of view the alternative site is not recommended due to the proximity of structures south of the plant. These structures may be inhabited.
6. The individual safety risk transect indicates that the risk profile of the facility lies partly above the norm for tolerable public risk (1.00E-4) as well as the norm for tolerable worker risk (1.00E-3) as recommended by the UK Health and Safety Executive (HSE).

7. The societal risk profile for the Saldanha Bay Facility indicates that the safety risk at the facility lies below the local tolerability line as recommended by the Dutch Advisory Committee on Dangerous Substances.
8. The estimated number of human impacts at the Saldanha Bay facility could reach a level of 17 in case of a pool fire at the diesel tank farm, which will release toxic carbon monoxide. This number does not exceed the norm of 10 000 recommended by the Dutch Advisory Committee on Dangerous Substances.
9. Two criteria were used to determine whether the Vortum Energy (Pty) Ltd Saldanha Bay Facility could be classified as a major hazard installation or not. In order to be classified as a major hazard installation (MHI), the facility must satisfy at least one of the following two criteria:

The highest frequency of a major incident must be higher than 1.0E-4 / year

$$F > 0.0001 / \text{yr}$$

UK Health and Safety Executive

OR

The maximum number of human impacts (fatalities) that could be caused by the major incident must be higher than 10 000

$$N > 10\ 000$$

Dutch Advisory Committee on Dangerous Substances

7. There are no facilities outside the boundaries of the power plant that would be affected by a major incident.
8. Based on the above findings, it is concluded that the Vortum Energy (Pty) Ltd Saldanha Bay facility is not classified as a major hazard installation.

The following organisational measures are recommended for the Vortum Energy (Pty) Ltd site in Saldanha Bay:

1. The emergency response plan must be updated in accordance with the guidelines given in Section 13 of this report.
2. Operating procedures must be compiled for Vortum Energy (Pty) Ltd, to include preventative measures against possible diesel and natural gas leaks.
3. All possible ignition sources at the facility must be eliminated. Guidelines for the control of ignition sources are as follows:
 - Use only electrical equipment that is certified to be flameproof and spark proof in areas where natural gas is handled.
 - Control static electricity.
 - Ensure that vulnerable equipment is properly bonded to ground.
 - Prohibit smoking, open flames and sparks.
 - Prevent mechanical sparks and friction.
 - Use separator devices to remove foreign materials capable of igniting from process materials.
 - Separate heated surfaces from dust.

- Separate heating systems from dust.
 - Select and use industrial trucks properly.
 - Use cartridge activated tools properly.
 - Implement an equipment preventative maintenance programme.
4. The outcome of the risk assessment must be brought to the attention of all the employees at the facility.
 5. The bulk storage tanks and all diesel and natural gas pipelines must be protected against corrosion, to prevent leaks.
 6. A Maintenance Plan must be compiled for all the equipment used on the facility prior to commissioning of the plant. 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.
 7. All hazardous equipment and facilities on the facility must be inspected on a daily 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.
 8. Detailed operating procedure must be implemented for all sections of the facility, in collaboration with the equipment suppliers, prior to commissioning of the installation. All authorised operators must be trained in the application of the procedure.
 9. Preventative measures must be designed and implemented to prevent overfilling of diesel storage tanks.
 10. All operating personnel at the facility must be made aware and kept aware of the dangers involving diesel and natural gas.
 11. The facility must be under safety and security access control for 24 hours per day. The safety guard on duty 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 of Vortum Energy (Pty) Ltd.
 - The guard must be able to contact the Saldanha Bay Fire Department immediately.
 12. A site layout plan must be compiled for the proposed diesel tank farm in accordance with the relevant SANS code and must be submitted to the Saldanha Bay Fire Department for approval.
 13. The Emergency Evacuation Procedure aimed at workers as well as the surrounding residences must be updated in collaboration with the emergency services of Saldanha Bay and interested and affected parties such as members of community liaison committees.

14. The Emergency Response Plan and Emergency Evacuation Procedure of Vortum Energy (Pty) Ltd must be tested at least once every 12 months by means of mock emergencies. The Fire Department of Saldanha Bay must participate in such tests.
15. A fire water reservoir must be installed on site if the water flow and pressure of the municipal hydrant network is insufficient.
16. Customer parking bays must be located in an area where public vehicles will not cause obstruction of emergency vehicles.
17. The bulk diesel storage tanks and pipe work and all natural gas pipelines must be protected against lightning by means of efficient earthing.

Legal framework

1. Inclusion

This risk assessment focuses only 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).

2. Exclusions

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 Vortum Energy (Pty) Ltd facility, or part of it, could have on the biophysical and socio-economic environment. The Environment Conservation Act (Act No 73 of 1989), the National Environmental Management Act (Act No 107 of 1998) and the National Environmental Second Amendment Act (Act No 8 of 2004) govern this aspect.
- Future development of residential, commercial, industrial or recreational areas around the Vortum Energy (Pty) Ltd site.
- Future modifications that may be made to the site and the installations on it.

3. Report structure

This risk assessment report has been structured in accordance with the requirements of the Major Hazard Installation Regulations, Section 5.5 (b).

Section 1

Statements and Declarations

1. Statement of competence

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.
- 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.
- Certificate of training in ALOHA / CAMEO software, University of California Davis Campus.

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).
- American Institute of Chemical Engineers (AIChE).
- South African Institute of Occupational Safety and Health (SAIOSH).
- Member of Disaster Management Institute of SA.
- Member of SA Society for Disaster Risk Reduction.
- Member of International Society for Integrated Disaster Risk Management.

Alfonso Niemand has 32 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.

2. Quality manual and accreditation

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).

3. Registration as Approved Inspection Authority (AIA)

Nature & Business Alliance Africa (Pty) Ltd is registered by the Department of Labour as an Approved Inspection Authority (AIA) for toxic, flammable and explosive substances (registration number MHI-0002).

4. Statement of indemnity

This risk assessment specifically pertains to the facilities of Vortum Energy (Pty) Ltd located in Saldanha Bay. 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 Vortum Energy (Pty) Ltd (the client) or the client's subcontractors, before, during and after the requested risk assessment has been conducted.

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.

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.

5. Copyright

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.

6. Condition of non-influence

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.

7. Declaration of independence

Nature & Business Alliance Africa (Pty) Ltd and Alfonso Niemand (the author) in particular, declare that the organization and its personnel are not related to Vortum Energy (Pty) Ltd 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.

8. Confidentiality

All information disclosed to us by Vortum Energy (Pty) Ltd 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 Vortum Energy (Pty) Ltd.

9. Validity period

This report is valid for a period of 5 years only, in accordance with the Major Hazard Installation Regulations.

Section 2

General Process Description

1. Organisational profile

Vortum Energy (Pty) Ltd (Reg. No. 2013/088004/07) is proposing the establishment of an energy generation facility (thermal power plant) with associated infrastructure and structures on a portion (± 130 ha) of the Remaining Extent of the Farm Langeberg 188, Malmesbury RD (861ha), located in the Saldanha Bay Local Municipality, West Coast District Municipality, Western Cape Province. The project site is located 9 km North-East of the Port of Saldanha Bay, West of the regional road R27, in an area excluded from the provisions of the Subdivision of Agricultural Land Act (Act 70 of 1970) and already earmarked for Industrial Uses.

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Should natural gas not be available at the time of the commissioning of the Vortum Thermal Power Plant, the proposed facility will be fuelled with liquid fuel (diesel or other types of liquid fuels) until natural gas is available. Gas turbines can be fuelled either with natural gas or liquid fuel. Due to the current electricity shortage and the urgent need for new power generation units in the Country, the Vortum Thermal Power Plant will operate:

- as an Open Cycle Gas Turbine (OCGT) power plant as a first phase;
- in the second phase, with the "closure" of the open cycle (by means of steam turbine units added to the gas turbine units), as a Combined Cycle Gas Turbine (CCGT) power plant.

Liquid fuel (first phase) and gas (second phase) will be imported from the oil pier of the Port of Saldanha / planned location of the LNG Import and Re-gas Facility proposed by the Department of Energy by means of a pipeline approximately 12 km long.

The Vortum Thermal Power Plant will deliver energy to the Eskom Aurora main transmission substation via two 400 kV power lines (double circuit each) approximately 27 km long.

2. The facilities on site

A site layout plan for the facility is shown in Figure 2.1.

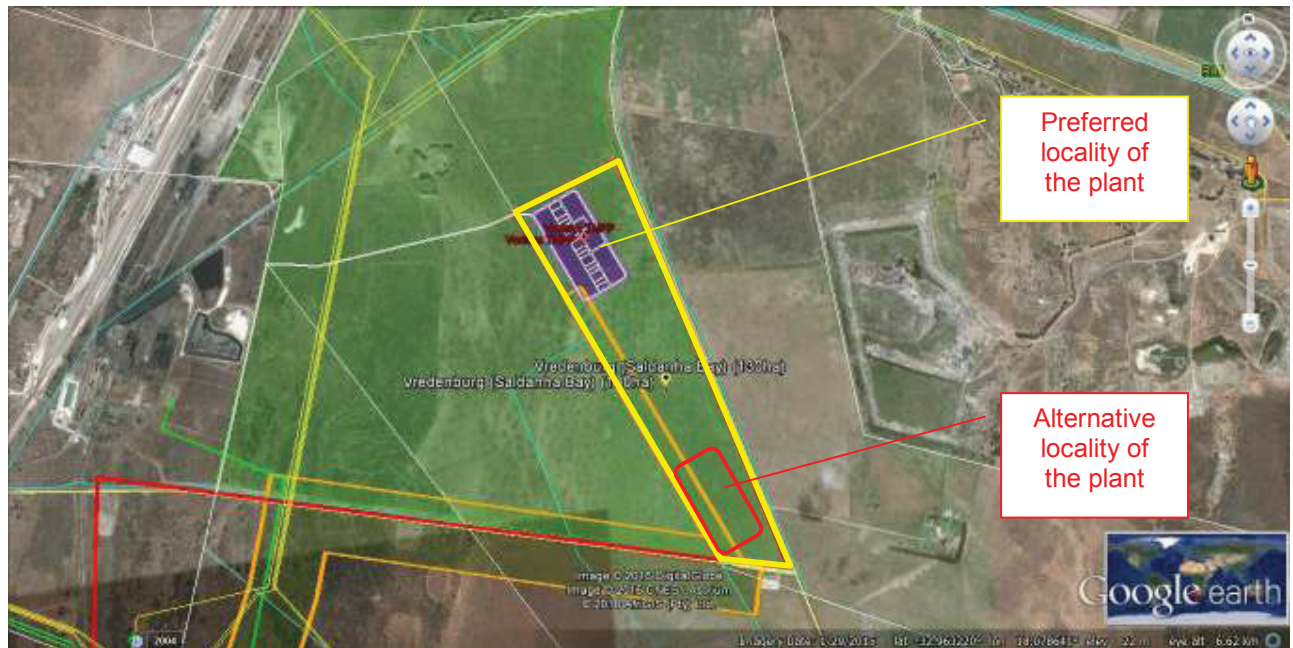
An aerial view of the Saldanha Bay site is shown in Figure 2.2. The location of adjacent facilities around the Vortum Energy (Pty) Ltd site as well as some safety distances are shown in Figure 2.3.

3. Scope of this risk assessment

Vortum Energy (Pty) Ltd is proposing the establishment of an energy generation facility (thermal power plant) with associated infrastructure and structures on a portion of the Remaining Extent of the Farm Langeberg 188, Malmesbury RD (861ha), located in the Saldanha Bay Local Municipality, West Coast District Municipality, Western Cape Province. This risk assessment focuses on the health and safety risks associated with the use of the following hazardous products at the plant:

- Diesel for Phase 1 of the project.
- Natural gas for Phase 2 of the project.

Figure 2.2: Aerial view of the site



Section 3**Potential Major Incidents associated with the installation**

The following potential major incidents are associated with the installation:

Product	Quantity	Potential major incident
1. Diesel	6 tanks of 5 400 m ³ each	Diesel oil leak
2. Natural gas	2 890 tons per day via pipeline	Natural gas leak

Section 4

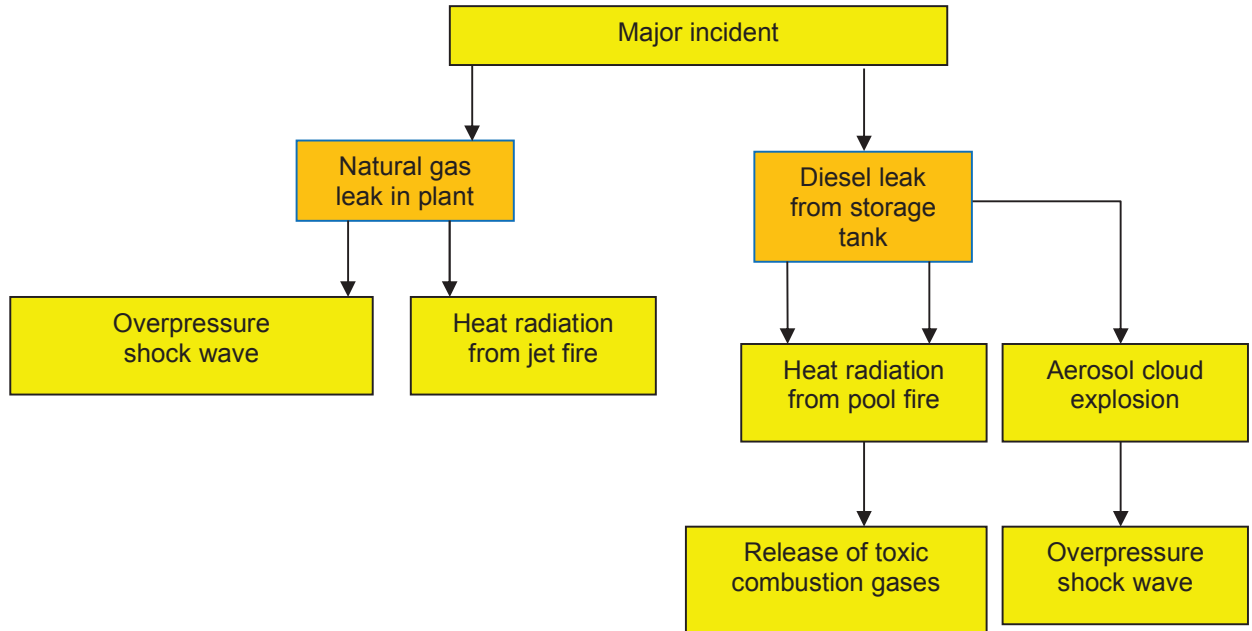
Consequences of Potential Major Incidents

The following consequences of major incidents could be expected at the Vortum Energy (Pty) Ltd Saldanha Bay site:

Product	Quantity	Potential major incident	Potential consequence
1. Diesel	6 tanks of 5 400 m ³ each	Diesel oil leak	<ul style="list-style-type: none">• Pool fire• Release of toxic combustion products
2. Natural gas	2 890 tons per day via pipeline	Natural gas leak	<ul style="list-style-type: none">• Jet fire• Gas cloud explosion

Figure 4.1

Consequences of a major event



Section 5

Estimation of Probabilities of Potential Major Incidents

Probabilities of major incidents

5.1 Modelling basis

Product	Quantity
1. Diesel in Phase 1	6 tanks of 5 400 m ³ each
2. Natural gas in Phase 2	2 890 tons per day via pipeline

5.2 The effect of human error

The probability and frequency of a major incident at the Vortum Energy (Pty) Ltd gas site depend on two main parameters, namely:

- The frequency of operations at the gas site (F). F is estimated as follows:
 - Diesel tank filling: $F_1 = 1$ per day or 365 fillings per year.
 - Total frequency $F_T = 365$ events per year ($3.65 \text{ E}+2$), which exceeds the norm of $1.0 \text{ E}-4$.
- The probability of an uncontrolled (accidental) release of flammable material (P_a). P_a is a function of human error.

The probability of a human error (P_{he}) is defined as follows:

$$P_{he} = [\text{Number of errors}] / [\text{Number of opportunities for error}]$$

Human error occurrence has been analysed extensively by Swain, Taylor and Rasmussen. The results were reported by Mannan [6; P14/46] and the American Institute of Chemical Engineers [1; P377]. A detailed classification of operator error was done by analysing 200 licensee event reports for nuclear plants. The classification includes categories both of human behaviour and of task and is summarised in Table 5.1.

5.3 Fault-trees and event-trees

A fault-tree analysis method [1] was applied to determine the possible causes of an event (fault) that could eventually lead to a major incident at Vortum Energy (Pty) Ltd. Incident data on major incidents involving LPG was obtained from the *Canvey Reports* [8]. It appeared from the data that a leak of LPG is more likely to originate from pipe work than from storage tanks. The higher frequency is taken as the determinant frequency for this risk assessment.

The following assumptions were made with regard to the probabilities of potential causes of a LPG leak at Vortum Energy (Pty) Ltd:

• External interference	0,18
• Construction defect / material failure	0,18
• Corrosion	0,18
• Ground movement	0,18
• Hot-tap made by error	0,18
• Offloading/refilling	0,10
• Total	1,00

An event-tree analysis method [1] was applied to determine the potential major incidents that could be the end result of each event.

The fault-tree and event-tree analysis are shown in the following figures. It is also important to take note of the potential causes of human error as outlined in Table 5.1.

Table 5.1

Classification and probabilities of human errors

Human Error	Number of Errors	Probability of Error
<i>Task condition</i>		
Routine task on schedule	89	0.064
Routine task on demand	11	0.008
Special task on schedule	51	0.037
Ad hoc, improvisation	21	0.015
Other	27	0.019
<i>Task control</i>		
Paced by system dynamics	9	0.006
Paced by programme or orders	4	0.003
Self-paced	166	0.119
Other	21	0.015
<i>Error situation</i>		
Spontaneous error in undisturbed task	93	0.067
Change in condition of familiar task	27	0.019
Operator distracted in task, preoccupied	10	0.007
Unfamiliar task	22	0.016
Other	48	0.034
<i>Task</i>		
Monitoring and inspection	3	0.002
Supervisory control	13	0.009
Manual operation and control	17	0.012
Inventory control	30	0.022
Test and calibration	47	0.034
Repair and modification	60	0.043
Administrative and recording	4	0.003
Management and staff planning	13	0.009
Other	13	0.009
<i>Effect from</i>		
Specified act not performed	103	0.074 max
Positive effect of wrong act	65	0.047
Extraneous effect	15	0.011
Sneak path	12	0.009
Other	6	0.004
<i>Potential for recovery</i>		
Effect not immediately reversible	29	0.021
Effect not immediately observable	137	0.098
Other	34	0.024
<i>Error categories</i>		

Absent-mindedness	3	0.002
Familiar association	6	0.004
Capability exceeded	1	0.001
Low alertness	10	0.007
Manual variability and lack of precision	10	0.007
Topographic and spatial orientation inadequate	10	0.007
Familiar routine interference	0	0.000
Omission of functionally isolated act	56	0.040
Omission of administrative act	12	0.009
Other omissions	9	0.006
Mistake, interchange among alternative possibilities	11	0.008
Expect and assume rather than observe	10	0.007
System knowledge insufficient	2	0.001
Side-effects of process not adequately considered	15	0.011
Latent causal condition or relations not adequately considered	20	0.014
Reference data recalled wrongly	1	0.001
Sabotage	1	0.001
Other	17	0.012
Total opportunities for error	1394	-

Figure 5.1: Causal factors for unexpected fire or explosion

Probabilities are given between 0 and 1

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
Other	0.015
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
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
Specified act not performed	0.074
Positive effect of wrong act	0.047
Extraneous effect	0.011
Sneak path	0.009
Other	0.004
Effect not immediately reversible	0.021
Effect not immediately observable	0.098
Other	0.024
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



Unexpected event
0.119 max

Figure 5.2**Fault-tree analysis on natural gas pipe work**

*Probabilities are indicated in brackets < >
Frequencies (average number of incidents per year) are indicated in brackets () for
data obtained from the Canvey reports [8; PA7-8]*

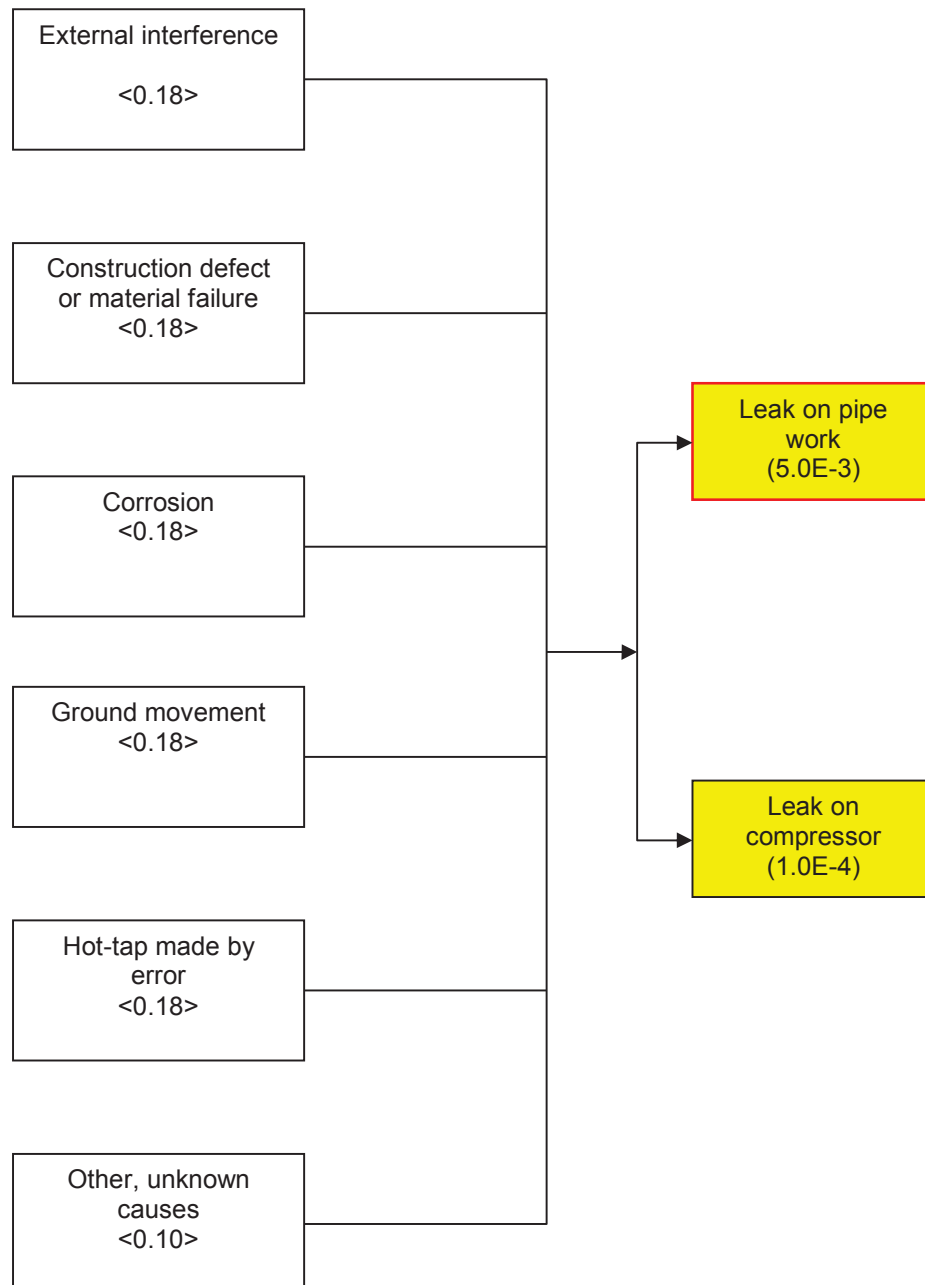


Figure 5.3**Event-tree analysis on natural gas pipe work**

*Frequencies are given in () brackets
Probabilities are given in < > brackets*

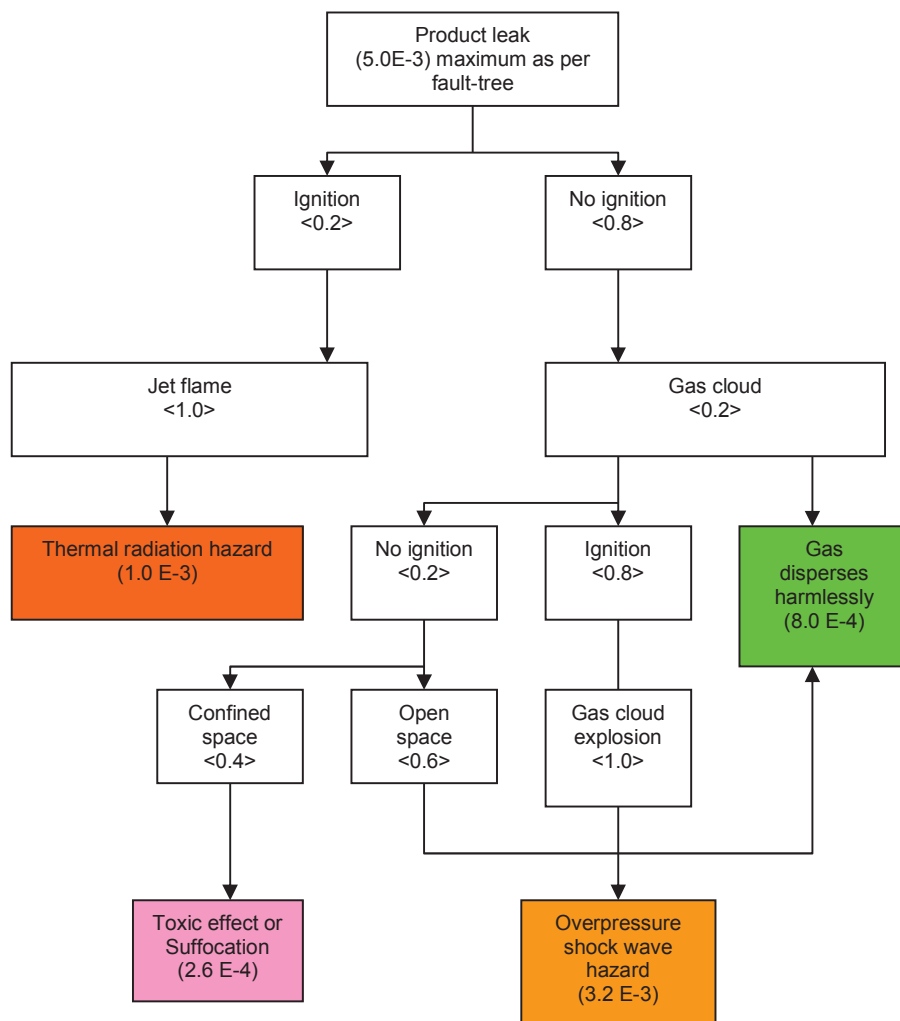


Figure 5.4

Fault-tree for diesel storage tanks aboveground

Frequencies are given in () brackets
Probabilities are given in <> brackets

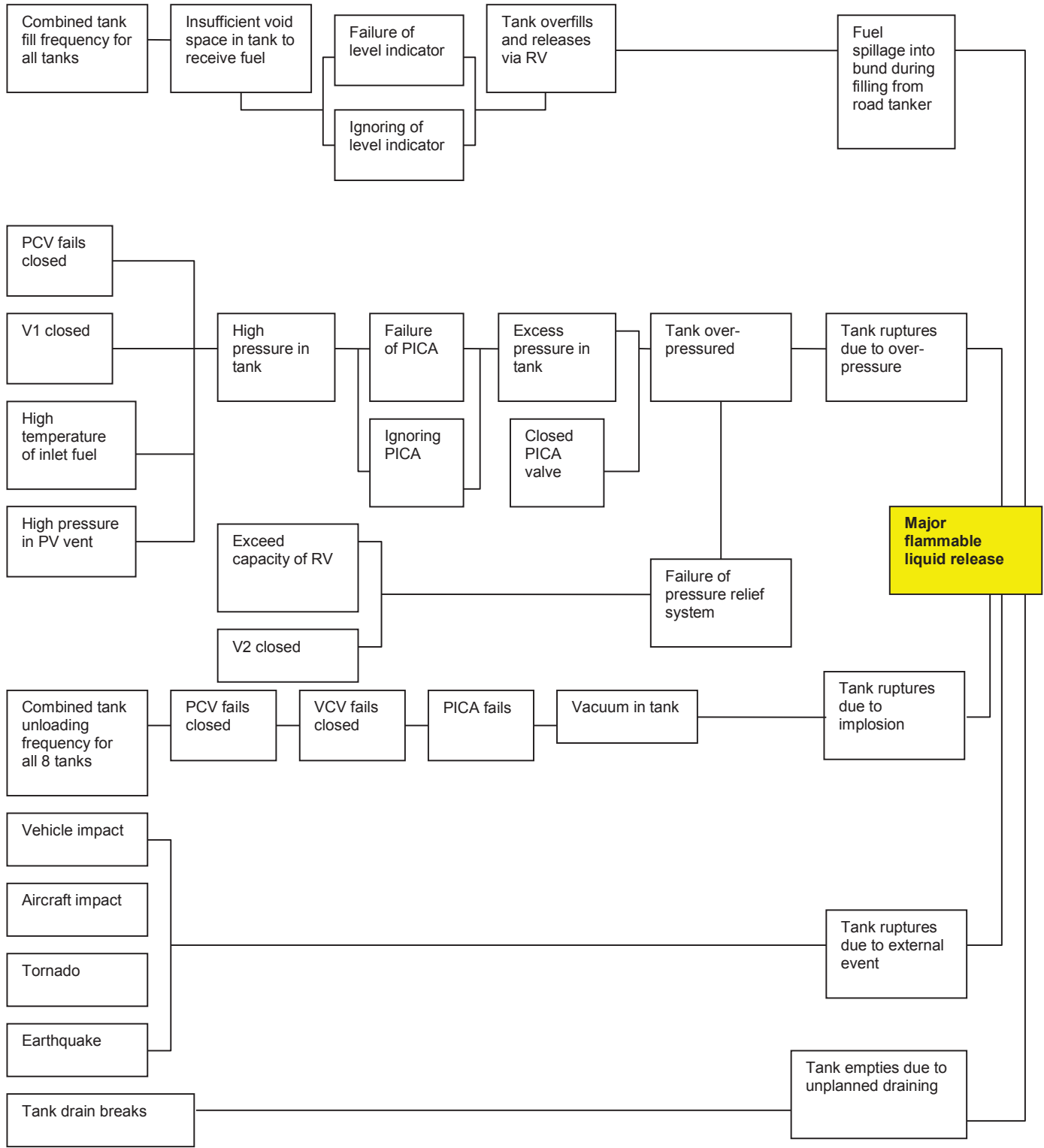


Figure 5.5

Event-tree for diesel storage tanks aboveground

Frequencies are given in () brackets
 Probabilities are given in <> brackets

Refer to [42]

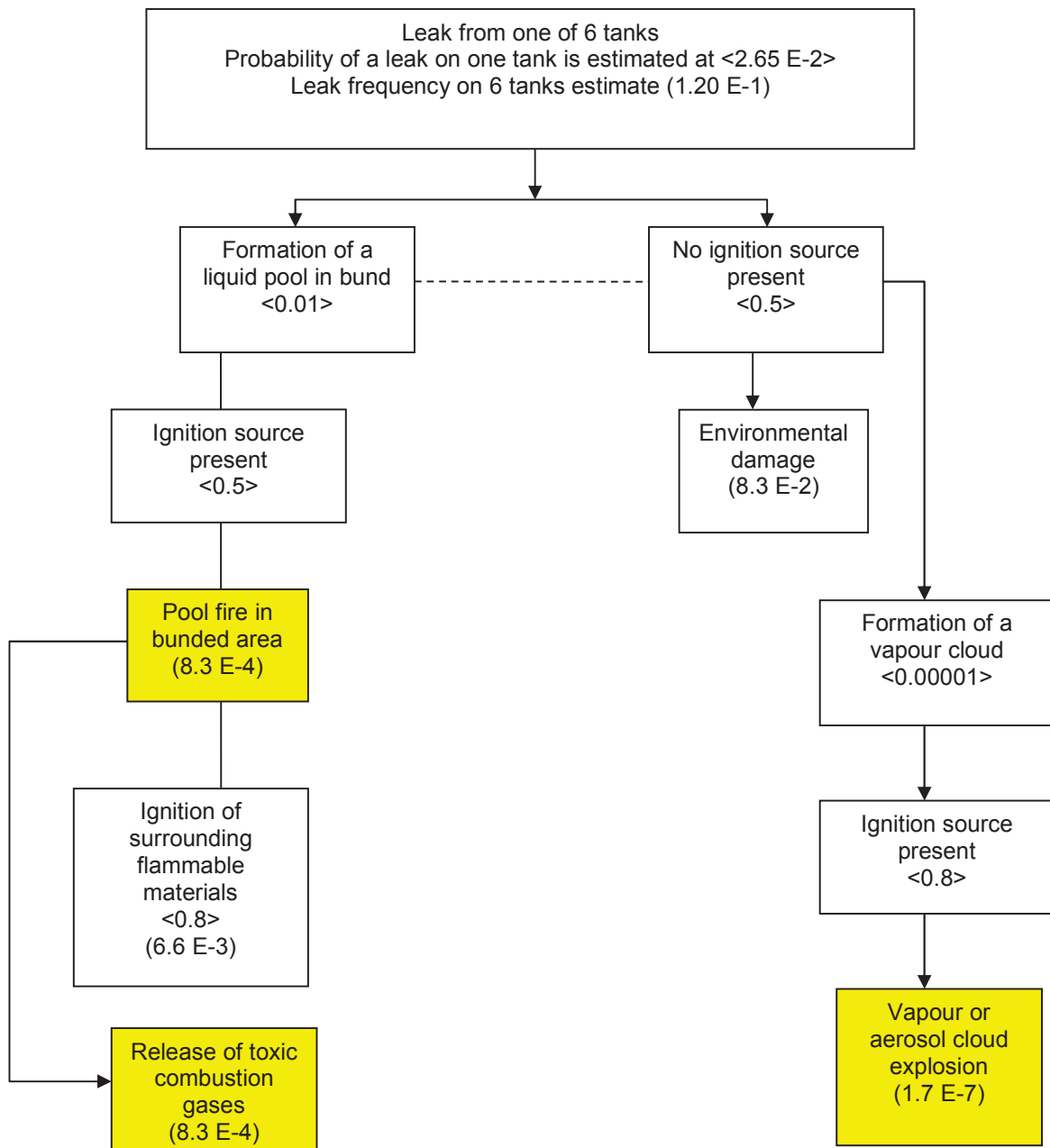
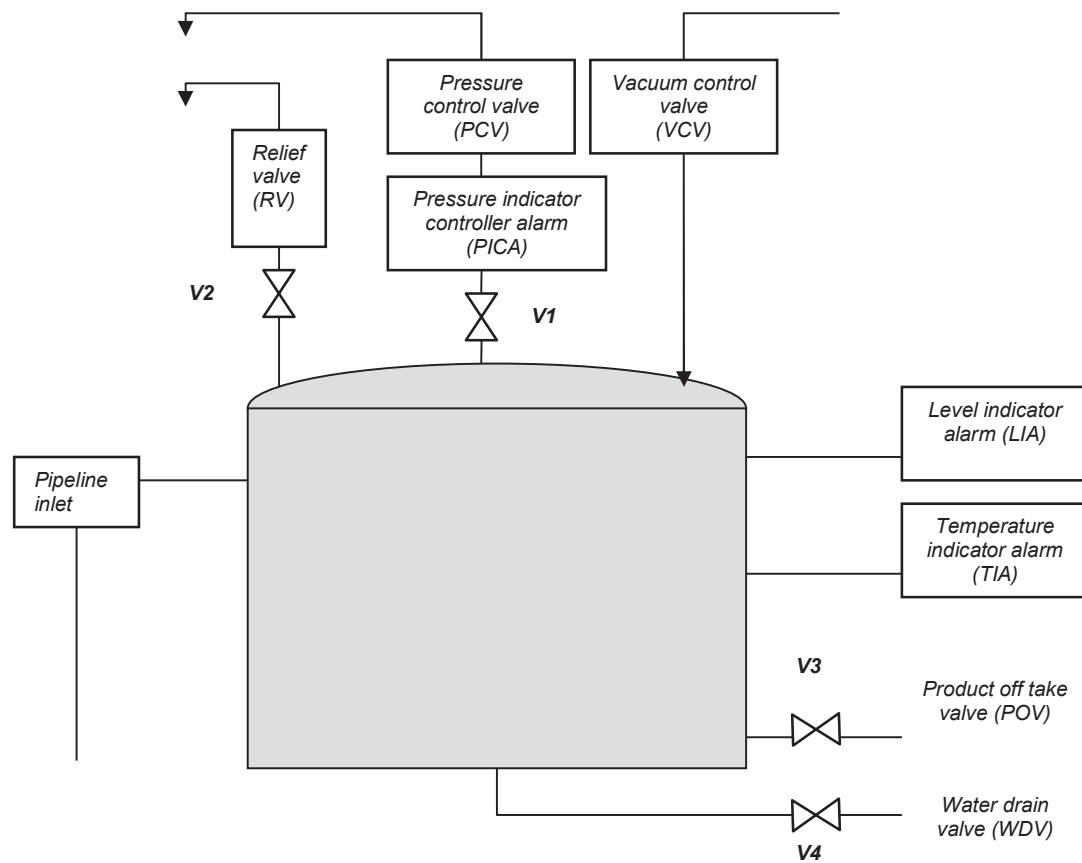


Figure 5.6

Typical conceptual piping and instrumentation diagram for a diesel oil tank
aboveground
[1, 316]



Section 6

Meteorological Tendencies

6.1 Lightning

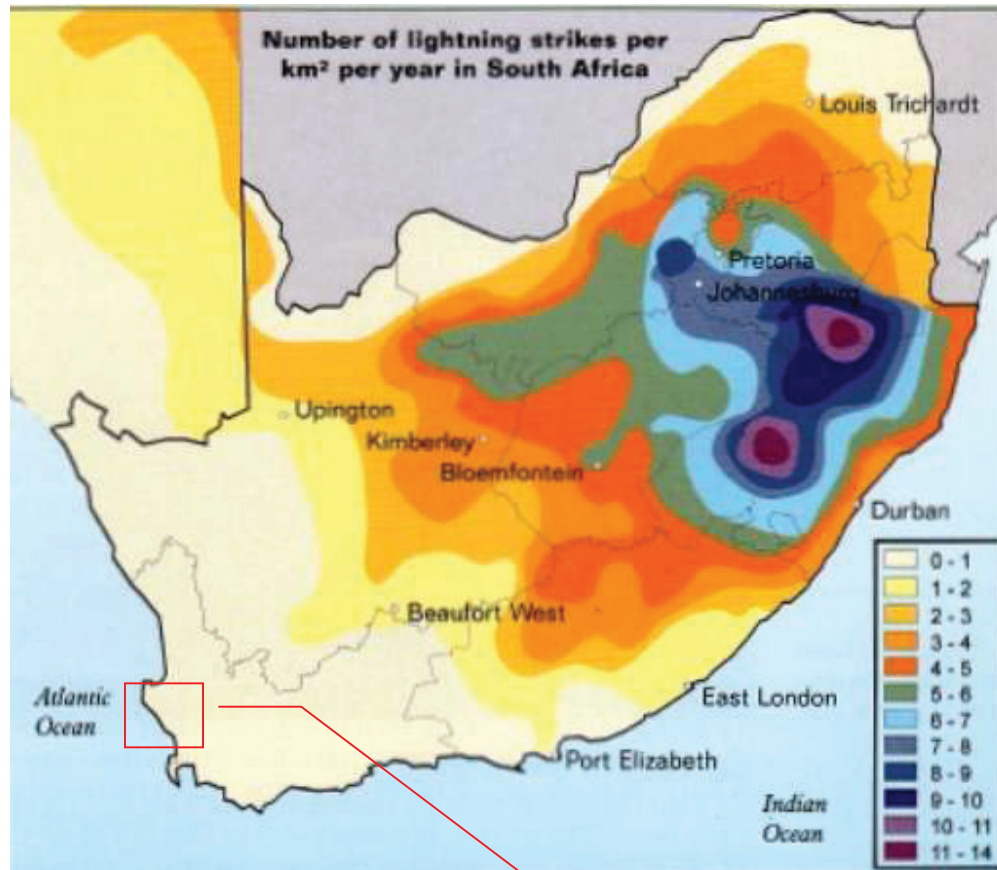
Lightning can be a trigger to serious plant disasters, for example when a strike hits vulnerable parts of the complex where flammable or explosive materials are stored. The incidence of lightning in the Saldanha Bay area was investigated [30] and is shown in Figure 6.1. In the Durban/Pietermaritzburg area thunder is heard about 4 times per year, compared with 50 to 60 times per year for Johannesburg, 11 times per year for the most of Europe and 150 times per year for central Africa. Thunderstorms are common in South Africa and typical for the north-eastern summer rainfall regions.

The incidence of lightning in the Saldanha Bay area, where the facility is located, is 0 to 1 strikes per square kilometer (10^6 m^2) per year. The surface area of the site amounts to about 130 000 m^2 , which implies that the incidence of lightning at the site area is about 0.13 per year. In other words, one strike is likely to occur at the site every 7.6 years.

It is unlikely that lightning could be the cause of a major incident at the site. It is nevertheless recommended that all parts of the installation be inspected to ensure that adequate earth links are installed on vulnerable components, such as aboveground pipe work, valves and electrical connections.

Figure 6.1

Number of lightning strikes per square kilometer per year in South Africa



Site
0 - 1 lightning strikes
per km² per year

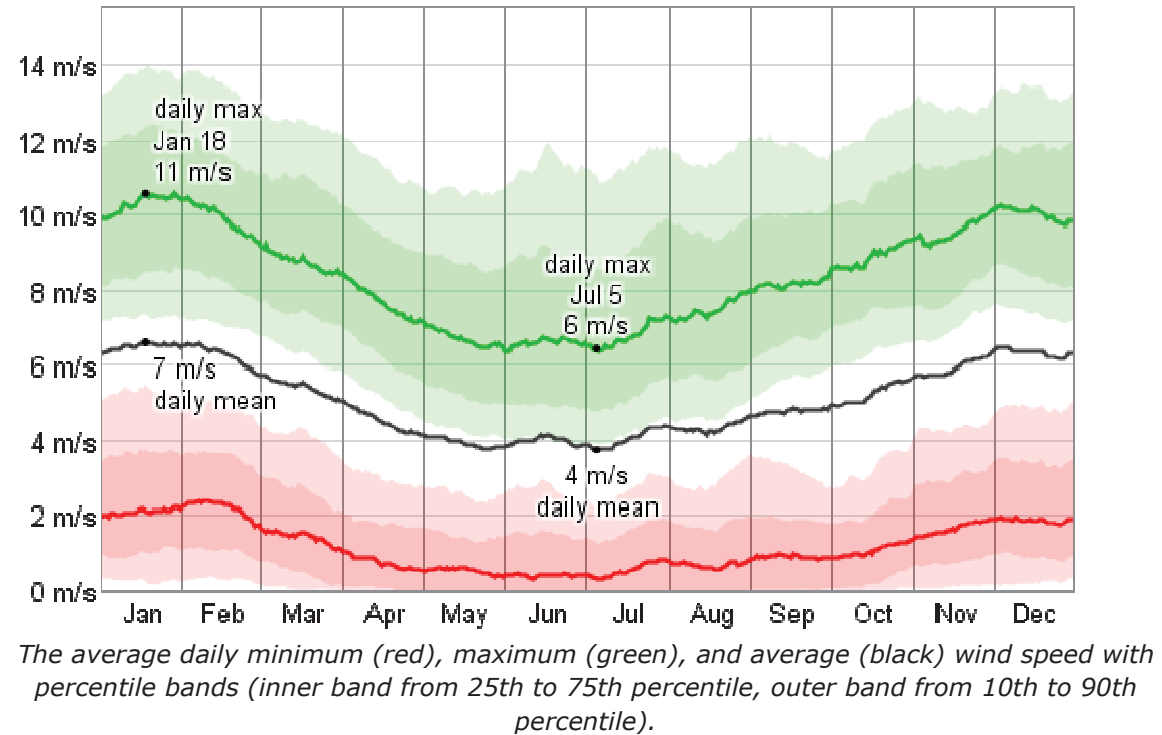
6.2 Wind direction and speed

Over the course of the year typical wind speeds vary from 0 m/s to 11 m/s (light air to fresh breeze), rarely exceeding 14 m/s (high wind).

The *highest* average wind speed of 7 m/s (moderate breeze) occurs around January 18, at which time the average daily maximum wind speed is 11 m/s (fresh breeze).

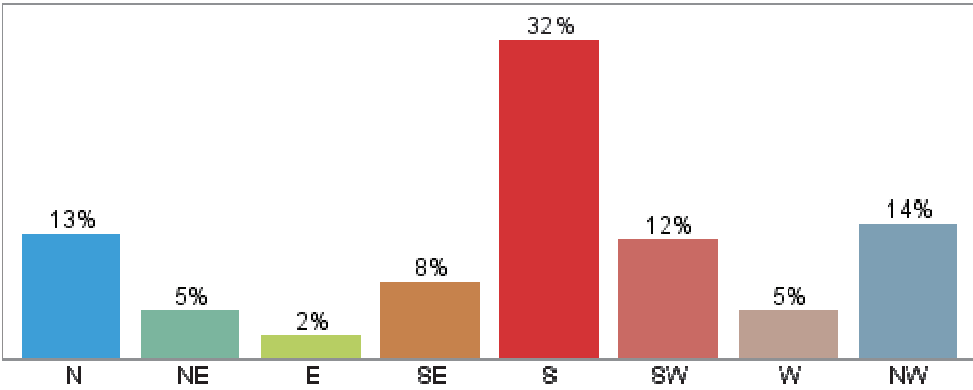
The *lowest* average wind speed of 4 m/s (gentle breeze) occurs around July 5, at which time the average daily maximum wind speed is 6 m/s (moderate breeze).

Figure 6.2: Wind Speed



The wind is most often out of the *south* (32% of the time), *northwest* (14% of the time), *north* (13% of the time), and *south west* (12% of the time). The wind is least often out of the east (2% of the time), north east (5% of the time), and west (5% of the time).

Figure 6.3: Wind Directions for the Entire Year

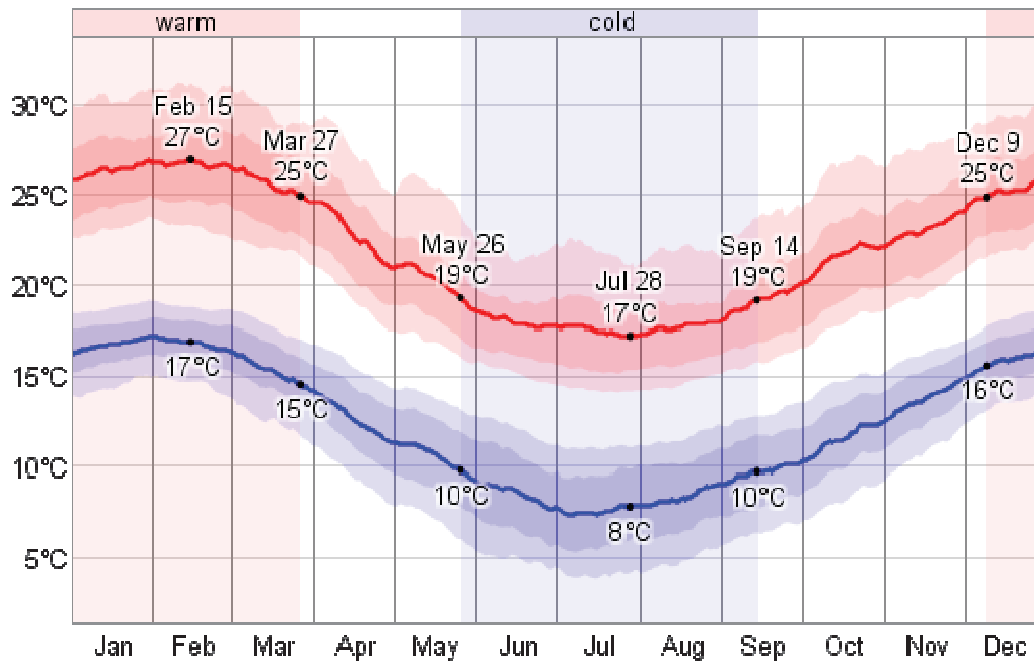


The fraction of time spent with the wind blowing from the various directions over the entire year. Values do not sum to 100% because the wind direction is undefined when the wind speed is zero.

6.3 Surface temperature

Over the course of a year, the temperature typically varies from 7°C to 27°C and is rarely below 4°C or above 31°C.

Figure 6.4: Daily High and Low Temperature

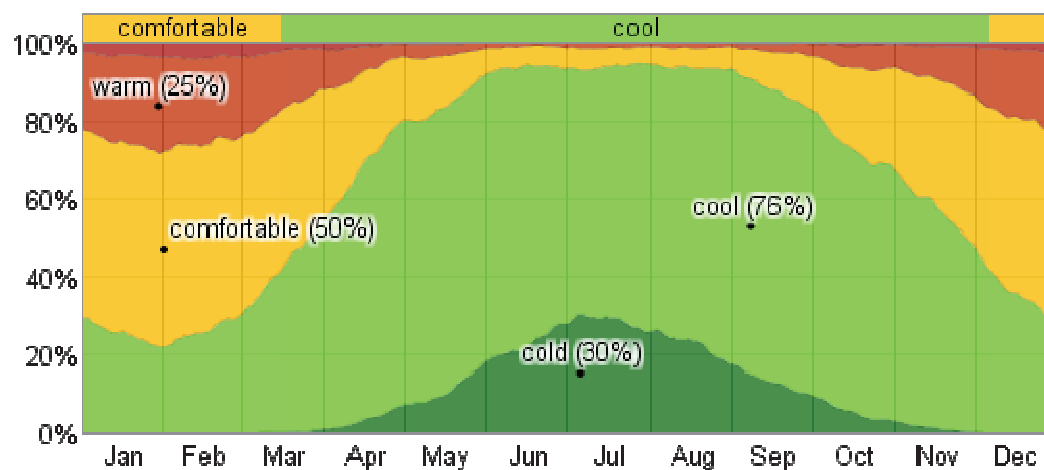


The daily average low (blue) and high (red) temperature with percentile bands (inner band from 25th to 75th percentile, outer band from 10th to 90th percentile).

The *warm season* lasts from December 9 to March 27 with an average daily high temperature above 25°C. The hottest day of the year is February 15, with an average high of 27°C and low of 17°C.

The *cold season* lasts from May 26 to September 14 with an average daily high temperature below 19°C. The coldest day of the year is July 5, with an average low of 7°C and high of 18°C.

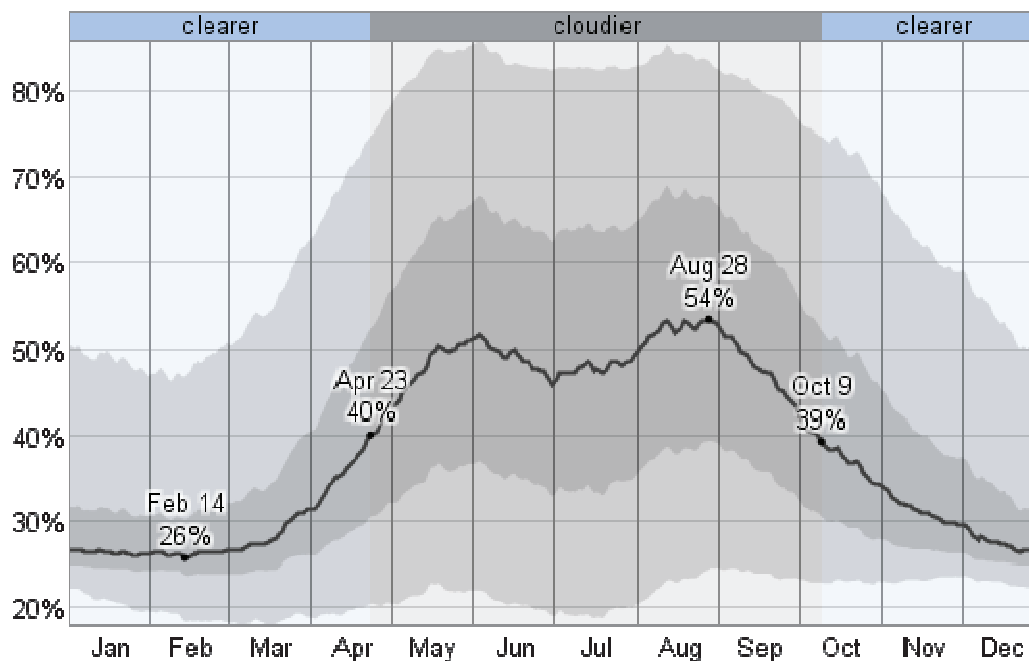
Figure 6.5: Fraction of Time Spent in Various Temperature Bands



6.4 Cloud cover

The median cloud cover ranges from 26% (mostly clear) to 54% (partly cloudy). The sky is cloudiest on August 28 and clearest on February 14. The clearer part of the year begins around October 9. The cloudier part of the year begins around April 23.

Figure 6.6: Median Cloud Cover

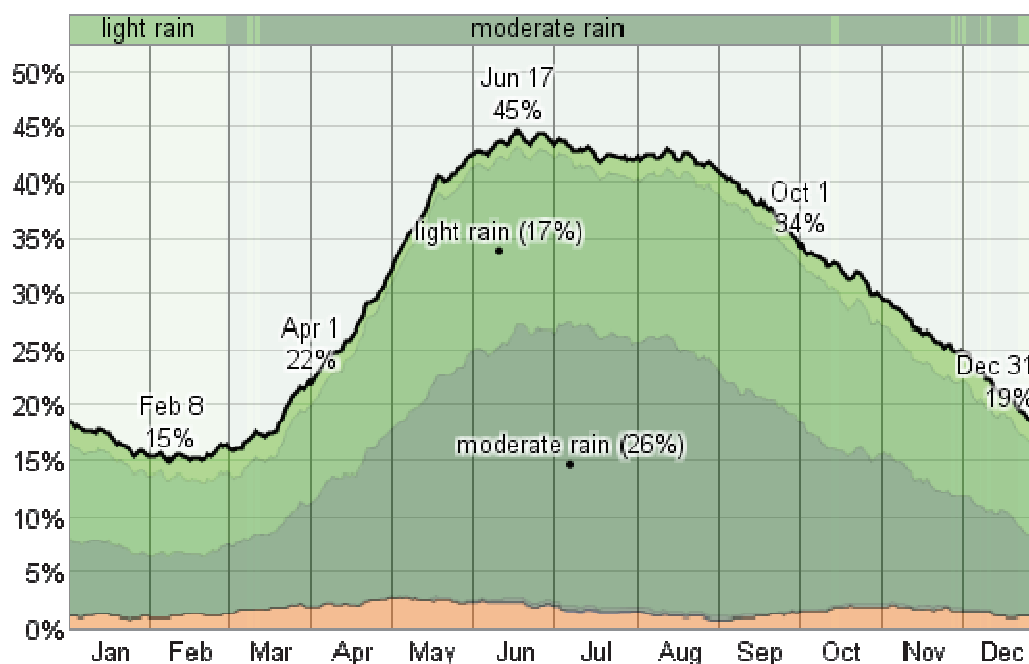


The median daily cloud cover (black line) with percentile bands (inner band from 40th to 60th percentile, outer band from 25th to 75th percentile).

On February 14, the *clearest day* of the year, the sky is *clear, mostly clear, or partly cloudy* 71% of the time, and *overcast or mostly cloudy* 15% of the time.

6.5 Rainfall (mm)

The probability that precipitation will be observed at this location varies throughout the year. Precipitation is most likely around June 17, occurring in 45% of days. Precipitation is least likely around February 8, occurring in 15% of days.

Figure 6.7: Probability of Precipitation at Some Point in the Day

The fraction of days in which various types of precipitation are observed. If more than one type of precipitation is reported in a given day, the more severe precipitation is counted. For example, if light rain is observed in the same day as a thunderstorm, that day counts towards the thunderstorm totals. The order of severity is from the top down in this graph, with the most severe at the bottom.

Over the entire year, the most common forms of precipitation are moderate rain and light rain.

Moderate rain is the most severe precipitation observed during 49% of those days with precipitation. It is most likely around July 7, when it is observed during 26% of all days.

6.6 Atmospheric stability classification

The stability conditions of the atmosphere play an important role when toxic cloud dispersion patterns are evaluated. The Pasquill atmospheric stability classification system [18; 32] was used in this risk assessment. The various stability classes are explained in [Table 6.1](#).

The dominant parameters that determine atmospheric stability is **wind speed**, **cloud cover** and **time of day**.

A boundary layer exists in the atmosphere and consists of the first few hundred meters above the surface of the earth. This layer is affected by the retardation of airflow due to frictional drag of the surface of the earth as well as heat and moisture exchanges that take place at the surface. During the day the atmospheric boundary layer is characterized by thermal turbulence caused by heating of the earth's surface. During the night weak vertical mixing occurs and a stable layer is common. This condition is usually associated with low wind speeds with little potential for dilution of xenobiotic molecular species.

The release of atmospheric emissions will result in maximum concentrations at ground level during low wind speeds and stable atmospheric conditions (Pasquill class E to F), typically experienced during the night.

Taking all the above factors into consideration, the dominant atmospheric classification for the Saldanha Bay area is as follows:

January (summer):	Class C-D
April (autumn):	Class C
July (winter):	Class C-D
October (spring):	Class D

For the purpose of mathematical modeling of the dispersion effects of toxic releases from the site, **atmospheric classification D** was considered to be the dominant condition for the site under study. This condition represents a worst case scenario of neutral conditions with high winds and cloudy sky where little dilution of xenobiotic molecular species will occur.

Table 6.1

Pasquill atmospheric stability classification system

Surface wind speed in m/s	Daytime conditions			Night time conditions	
	Strong sunlight Cloudiness <10%	Moderate sunlight Cloudiness <50%	Slight sunlight Cloudiness >50%	Cloudiness >50% **	Cloudiness <50% **
<2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D
A	Extremely unstable conditions (calm wind, clear sky, hot daytime)				
B	Moderately unstable conditions (clear sky, daytime)				
C	Slightly unstable conditions (moderate wind, slightly overcast, daytime)				
D	Neutral conditions * (high winds, cloudy, day or night)				
E	Slightly stable conditions (moderate wind, slightly overcast, night time)				
F	Moderately stable conditions (low winds, clear sky, cold, night time)				
* Applicable to heavy overcast conditions, day or night					
** Degree of cloudiness: Fraction of sky above the horizon covered by clouds					

Section 7

Estimation of the Total Result in Case of an Explosion

Background discussion

An explosion is defined as a sudden increase in volume and release of energy in a violent manner, usually with the generation of high temperatures and the release of combustion gases. An explosion causes pressure waves in the local medium in which it occurs.

Explosions are categorized as deflagrations if these waves are subsonic and detonations if they are supersonic (shock waves) [35]. Any speed faster than the speed of sound, which is approximately 343 m/s in air at sea level, is said to be supersonic. Speeds greater than 5 times the speed of sound are referred to as hypersonic.

Deflagration is a process of subsonic combustion that usually propagates by means of thermal conductivity, where hot burning material heats the next layer of cold material and ignites it. Deflagration is different from detonation, which is supersonic and propagates through shock wave compression of the unreacted material.

Detonation is a process of supersonic combustion in which a shock wave is propagated forward due to energy release in a reaction zone behind it. Detonation is more powerful than deflagration. The shock wave compresses the material and thus increases the temperature to the point of ignition. The ignited material burns behind the shock wave and releases energy that supports the shock propagation. This self-sustained detonation wave is different from a deflagration that propagates at a subsonic speed (i.e. slower than the speed of sound) and without a shock wave. Because detonations generate high pressures, they are usually much more destructive than deflagrations.

The simplest theory to predict the behavior of detonations in gases is known as Chapman-Jouguet (CJ) theory, developed around the turn of the 20th century. This theory, described by a relatively simple set of algebraic equations, models the detonation as a propagating shock wave accompanied by exothermic heat release. Such a theory confines the chemistry and diffusive transport processes to an infinitely thin zone.

A more complex theory was advanced independently during World War II by Zel'dovich, von Neumann, and Doering. This theory, now known as ZND theory, admits finite-rate chemical reactions and thus describes a detonation as an infinitely thin shock wave followed by a zone of exothermic chemical reaction. In the reference frame in which the shock wave is stationary, the flow following the shock wave is subsonic. Because of this, energy release behind the shock wave is able to be transported acoustically to the shock wave front for its support. For a self-propagating detonation, the shock wave relaxes to a speed given by the Chapman-Jouguet condition, which induces the material at the end of the reaction zone to have a locally sonic speed in the reference frame in which the shock wave is

stationary. In effect, all of the chemical energy is harnessed to propagate the shock wave forward.

Both CJ and ZND theories are one-dimensional and steady. However, in the 1960's experiments revealed that gas-phase detonations were most often characterized by unsteady, three-dimensional structures, which can only in an averaged sense be predicted by one-dimensional steady theories. Modern computations are presently making progress in predicting these complex flow fields. Many features can be qualitatively predicted, but the multi-scale nature of the problem makes detailed quantitative predictions very difficult.

Detonations can be produced by high explosives, reactive gaseous mixtures, certain dusts and aerosols. Thermonuclear detonations are believed to be involved in supernova explosions.

Most common artificial explosives are chemical explosives, usually involving a rapid and violent oxidation reaction that produces large amounts of hot gas. Gunpowder was the first explosive to be discovered and put to use. Other notable early developments in chemical explosive technology were Frederick Augustus Abel's development of nitrocellulose (guncotton) in 1865 and Alfred Nobel's invention of dynamite (stabilized nitroglycerin). A new order of explosive, the nuclear bomb, was invented in 1945 by Allied scientists. In 1952, the US military developed the first fusion bomb.

Boiling liquid expanding vapour explosions (BLEVE) are a type of explosion that can occur when a tank containing a pressurized liquid is ruptured, causing a rapid increase in gaseous volume as the liquid evaporates. High current electrical faults can create *electrical explosions* by forming a high energy electrical arc which rapidly vaporizes electrode and insulation material and produces a resultant shock wave in air.

Explosions are common in nature. On earth, most natural explosions arise from volcanic processes of various sorts. Explosive volcanic eruptions occur when magma rising from below has much dissolved gas in it. The reduction of pressure as the magma rises causes the gas to bubble out of solution, resulting in a rapid increase in gas volume. Explosions also occur as a result of earth impacts. On other planets, volcanic activity and impacts cause explosions with various frequencies.

Solar flares are an example of explosions common on the sun, and presumably on most other stars as well. The energy source for solar flare activity comes from the tangling of magnetic field lines resulting from the rotation of the sun's conductive plasma.

Among the largest known explosions in the universe are supernovae, which result from stars exploding, and gamma ray bursts, whose nature is still in some dispute.

When a large amount of LPG is rapidly released, a vapour cloud forms and disperses into the surrounding air [1]. If the gas cloud is ignited before the cloud is diluted below its lower flammability limit (LFL) a vapour cloud explosion or flash fire will occur. The main consequence of a vapour cloud explosion is an overpressure or

shock wave. The main consequence of a flash fire is direct flame contact and thermal radiation.

Four features must be present for a vapour cloud explosion to occur, namely:

- The released material must be flammable.
- A cloud of sufficient size must form prior to ignition. Delay times for ignition usually vary between 5 and 60 seconds.
- A sufficient amount of the cloud must be in the flammable range, between the lower and upper flammability limits of the specific gas.
- Sufficient confinement or turbulent mixing of a portion of the vapour cloud must be present.

The blast effects of a vapour cloud depend on whether deflagration or detonation follows, with a deflagration being the most likely event. A transition from deflagration to detonation is unlikely in open air. A deflagration or detonation is also dependent on the energy of the ignition source. Larger ignition sources increase the likelihood of a direct detonation.

Some approximate damage estimates for common structures based on overpressure are given in Table 7.1. [1; P163]

Table 7.1

Overpressure damage estimates

Overpressure, psi	Estimated Damage
0.1	Breakage of small windows under strain.
1	Partial demolition of houses. Houses made uninhabitable.
2	Corrugated asbestos shattered. Corrugated steel or aluminium panels fastenings fail, followed by buckling. Wood panels in standard housing fail and panels blown in. Partial collapse of walls and roofs of houses.
3	Concrete or cinder block walls, not reinforced, shattered. Steel frame buildings distorted and pulled away from foundations.
4	Frameless, self-framing steel panel buildings demolished. Rupture of oil storage tanks. Cladding of light industrial buildings ruptured.
5	Wooden utility poles snap. Tall hydraulic press (18 000 kg) in building slightly damaged.
6	Nearly complete destruction of houses.
7	Loaded train wagons overturned.
8	Brick panels, 8-12 inches thick, not reinforced, fail by shearing or flexure.
9	Loaded train boxcars completely demolished.
10	Probable total destruction of buildings. Heavy machine tools (3 100 kg) moved and badly damaged.
300	Limit of crater lip.

Scenario modelling

1. Natural gas cloud explosion

Assumptions:

- Natural gas pressure at point of consumption is 1 barg.
- Leakage is equivalent to 25 mm diameter.

Table 7.2

Cross-correlation 2.4: Gas Discharge through a Hole

Input Data:

Heat capacity ratio of gas:	1,15	
Hole size:	25	mm
Upstream pressure:	1	bar abs
Downstream pressure:	1,01	bar abs
Temperature:	298	K
Gas molecular weight:	16	

Excess Head Loss Factors:

Entrance:	0,5
Exit:	1
Others:	0
TOTAL:	1,5

Calculated Results:

Hole area:	0,000490874	m**2
Upstream gas density:	0,65	kg/m**3
Expansion factor, Y:	0,614	

Actual pressure ratio: -0,01 <-- Must be greater than sonic pressure ratio below to insure sonic flow.

Heat capacity ratio, k:	1,2	1,4	1,67	
Sonic pressure ratios:	0,536	0,575	0,618	
Choked pressure:	0,46	0,43	0,38	bar

Mass flow: 0,0648 0,0671 0,0696 kg/s

Interpolation table: 1,2 0,064778353
1,4 0,067088633

Interpolated mass flow:	0,064201 kg/s
-------------------------	---------------

Assume the gas leaks out for 60 minutes and is then ignited. Total mass of gas cloud is therefore 231 kg.

Table 7.3

Cross-correlation 2.20: TNT Equivalency of a Vapour Cloud

Input Data:

TNT Mass:	231	kg
Distance from blast:	110	m

Calculated Results:

Scaled distance, z:	17,9276	m/kg ^{1/3}
---------------------	---------	---------------------

Overpressure Calculation: (only valid for $z > 0.0674$ and $z < 40$)

a+b*log(z):	1,478321
-------------	----------

Overpressure:	6,96	kPa
	1,009309	psig

Impulse

Calculation: (only valid for $z > 0.0674$ and $z < 40$)

a+b*log(z):	1,070111
-------------	----------

Impulse:	17,63854	Pa s
----------	----------	------

Duration

Calculation: (only valid for $z > 0.178$ and $z < 40$)

a+b*log(z):	0,805308
-------------	----------

Duration:	5,75092	ms
-----------	---------	----

Arrival Time Calculation: (only valid for $z > 0.0674$ and $z < 40$)

a+b*log(z):	1,52473
-------------	---------

Arrival time:	43,911	ms
---------------	--------	----

Section 8

Estimation of the Total Result in the Case of a Fire

Background discussion

The most critical effect of a hydrocarbon fire is exposure of people to the radiation flux caused by a torch flame or a pool fire [1].

Direct contact with a flame of any sort is serious for any prolonged period of time, since the extreme heat will severely burn and destroy living tissue and will ignite combustible materials. What is even more important is that fires can also cause injury or damage from a distance through the transmission of thermal radiation similar to the way in which the sun warms the earth. Such radiation (which is completely different from nuclear radiation) will be stronger at the surface of the flame and will become progressively weaker as one moves away in any direction. Therefore, during a hazardous material release involving fire, human injury and property damage may occur not only in the immediate vicinity of the burning area, but also in a remote zone surrounding the fire.

Thermal radiation levels (also referred to as thermal radiation flux) are measured and expressed in units of power per unit area of the item that receives the energy. However, since the injury or damage sustained by a receiving object is a function of the duration of exposure as well as the radiation intensity, thermal radiation dosages are also of concern. These dosages are determined by combining radiation levels with exposure times and are expressed in units of energy per unit time per unit area of the receiving surface. Table 8.1 lists some of the known effects of thermal radiation on bare skin as a function of exposure level and time.

Storage tanks or pipelines that contain gases under pressure or normally gaseous substances that have been pressurized to become liquids, may discharge gases at a high speed if the container is punctured. This condition also applies to a situation where a liquid has been heated in a closed system to a temperature above its normal boiling point. The gas venting from the hole will form a jet that blows perpendicularly away from the hole, while entraining air into the stream. If the gas is flammable and it encounters an ignition source, a flame jet of considerable length may form. The length of the flame may reach several hundred meters from a hole less than 300 mm in diameter. Such jets pose a thermal radiation threat to people and property in the vicinity and are particularly hazardous if they impinge upon the exterior of a nearby intact container with a flammable, volatile and/or self-reactive material in it. Such incidents can occur in crowded chemical facilities or where petroleum products are stored. In these cases the jet flame increases the pressure inside the container while at the same time weakening its outer wall through the transfer of thermal energy. This may eventually cause the container to rupture violently or explode in an event called a boiling liquid expanding vapour explosion (BLEVE). This condition is especially serious if the jet flame impinges on the container wall in the vapour space where there is no liquid to conduct the heat away from the wall surface. If the contents of the container are flammable, a large rising fireball may result. If the contents are non-flammable, but toxic, a large amount of toxic vapours or gases may suddenly be released into the atmosphere.

Table 8.1

Thermal radiation burn injury criteria [2]

Radiation intensity in kW/m ²	Time in seconds for severe pain	Time in seconds for second degree burns
1	115	663
2	45	187
3	27	92
4	18	57
5	13	40
6	11	30
8	7	20
10	5	14
12	4	11

Fireballs resulting from BLEVEs are among the most feared major incidents when sealed containers (including tanks and pipelines) of liquid or gaseous materials are exposed to fires. Although they are called explosions, they are not associated with strong blast waves in many cases. Rather, they involve a violent rupture of the container with flammable material and the rapid vaporization of the material. The size of the fireball will depend upon the amount of hazardous material present and may reach as much as 300 meters in diameter when involving a rail tank car with liquid compressed gas such as propane or butane. Although the fireball is generally of short duration, the intense thermal radiation generated by it can cause severe and possibly fatal burns to exposed people over considerable distances in a matter of seconds. In addition, the container may be loosened from its foundations to rocket away, spewing out burning gases or liquids as it goes along. Fragments of the container may also form projectiles with a high impact potential. Such projectiles have been recorded to travel more than 1 500 meters in the case of railroad tank cars. The projectiles may in itself cause secondary fires at remote distances.

It is important to note that BLEVEs can occur with most liquids excessively heated in a closed or inadequately vented container, whether they are flammable or not. Two important factors are the duration of the external exposure fire and the flow capacity of any relief valve installed on the container. If the external fire is of short duration or if the relief valve can vent vapour as fast as it is generated, a BLEVE will not occur. An additional factor is the availability of external cooling via fixed water spray systems, fire monitors and water hose streams. Sufficient suppression of the external fire or cooling of the material container can prevent a BLEVE.

Vapours that evolve from a pool of volatile liquid or gases venting from a container puncture may form a plume or cloud of gas or vapour that will move in a downwind direction. If the cloud contacts an ignition source at a point where its concentration is within the lower and upper flammability limits, a vapour cloud fire will be the result and a wall of flame may flash back towards the source of the gas or vapour, engulfing anything and everything in its path.

If a quantity of liquid is spilled on the ground and an ignition source is present, a liquid pool fire will start. In such a case the primary hazard to people and property is exposure to thermal radiation or toxic products of combustion. An added complication is that the liquid pool, if not contained by means of bund walls, may spread from the spillage site over a vast area and into drains and sewers to start secondary fires and even BLEVEs. Hydrocarbon compounds are usually lighter than water and will float on water surfaces into unwanted or unprotected areas where it may cause explosions in confined spaces.

Scenario modelling

1. Pool fire at the vertical aboveground diesel storage tanks with individual bund walls, including tank top fires

Bund wall area of each individual storage tank is 2 970 m².

Table 8.2

Model for the calculation of thermal radiation flux safety distance from a pool fire AICHe

Norm for maximum thermal radiation exposure: 12kW/m²

			Value	
V	Volume of fuel in pool			m ³
E	Maximum allowable thermal radiation flux	12 kW/m ²	12	kW/m ²
t	Atmospheric transmissivity for the specific site		0,5	
n	Fraction of the combustion energy radiated		0,35	
m	Mass burning rate for the specific fuel type		0,04	kg/m ² /s
H	Heat of combustion of the fuel		45000	kJ/kg
A	Total area of the burning fuel pool	0,003	2970	m ²
F	View factor for point source heat radiation		-	
L	Thermal radiation safety distance			
L2	[(tnmHA)/(4*E*Π)]		6201,563	
L	SQRT	Safety distance	78,8	meter

2. Pool fire at the vertical aboveground diesel storage tanks with common bund walls, including tank top fires

Bund wall area of combined tank farm is 17 820 m².

Table 8.2

Model for the calculation of thermal radiation flux safety distance from a pool fire

AICHe

Norm for maximum thermal radiation exposure:

12kW/m²

			<i>Value</i>	
V	Volume of fuel in pool			m ³
E	Maximum allowable thermal radiation flux	12 kW/m ²	12	kW/m ²
t	Atmospheric transmissivity for the specific site		0,5	
n	Fraction of the combustion energy radiated		0,35	
m	Mass burning rate for the specific fuel type		0,04	kg/m ² /s
H	Heat of combustion of the fuel		45000	kJ/kg
A	Total area of the burning fuel pool	0,003	17820	m ²
F	View factor for point source heat radiation		-	
L	Thermal radiation safety distance			
L2	$[(tnmHA)/(4 \cdot E \cdot t)]$		37209,38	
L	SQRT	Safety distance	192,9	meter

3. Jet flame from a natural gas leak

Assume that natural gas leaks out from a hole equivalent to 25 mm diameter under an upstream transmission line pressure of 40 barg.

Table 8.4

Cross-correlation 2.31: Radiant Flux from a Jet Fire

Input Data:		
Distance from flame:	14	m
Hole diameter:	25	mm
Leak height above ground:	0,5	m
Gas pressure:	40	bar gauge
Ambient temperature:	298	K
Relative humidity:	50	%
Heat capacity ratio for gas:	1,32	
Heat of combustion for gas:	54000	kJ/kg
Molecular weight of gas:	16	
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:	0,2	
Calculated Results:		
Area of hole:	0,000491	m**2
Gas discharge rate:	3,347	kg/s
L/d ratio for flame:	199,7	
Flame height:	4,99	m
Location of flame centre above ground:	3,00	
Radiation path length:	14,32	m
Point source view factor:	0,000388	m**2
Water vapour partial pressure:	1580	Pa
Atmospheric transmissivity:	0,819	
Flux at receptor location:	11,50	kW/m**2

Section 9

Estimation of the Concentration Effects of Potential Toxic Releases

1. Uncontrolled release of toxic emissions from a liquid fuel pool fire

Approximated combustion analysis for diesel:



It is assumed that fuel leaks out from the vertical storage tank into the bund area to form a pool with a surface area of about 2 970 m². This is a worst case scenario for a pool fire on the plant.

Combustion rate of diesel, petrol or paraffin: 0.04 kg/sec/m²

Table 9.1

C₁₈H₃₈	CO	CO₂	C
254 g/mole	28 g/mole	44 g/mole	12 g/mole
2 moles	2 moles	32 moles	2 moles
508 g	56 g	1 408 g	24 g
0.508 kg	0.056 kg	1.408 kg	0.024 kg
1 kg	0.110 kg	2.772 kg	0.047 kg
0.04 kg	0.0044 kg	0.111 kg	0.002 kg

Table 9.2

Product	Fire Surface Area m²	Emission formation Rate Kg/m²/sec	Emission formation Rate Kg/sec
Diesel	2 970	-	-
CO	-	0.004	12
CO ₂	-	0.111	330
C	-	0.002	6

SITE DATA:

Location: SALDANHA BAY, SOUTH AFRICA

Building Air Exchanges Per Hour: 0.50 (enclosed office)

CHEMICAL DATA:

Chemical Name: CARBON MONOXIDE

CAS Number: 630-8-0

Molecular Weight: 28.01 g/mol

AEGL-1 (60 min): N/A AEGL-2 (60 min): 83 ppm AEGL-3 (60 min): 330 ppm

IDLH: 1200 ppm LEL: 125000 ppm UEL: 742000 ppm

Ambient Boiling Point: -191.7° C

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 4 meters/second from S at 3 meters

Ground Roughness: open country Cloud Cover: 10 tenths

Air Temperature: 25° C

Stability Class: D

No Inversion Height

Relative Humidity: 75%

SOURCE STRENGTH:

Direct Source: 12 kilograms/sec Source Height: 0

Release Duration: 60 minutes

Release Rate: 720 kilograms/min

Total Amount Released: 43,200 kilograms

Note: This chemical may flash boil and/or result in two phase flow.

Use both dispersion modules to investigate its potential behavior.

THREAT ZONE:

Model Run: Gaussian

Red : 921 meters --- (330 ppm = AEGL-3 [60 min])

Orange: 2.2 kilometers --- (83 ppm = AEGL-2 [60 min])

Yellow: no recommended LOC value --- (N/A = AEGL-1 [60 min])

SITE DATA:

Location: SALDANHA BAY, SOUTH AFRICA

Building Air Exchanges Per Hour: 0.50 (enclosed office)

Time: February 11, 2016 1238 hours ST (using computer's clock)

CHEMICAL DATA:

Chemical Name: CARBON DIOXIDE

CAS Number: 124-38-9

Molecular Weight: 44.01 g/mol

PAC-1: 30000 ppm PAC-2: 40000 ppm PAC-3: 50000 ppm

IDLH: 40000 ppm

Normal Boiling Point: -unavail-

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

Note: Not enough chemical data to use Heavy Gas option

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 4 meters/second from S at 3 meters

Ground Roughness: open country Cloud Cover: 10 tenths

Air Temperature: 25° C Stability Class: D

No Inversion Height Relative Humidity: 75%

SOURCE STRENGTH:

Direct Source: 330 kilograms/sec Source Height: 0

Release Duration: 60 minutes

Release Rate: 19,800 kilograms/min

Total Amount Released: 1,188,000 kilograms

THREAT ZONE:

Model Run: Gaussian

Red : 270 meters --- (50000 ppm = PAC-3)

Orange: 305 meters --- (40000 ppm = PAC-2)

Yellow: 357 meters --- (30000 ppm = PAC-1)

SITE DATA:

Location: SALDANHA BAY, SOUTH AFRICA

Building Air Exchanges Per Hour: 0.50 (enclosed office)

CHEMICAL DATA:

Chemical Name: CARBON PARTICULATES

CAS Number: 124-38-9

Molecular Weight: 44.01 g/mol

PAC-1: 30000 ppm PAC-2: 40000 ppm PAC-3: 50000 ppm

IDLH: 40000 ppm

Normal Boiling Point: -unavail-

Vapor Pressure at Ambient Temperature: greater than 1 atm

Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

Note: Not enough chemical data to use Heavy Gas option

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)

Wind: 4 meters/second from S at 3 meters

Ground Roughness: open country

Cloud Cover: 10 tenths

Air Temperature: 25° C

Stability Class: D

No Inversion Height

Relative Humidity: 75%

SOURCE STRENGTH:

Direct Source: 6 kilograms/sec

Source Height: 0

Release Duration: 60 minutes

Release Rate: 360 kilograms/min

Total Amount Released: 21,600 kilograms

THREAT ZONE:

Model Run: Gaussian

Red : 34 meters --- (50000 ppm = PAC-3)

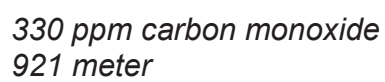
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Orange: 38 meters --- (40000 ppm = PAC-2)

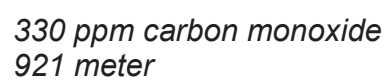
Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.

Yellow: 44 meters --- (30000 ppm = PAC-1)

Note: Threat zone was not drawn because effects of near-field patchiness make dispersion predictions less reliable for short distances.



330 ppm carbon monoxide
921 meter



330 ppm carbon monoxide
921 meter

Figure 9.3: Toxic concentration isopleth for carbon dioxide at the preferred site



50 000 ppm
270 meter

Figure 9.4: Toxic concentration isopleth for carbon dioxide at the alternative site



50 000 ppm
270 meter

Section 10

The Potential Effect of an Incident at the Major Hazard Installation or Part Thereof on an Adjacent Major Hazard Installation or Part Thereof

1. Description and localities of adjacent major hazard installations

The distances (in meters) from the Vortum Energy (Pty) Ltd facility to immediate surrounding facilities are as follows:

Table 10.1

No	Adjacent Facility	Distance from Vortum Energy (Pty) Ltd, meter
1	R27 freeway	470
2	Duferco Steel Processing Plant	7 395
3	Arcelor Mittal Steel Processing	5 080

2. Potential effect of an incident on the adjacent major hazard installations

The most critical effect that a major incident at the Vortum Energy (Pty) Ltd facility could have is a diesel pool fire at the tank farm where the bunded areas of all 6 tanks are filled with diesel. All the diesel storage tanks in the plant could be inter-affected by a major incident. The safety distance in such a case would be 193 meter.

Section 11

The Potential Effect of an Incident at the Major Hazard Installation or Part Thereof on Any Other Installation and Members of the Public and Residential Areas

1. Description and localities of adjacent installations

The Vortum Energy (Pty) Ltd facility is situated in an industrial area of Saldanha Bay as shown in Section 2.

2. Description of adjacent residential areas

The closest residential area is located more than 3 000 meter from the facility.

3. Potential effect of an incident on the adjacent installations

This aspect has been covered under Section 10.

4. Potential effect of an incident on residential areas

The closest residential area is located more than 3 000 meter from the Vortum Energy (Pty) Ltd power plant. These residences would not be affected by a potential major incident at the plant.

5. Population density

The population density in the Saldanha Bay area is estimated as 49 persons per km², or 0.00005 persons per m² according to the 2011 census data of Statistics SA.

Section 12**The Site Emergency Plan**

Note that a copy of the Emergency Procedures must always accompany this risk assessment report.

ON-SITE EMERGENCY RESPONSE PLAN

THERMAL POWER PLANT OF VORTUM ENERGY (PTY) LTD IN SALDANHA BAY

Date of Compilation

7 February 2016

A General Requirements	
Date of compilation	7 February 2016
Date of next revision	Prior to commissioning of the plant
Categories of emergency situations	<ul style="list-style-type: none"> • Diesel pool fire • Release of toxic combustion gases from a diesel pool fire • Natural gas jet fire • Natural gas cloud explosion
Potential natural or man-made emergencies that could disrupt the operation of the MHI facility	<ul style="list-style-type: none"> • Diesel pool fire • Release of toxic combustion gases from a diesel pool fire • Natural gas jet fire • Natural gas cloud explosion
Potential internal sources of emergencies that could disrupt the operation of the MHI facility	<ul style="list-style-type: none"> • Human error. • Faulty equipment. • Poor maintenance of equipment. • Metal corrosion. • Incorrect operating procedures. • Poor worker on-the-job training. • Poor safety supervision.
Internal emergencies effect on the operation of the MHI facility	<ul style="list-style-type: none"> • Power failure. • Diesel pool fire • Release of toxic combustion gases from a diesel pool fire • Natural gas jet fire • Natural gas cloud explosion
External emergencies effect on the operation of the MHI facility	<ul style="list-style-type: none"> • Diesel pool fire • Release of toxic combustion gases from a diesel pool fire • Natural gas jet fire • Natural gas cloud explosion
Response actions tailored to the specific MHI facility	Refer to <u>Annexure A</u> for the handling of LPG emergencies.
List of key personnel with their responsibilities and contact information	<i>To be completed prior to plant start-up</i>
Local emergency responders with their contact information	Police: 10111 Ambulance: 10177 Fire brigade: 10177
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	<i>To be completed prior to plant start-up</i>

How rescue operations will be performed	<ul style="list-style-type: none"> Any employee, who discovers a sign of fire on the premises, must immediately sound the fire alarm. Phone the local Fire Brigade. All employees on the premises must orderly walk (do not run to the emergency assembly point indicated in <u>Annexure B</u>). The designated Evacuation Controller must inspect the premises to ensure that all staff has left the buildings. The Evacuation Controller must take roll call at the assembly point to record the names of all assembled staff members. The designated Fire Fighters must use portable fire extinguishers or hose reels to fight small fires, if it can be done safely. Strictly follow the emergency actions stipulated in <u>Annexure A</u>. Take instructions from the Officer in Command of the Fire Brigade.
How medical assistance will be provided	<ul style="list-style-type: none"> In case of minor injuries, the designated First Aid Officer must apply treatment. Wait for instructions from the Officer in Command of the Fire Brigade and external paramedic personnel.
How and where personal information on employees can be obtained in an emergency	<p>Personnel information can be obtained from the following person by telephone:</p> <p><i>To be completed prior to plant start-up</i></p>
How affected members of the public will be contacted, who the contact persons are and their contact numbers	<p>The following neighbouring businesses must be contacted:</p> <p><i>To be completed prior to plant start-up</i></p>
B Evacuation Procedure	
Conditions under which an evacuation of people would be necessary	<p>Any fire on the premises.</p> <p>Bomb threat.</p> <p>Industrial action.</p> <p>Smoke alarm.</p>
Evacuation of employees on site as well as affected members of the public	All employees on the premises must orderly walk (do not run to the emergency assembly point indicated in <u>Annexure B</u>).
Chain of command and specific person with a standby authorized to order an evacuation or operational shutdown	<i>To be completed prior to plant start-up</i>
Types of actions expected from different employees for the various categories of emergencies	<p><u>Chief Executive Officer:</u></p> <ul style="list-style-type: none"> Liaise with the Officer in Command of the Fire Brigade. Liaise with reporters from the news media. <p><u>Second in command:</u></p> <ul style="list-style-type: none"> Take the role of the Chief Executive Officer in case of his absence. <p><u>First Aid Officer:</u></p>

	<ul style="list-style-type: none"> • Apply first aid treatment in case of minor injuries. • Assist paramedic personnel. • Assist disabled persons. <p><u>Evacuation Controller:</u></p> <ul style="list-style-type: none"> • Ensure that all staff members evacuate the buildings on the premises and assemble at the emergency assembly point shown in <u>Annexure B</u>. • Take roll call of all assembled staff. • Direct members of the public away from the premises. <p><u>Fire Fighters:</u></p> <ul style="list-style-type: none"> • Fight small fires if it can be done safely. • Assist fire fighters of the Fire Brigade if required.
Who will stay behind to shut down critical operations during an evacuation	The designated Second in Command.
Specific evacuation routes for employees posted at the MHI facility where they are easily accessible to all employees	<p>See <u>Annexure B</u>.</p> <p>Posters must be displayed inside all buildings to show the evacuation routes.</p>
Specific evacuation routes for members of the public	<ul style="list-style-type: none"> • Members of the public, who are on or near the premises, must be directed away from the premises. • It is the responsibility of the Evacuation Controller.
Procedures for assisting people during an evacuation, people with disabilities or those who cannot speak English or cannot read	<ul style="list-style-type: none"> • All employees on the premises must orderly walk (do not run) to the emergency assembly point indicated in <u>Annexure B</u>. • The designated Evacuation Controller must inspect the premises to ensure that all staff has left the buildings. • The Evacuation Controller must take roll call at the assembly point to record the names of all assembled staff members. • Disabled persons must be assisted by the First Aid Officers. • The Evacuation Controller must confirm that all staff members understand his instructions in a suitable language.
Assembly areas where employees will gather	See <u>Annexure B</u> .
Method of accounting for all employees	<ul style="list-style-type: none"> • The Evacuation Controller must take roll call at the emergency assembly point. • Report all names to the Chief Executive Officer.
How visitors will be assisted and accounted for during an evacuation	<ul style="list-style-type: none"> • All members of the public on the premises must orderly walk (do not run) to the emergency assembly point indicated in <u>Annexure B</u>.

C Reporting of an Emergency Condition	
Method of reporting fires and other emergencies to the local emergency services	<ul style="list-style-type: none"> Any employee, who discovers a sign of fire on the premises, must immediately sound the fire alarm. Phone the Local Fire Brigade.
Method of alerting employees, including disabled employees, to evacuate from the MHI site or to take other action	<ul style="list-style-type: none"> Any employee, who discovers a sign of fire on the premises, must immediately sound the fire alarm. Staff evacuation must take place under the command of the Evacuation Controller.
D Employee Training and Drills	
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	<ul style="list-style-type: none"> Training for the following personnel must be given in collaboration with the Local Fire Department: Evacuation Controller. First Aid Officer. Chief Executive Officer. Second in Command. Fire Fighters. Training must be done before start of operations.
How and when retraining of employees will take place	Retraining of staff must be done at least annually.
How often drills will take place. These drills must involve all employees at the MHI site as well as affected members of the public	<ul style="list-style-type: none"> Drills must be held at least annually. The drill must be thoroughly planned and all staff members must be involved. The Local Fire Department must participate in such drills. Neighbouring businesses must participate in such drills.
E Management of the News Media	
The person whose responsibility it will be to provide information about the emergency to the news media	<i>To be completed prior to plant start-up</i>
Channels for the approval of media releases to journalists.	All written news statements must be approved by the Chief Executive Officer prior to release to journalists.

ANNEXURE A

EMERGENCY RESPONSE ACTIONS

DIESEL

POTENTIAL HAZARDS
<p style="text-align: center;">Fire or explosion</p> <ul style="list-style-type: none"> • Highly flammable. • Will be easily ignited by heat, sparks or flames. • Vapours may form explosive mixtures with air. • Vapours may travel to the source of ignition and flash back. • Vapour is heavier than air. Vapour will spread along the ground and collect in low-lying areas or confined spaces such as sewers, basements, tanks and canals. • Vapour explosion hazard indoors, outdoors or in sewers. • Run-off into sewers may create a fire or explosion hazard. • Containers may explode when heated. • Water run-off may cause environmental pollution. • Substance is lighter than water.
<p style="text-align: center;">Health</p> <ul style="list-style-type: none"> • Avoid any skin contact. • Inhalation or contact with the skin or eyes may irritate or burn skin and eyes. • Fire may produce irritating, corrosive and toxic gases. • Vapours may cause dizziness or suffocation. • Water run-off from fire control may cause pollution of the environment.
PUBLIC SAFETY
<p style="text-align: center;">General</p> <ul style="list-style-type: none"> • Call the emergency services. • As an immediate precautionary measure, isolate the spill or leak area in all directions for at least 50 meter. • Keep unauthorised persons away from the spill. • Stay upwind. • Keep out of low-lying areas. • Ventilate closed spaces before entering.
<p style="text-align: center;">Protective clothing</p> <ul style="list-style-type: none"> • Wear positive pressure self-contained breathing apparatus (SCBA). • Wear chemical protective clothing that is specifically recommended by the manufacturer. It may provide little or no thermal protection. • Structural firefighters' protective clothing will only provide limited protection.

Evacuation

Large spill

- Consider initial downwind evacuation for at least 300 meters.

Fire

- If a storage tank, road tanker or rail tank car is involved in a fire, isolate for 800 meters in all directions.
- Consider initial evacuation for 800 meters in all directions.

EMERGENCY RESPONSE

Fire

- Substance has a low flash point.
- Use of water spray to fight a fire may be inefficient.

Small fires:

- Use dry chemicals, CO₂, regular foam or water spray.

Large fires:

- Fog, regular foam or water spray.
- Use water spray or fog. Do not use straight streams.
- Move containers away from the fire area if it can be done safely.

Fire involving bulk tanks

- Fight fire from a maximum distance or use unmanned hose holders or monitor nozzles.
- Cool containers with flooding quantities of water until well after the fire is out.
- Always stay away from tanks and containers engulfed in fire.
- Withdraw immediately in case of rising sound from venting devices or discolouration of tank.
- For a massive fire, use unmanned hose holders or monitor nozzles. If it is impossible, withdraw from the area and let the fire burn out.

Spill or leak

- Eliminate all ignition sources such as smoking, flares, sparks or flames, in the immediate area.
- All equipment used when handling the product must be earthed.
- Prevent entry of material into waterways, sewers, basements or confined spaces.
- Stop the leak if it can be done safely.
- Do not touch or walk through spilled material.
- Absorb or cover with dry earth, sand or other non-combustible material and transfer to clean containers.
- Use clean, non-sparking tools to collect absorbed material.
- Vapour-suppressing foam may be used to reduce vapours.

Small spills

- Use a non-combustible material such as vermiculite, sand or earth to soak up[the product and place it in a clean container for later disposal.

Large spills

- Dike far ahead of liquid spill for later disposal.
- Water spray may reduce vapour, but may not prevent ignition in closed spaces.

First aid

- Move the victim to fresh air.
- Call emergency medical care.
- Give artificial respiration if the victim is not breathing.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- In case of contact with the substance, immediately flush the skin or eyes with clean running water for at least 20 minutes.
- Wash skin with soap and water.
- In case of burns, immediately cool affected skin for as long as possible with cold water.
- Do not remove clothing if it adheres to the skin.
- Keep victim warm and quiet.
- Ensure that medical personnel are aware of the material involved and take precautions to protect themselves.

NATURAL GAS

POTENTIAL HAZARDS	
Fire or explosion <ul style="list-style-type: none"> Extremely flammable. Will easily be ignited by heat, sparks or flames. Will form explosive mixtures with air. Vapours are lighter than air and will rise. Flames may be invisible. Use a thermal camera or broomstick to detect flames if it can be done safely. Vapours may travel to a source of ignition and flash back. 	
Health <ul style="list-style-type: none"> Vapours may cause dizziness or asphyxiation without warning. The gas may be irritating if inhaled at high concentrations. Skin contact with the unignited gas may cause burns, severe injury and/or frostbite. Fire may produce irritating and/or toxic gases. 	
PUBLIC SAFETY	
General <ul style="list-style-type: none"> Call the emergency services. Isolate a leak immediately for at least 100 meters in all directions. Keep unauthorized persons away. Stay upwind. 	
Protective clothing <ul style="list-style-type: none"> Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters' protective clothing will only provide limited protection. Always wear thermal protective clothing. 	
Evacuation <ul style="list-style-type: none"> Consider initial downwind evacuation for at least 800 meters. In case of a fire, isolate for at least 1 600 meters in all directions. In case of a fire, evacuate for at least 1 600 meters in all directions. 	
EMERGENCY RESPONSE	
Fire <ul style="list-style-type: none"> Do not attempt to extinguish a leaking gas fire. Try to stop the gas leak if it can be done safely. <p><u>Small fires:</u></p> <ul style="list-style-type: none"> Use dry chemical or CO₂. 	

Large fires:

- Use water spray or fog.
- Move nearby containers from the fire if it can be done safely.
- Fight fire from a maximum distance or use unmanned hose holders or monitor nozzles.
- Cool nearby containers with flooding quantities of water until well after the fire is out.
- Do not direct water at the source of the gas leak or safety devices – icing and resultant blockage may occur.
- Withdraw immediately if a rising sound from venting safety devices is heard or if discolouration of a tank or vessel is noticed.
- Always stay away from tanks and vessels engulfed in a fire.
- For a massive fire, use unmanned hose holders or monitor nozzles. If it is impossible or unsafe, withdraw from the area and let the fire burn.

Spill or leak

- Eliminate all ignition sources such as smoking, sparks or flames in the immediate area.
- All equipment used when handling the product must be earthed.
- Do not touch or walk through a leaking gas stream.
- Stop the gas leak if it can be done safely.
- Use water spray to reduce vapours or to divert a vapour cloud drift.
- Prevent the spreading of vapours through ventilation systems.
- Isolate the area until the gas has dispersed.
- Some materials may become brittle when in contact with escaping gas due to rapid cooling.

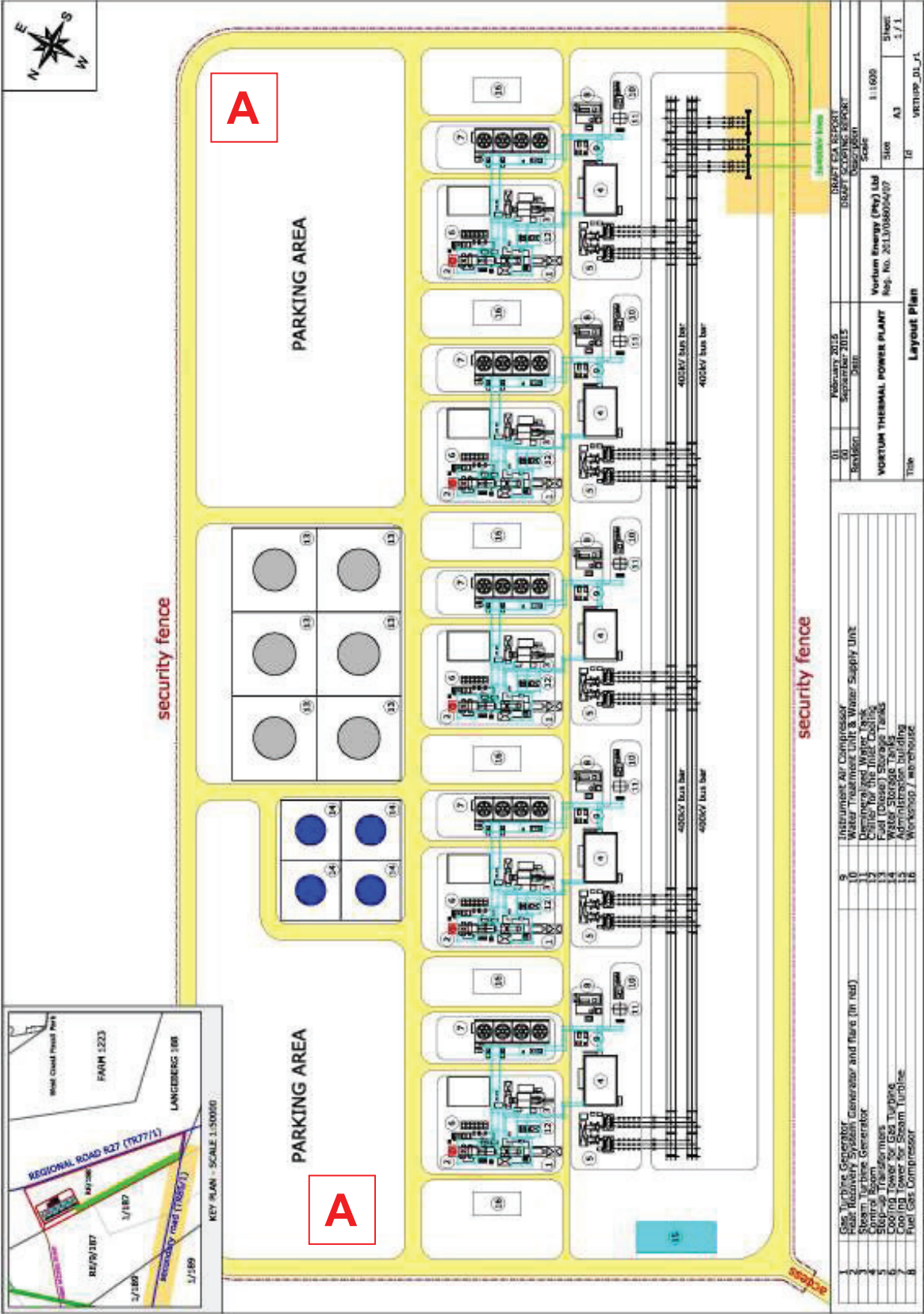
First aid

- Move victim to fresh air.
- Call emergency medical care.
- Give artificial respiration if the victim is not breathing.
- Administer oxygen if breathing is difficult.
- Remove and isolate contaminated clothing and shoes.
- Clothing frozen too the skin must be thawed before being removed.
- In case of contact with the gas, immediately flush skin or eyes with running water for at least 20 minutes.
- In case of burns, immediately cool affected skin for as long as possible with cold water.
- Do not remove clothing if it adheres to the skin.
- Keep the victim warm and still.
- Keep the victim under observation.
- Effects of contact with or inhalation of the gas may be delayed.
- Ensure that medical personnel are aware of the gas involved and take precautions to protect themselves.

ANNEXURE B

Emergency Assembly Point

A



Section 13

The Suitability of Existing Emergency Procedures for the Risks Identified [39]

The site emergency response plan of Vortum Energy (Pty) Ltd in Saldanha Bay has to comply with the aspects stipulated in Table 13.1 as a minimum requirement.

Table 13.1

EVALUATION OF THE EMERGENCY RESPONSE PLAN

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.	No
The Plan must contain a list of local emergency responders with their contact information.	No
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.	No
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.	No
The Plan must state clear channels for the approval of media releases to journalists.	No

Section 14

Requirements of Environmental legislation

This risk assessment does not include the impacts that the Vortum Energy (Pty) Ltd site could have on the environment during its normal operations. It was specifically excluded from the tender.

Section 15

Required Organisational Measures

The following organisational measures are recommended for the Vortum Energy (Pty) Ltd site in Saldanha Bay:

1. The emergency response plan must be updated in accordance with the guidelines given in Section 13 of this report.
2. Operating procedures must be compiled for Vortum Energy (Pty) Ltd, to include preventative measures against possible diesel and natural gas leaks.
3. All possible ignition sources at the facility must be eliminated. Guidelines for the control of ignition sources are as follows:
 - Use only electrical equipment that is certified to be flameproof and spark proof in areas where natural gas is handled.
 - Control static electricity.
 - Ensure that vulnerable equipment is properly bonded to ground.
 - Prohibit smoking, open flames and sparks.
 - Prevent mechanical sparks and friction.
 - Use separator devices to remove foreign materials capable of igniting from process materials.
 - Separate heated surfaces from dust.
 - Separate heating systems from dust.
 - Select and use industrial trucks properly.
 - Use cartridge activated tools properly.
 - Implement an equipment preventative maintenance programme.
4. The outcome of the risk assessment must be brought to the attention of all the employees at the facility.
5. The bulk storage tanks and all diesel and natural gas pipelines must be protected against corrosion, to prevent leaks.
6. A Maintenance Plan must be compiled for all the equipment used on the facility prior to commissioning of the plant. 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.
7. All hazardous equipment and facilities on the facility must be inspected on a daily 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.

8. Detailed operating procedure must be implemented for all sections of the facility, in collaboration with the equipment suppliers, prior to commissioning of the installation. All authorised operators must be trained in the application of the procedure.
9. Preventative measures must be designed and implemented to prevent overfilling of diesel storage tanks.
10. All operating personnel at the facility must be made aware and kept aware of the dangers involving diesel and natural gas.
11. The facility must be under safety and security access control for 24 hours per day. The safety guard on duty 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 of Vortum Energy (Pty) Ltd.
 - The guard must be able to contact the Saldanha Bay Fire Department immediately.
12. A site layout plan must be compiled for the proposed diesel tank farm in accordance with the relevant SANS code and must be submitted to the Saldanha Bay Fire Department for approval.
13. The Emergency Evacuation Procedure aimed at workers as well as the surrounding residences must be updated in collaboration with the emergency services of Saldanha Bay and interested and affected parties such as members of community liaison committees.
14. The Emergency Response Plan and Emergency Evacuation Procedure of Vortum Energy (Pty) Ltd must be tested at least once every 12 months by means of mock emergencies. The Fire Department of Saldanha Bay must participate in such tests.
15. A fire water reservoir must be installed on site if the water flow and pressure of the municipal hydrant network is insufficient.
16. Customer parking bays must be located in an area where public vehicles will not cause obstruction of emergency vehicles.
17. The bulk diesel storage tanks and pipe work and all natural gas pipelines must be protected against lightning by means of efficient earthing.

Section 16

Temporary Installations

Section 4 (1) and (2) of the MHI Regulations determine that a risk assessment must also be conducted for any temporary installation, which may be a major hazard installation, on the premises of the client.

In the case of Vortum Energy (Pty) Ltd, there will not be any temporary installations on site, such as fuel road tankers.

Section 17

Conclusions

The following conclusions are drawn from this risk assessment:

1. The hazardous events that could occur at the Vortum Energy (Pty) Ltd facility in Saldanha Bay are as follows:
 - Diesel pool fire at the tank farm.
 - Natural gas jet fire.
 - Natural gas cloud explosion.
10. The safety risks at the Vortum Energy (Pty) Ltd Saldanha Bay facility are summarised in Table 17.1.
11. The health and safety risks were assessed for two sites:
 - The preferred site in the northwest corner of the farm.
 - The alternative site in the southern part of the farm.
12. At both sites, the primary risk is the release of carbon monoxide from a diesel pool fire at the tank farm during Phase 1 of the project. This risk has the potential to affect people beyond the boundaries of the farm. However, the risk is manageable in the sense that people will have time to evacuate to a safe separation distance from the tank farm. The secondary risks at the preferred and alternative sites are due to a pool fire at one or more of the diesel storage tanks during Phase 1 of the project, or a natural gas cloud explosion during Phase 2. It is important to note that these risks are confined to the boundaries of the plant.
13. From a health and safety point of view the alternative site is not recommended due to the proximity of structures south of the plant. These structures may be inhabited.
14. The individual safety risk transect is shown in Figure 17.1. It indicates that the risk profile of the facility lies partly above the norm for tolerable public risk ($1.00\text{E}-4$) as well as the norm for tolerable worker risk ($1.00\text{E}-3$) as recommended by the UK Health and Safety Executive (HSE).
15. The societal risk profile for the Saldanha Bay Facility is given in Figure 17.2. It indicates that the safety risk at the facility lies below the local tolerability line as recommended by the Dutch Advisory Committee on Dangerous Substances.
16. The estimated number of human impacts at the Saldanha Bay facility could reach a level of 17 in case of a pool fire at the diesel tank farm, which will release toxic carbon monoxide. This number does not exceed the norm of 10 000 recommended by the Dutch Advisory Committee on Dangerous Substances.
17. Two criteria were used to determine whether the Vortum Energy (Pty) Ltd Saldanha Bay Facility could be classified as a major hazard installation or not. In order to be classified as a major hazard installation (MHI), the facility must satisfy at least one of the following two criteria:

The highest frequency of a major incident must be higher than 1.0E-4 / year

$$F > 0.0001 / \text{yr}$$

UK Health and Safety Executive

OR

The maximum number of human impacts (fatalities) that could be caused by the major incident must be higher than 10 000

$$N > 10\,000$$

Dutch Advisory Committee on Dangerous Substances

9. There are no facilities outside the boundaries of the power plant that would be affected by a major incident.
10. Based on the above findings, it is concluded that the Vortum Energy (Pty) Ltd Saldanha Bay facility is not classified as a major hazard installation. xxx

Table 17.1

Potential Major Incident	Possible Consequences	Estimated Frequency per year	Estimated safety distance, m	Estimated number of human impacts *
Scenario 1: Diesel storage tanks and pipe work for Phase 1				
Diesel leak	Pool fire in the bund of one storage tank	8.3 E-4	79	1
Diesel leak	Pool fire in all bunds	6.9 E-7	193	3
Diesel leak	<u>Toxic emissions from diesel pool fire in one bund</u> <ul style="list-style-type: none"> Carbon monoxide Carbon dioxide Carbon particulates 	8.3 E-4	921 270 34	17 2 0
Scenario 2: Natural gas via pipeline for Phase 2				
Natural gas leak	Gas cloud explosion	3.2 E-3	110	1
Natural gas leak	Jet fire	1.0 E-3	14	0

* Based on a population density of 0.00005 persons per m² and an impact rate of 50%. In the case of toxic releases, one quadrant of the affected circle (25%) was taken into consideration to make provision for varying wind blow patterns.

Figure 17.1
Individual safety risk transect for preferred and alternative site

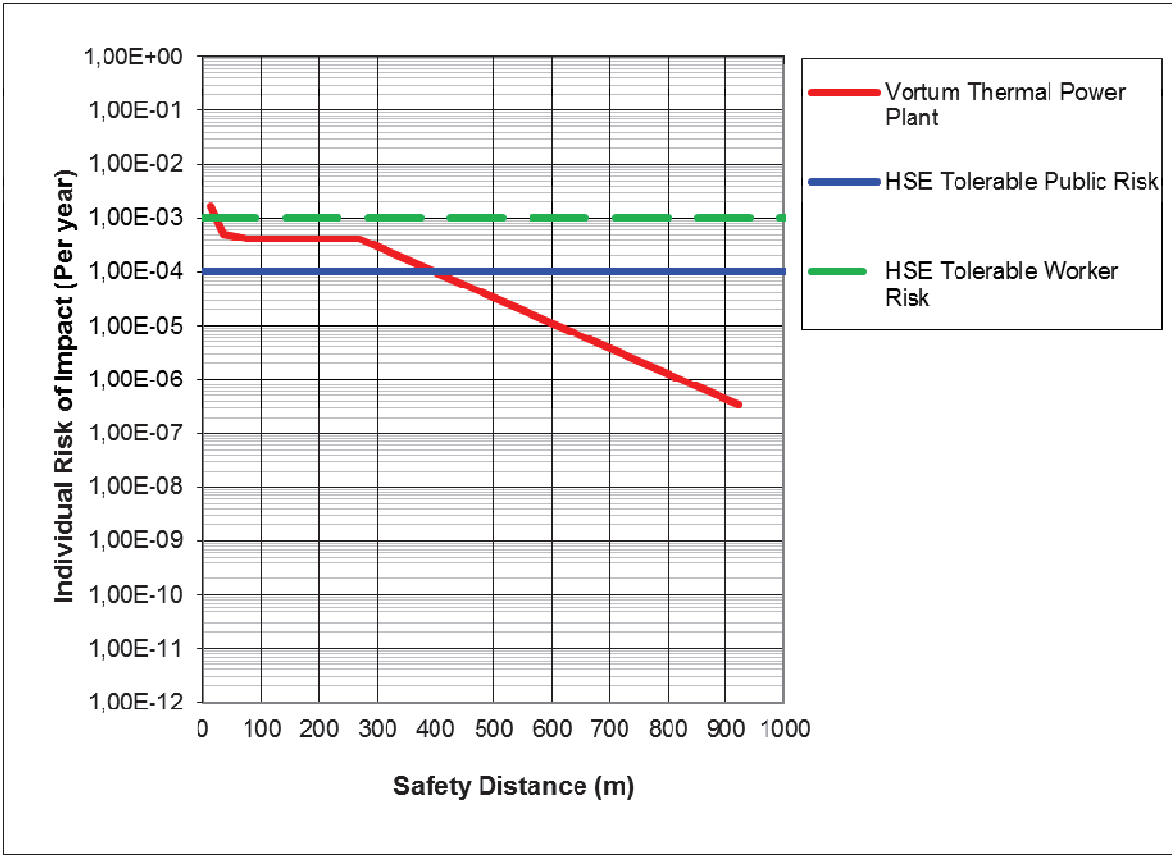
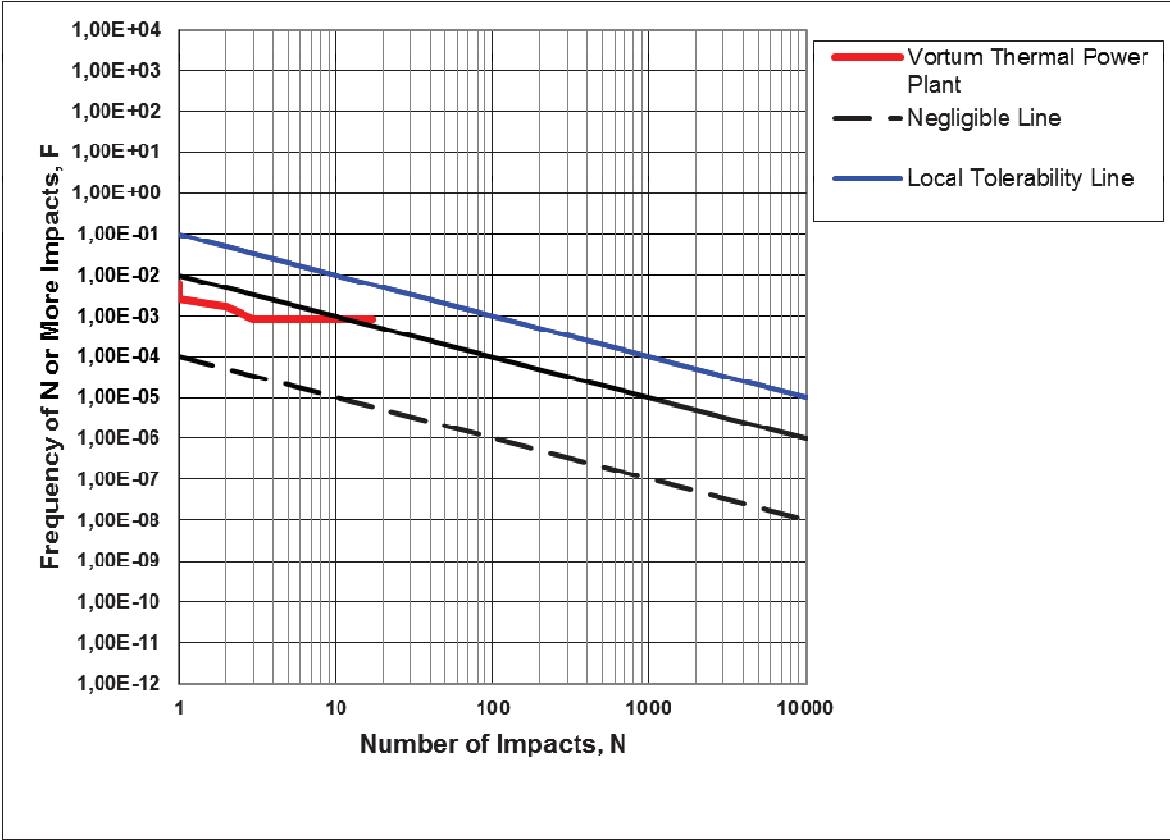


Figure 17.2

Societal risk profile for preferred and alternative site



Annexure 1

Definition of a Major Hazard Installation

1. The South African perspective

The South African Occupational Health and Safety Act (Act No 85 of 1993) defines a **major hazard installation** as follows:

- (a) “An installation where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily; or
- (b) An installation where any substance is produced, processed, used, handled or stored in such a form and quantity that it has the potential to cause a major incident”.

The Act defines a **major incident** as follows:

“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.

The Act defines **risk** as follows:

“The probability that injury or damage will occur.

It is important to note that human lives (injury, fatal or not) as well as assets (damage) are included in this definition.

2. The UK perspective

The UK Health and Safety Executive (HSE) defines **hazard** as follows [29]:

“The potential for harm arising from an intrinsic property or disposition of something to cause detriment”. Although the term “hazard” is absent in the UK Health and Safety at work etc Act (SI 1974/1439), UK Courts have ruled that “risk” means possibility of danger rather than actual danger. Conceptually the HSE therefore regards anything presenting the possibility of danger as a hazard.

The HSE defines **risk** as follows:

“The chance that someone or something that is valued will be adversely affected in a stipulated way by the hazard”. Here too, it is important to note that human lives (someone) as well as assets (something) are included in the definition.

In accordance with the above interpretations in South Africa and the United Kingdom, the following attributes were used in this report in order to identify

potentially hazardous situations and localities next to the Vortum Energy (Pty) Ltd facility and to assess their associated risks:

- The release of a toxic cloud that could cause suffocation.
- The release of a vapour cloud that could ignite into an explosion.
- Thermal radiation caused by a fuel torch flame.

In order to put the term “risk” in perspective, it may be useful to look at various individual risks identified in the United Kingdom as published by their Health and Safety Executive (HSE) [17], shown in Table 3.1. (Note: similar reliable statistics are not available for South Africa)

The meaningful application of risk evaluations and criteria very much depends upon the perception that people have about the risk. People tend not to think in terms of an abstract concept of risk, but rather to evaluate the characteristics of a hazard and to perceive risk in a multi-dimensional way [6]. Under some conditions the risk bearer is prepared to accept the risk, other times not. Some considerations that affect a person’s judgment with regard to safety are as follows:

- Risk assumed voluntarily *versus* risk borne involuntarily
- Immediate effect *versus* delayed effect
- No alternative available *versus* many alternatives available
- Risk known with certainty *versus* risk not known
- Exposure is essential *versus* exposure is a luxury
- Occupational risk *versus* non-occupational risk
- Common hazard *versus* “dread” hazard
- Affects average people *versus* affects especially sensitive people
- Will be used as intended *versus* likely to be misused
- Consequences reversible *versus* consequences irreversible

3. Acceptable risk

This term is contentious and raises the question: Acceptable to whom? A crucial distinction is made between risks that are assumed voluntarily and those that are borne involuntarily. In general, people are prepared to tolerate higher levels of risk to which they expose themselves voluntarily. The risk to which members of the public are exposed from an industrial activity is an involuntary one. However, it may be argued that settling in a neighbourhood where an industrial activity is already established represents a voluntary risk. It is a common view that the risk to which an employee is exposed from an industrial activity is in some degree voluntarily assumed.

Some hazards are accepted voluntarily, even when the risk is high. At one extreme one may say that the risk is embraced when it is an integral part of the challenge in a hazardous sport, such as motor racing or bungee jumping.

When a serious hazard is encountered involuntarily, acceptance may extend only to a much lower level of risk than otherwise. When, in addition, the sufferer feels impotent in the face of danger, tolerance is further reduced. Accidents in trains seem peculiarly unacceptable, perhaps more so than accidents in airplanes, where passengers are generally considered to have taken the risk on themselves for the

sake of the extra benefit of the time saved. In underground trains, only absolute safety seems to be good enough for most people, because perhaps the enclosed environment exerts a strong psychological influence.

4. Tolerable risk

Tolerability does not mean acceptability. It refers to the willingness to live with the risk in order to secure certain benefits and in the confidence that the risk is being properly controlled. To tolerate a risk means that one does not regard it as negligible or something that can be ignored, but rather as something that needs to be kept under review and reduce still further if and as we can. This classification would apply to a situation where members of the public settle around an existing industrial site.

5. Statistical (objective) risk

One way to evaluate the risk of a particular activity is to look only at historical records for similar incidents and to express that risk as a statistical frequency or probability. Such an assessment, which yields a statistical or mathematical risk, would completely eliminate personal judgment.

Risk assessments cannot provide an unambiguous and reproducible measure of risk. A study in the USA found widely differing assumptions underlying three separate studies of the same proposed facility. It is hardly possible to determine an objective measure of risk that can be used as a basis for judging perceptions of risk.

6. Perceived risk

Attempts to assess the risk associated with a particular hazard involve a number of areas of considerable difficulty. Two such difficulties are consequences and uncertainty.

A whole range of consequences is usually involved in risk assessment. There may be injuries, which may be fatal or non-fatal, prompt or delayed. There may be environmental damage where the effects may appear promptly or only after a delay. The consequences are therefore multifunctional.

Risk assessment is always subject to uncertainty, expressed as probabilities, which are further made complex by incompleteness (difficulty to obtain all and reliable data) and distortion. In the final analysis, the risk assessment outcome remains a perceived one and it is the responsibility of the assessor to substantiate outcomes with as many facts and sound reasoning as possible.

Table A1.1

Examples of individual risks in the UK

Cause of human death	Risk (deaths) per million people per year
1. Cancer	2 800
2. Road accidents	100
3. Accidents in private homes	93
4. Fire or flame	15
5. Drowning	6
6. Gas related incident	1,8
7. Excessive cold	8
8. Lightning	0,1
9. Deep-sea fishing	880
10. Coal extraction and manufacture of solid fuels	106
11. Construction	92
12. All manufacturing industry	23
13. Work in offices, shops, warehouses	4,5
14. Rock climbing	8 000
15. Canoeing	2 000
16. Hang-gliding	1 500

Annexure 2

Guidelines on Land Use

1. Introduction

It is not the intention of this risk assessment report to express an opinion regarding the viability or feasibility of land development *per se* around the Vortum Energy (Pty) Ltd facility. Such business falls outside the scope of the risk assessment as defined in the Major Hazard Installation Regulations. However, some comments regarding land development in relation to the proximity and severity of major hazardous installations would be appropriate. The following reference sources were consulted in this regard:

- South African Development Facilitation Act (Act No 67 of 1995).
- *Risk Criteria for Land-use Planning in the Vicinity of Major Industrial Hazards*, issued by the UK Health and Safety Executive.

2. South African Development Facilitation Act

The purpose of the Act is as follows:

- To facilitate and speed up the implementation of reconstruction and development programmes and projects in relation to land.
- To lay down general principles governing land development throughout South Africa.
- To provide for the establishment of a Development and Planning Commission for the purpose of advising Government on policy and laws concerning land development on national and provincial level.
- To provide for the establishment in the provinces of Development Tribunals, which have the power to make decisions and resolve conflict in respect of land development projects.
- To facilitate the formulation and implementation of land development objectives by reference to which the performance of local government bodies in achieving such objectives may be measured.
- To provide for nationally uniform procedures for the subdivision and development of land for residential, small-scale farming or other needs and uses.
- To promote security of tenure while ensuring that end-user finance in the form of subsidies and loans becomes available as early as possible during the land development process.

Section 3 (1) viii states as a general principle for land development that environmentally sustainable land development practices and processes are encouraged.

Section 33 (2) (n) states that, in its consideration of an application for land development, the Development Tribunal may impose any condition of establishment

relating to the environment or environmental evaluations in approving a land development application.

It is clear that land development in South Africa must take due cognizance of environmental requirements and constraints, biophysically and socio-economically.

3. UK Health and Safety Executive

In the United Kingdom it has been recognized for some years that safety should be taken into account when making decisions about the development of land near major hazards where a major accident might extend beyond the boundaries of the site.

The UK Health and Safety Executive makes a clear distinction between “individual risk” and “societal risk”. “**Individual risk**” is defined as the frequency at which an individual person may be expected to sustain a given level of harm from the realization of specified hazards. On the other hand, “**societal risk**” refers to the relationship between frequency and the number of people suffering from a given level of harm in a given population from the realization of specified hazards. In the case of the Vortum Energy (Pty) Ltd facility, it would be appropriate to primarily apply the principle of societal risk, given the fact that residential development has taken place south of the site and expansion may be considered in future. However, it must be noted that societal risk is a difficult concept, as it relates to the chances of a disaster due to the location of a particular development near a major hazard installation. It is necessary to consider the size of the disaster as well as its probability. In reality there could be a range of possible sizes, each with different probabilities. For example, there might be a low chance of injuring most of the people in a particular development, or a high chance of injuring only a few of them, from the same major hazard installation.

The Health and Safety Executive has given advice on about 5 000 developments near major hazard installations, requiring detailed risk assessments, over a period of 15 years. Of these, many were concluded not to be causes for concern. Of the developments, which were inadvisable, each one on its own would not have made a large addition to the overall societal risk from major hazard installations in the UK. However, taken altogether, there would perhaps have been a significant increase had the Health and Safety Executive not advised against it. In general, while it is likely that the extra societal risk due to any single development would be very small, unrestrained land developments could eventually add up to a noticeable worsening of the cumulative situation. The important point to take into consideration here is that small individual additions to societal risk will accumulate to lead to a considerable increase in the number of people at risk from major hazard installations on a regional or national scale.

In the UK the Health and Safety Executive will usually advise against developments near major hazard installations in the following cases, bearing in mind that societal risk figures are not always available or reliable:

- Residential developments for more than about 25 people, if the individual risk of receiving a defined dangerous dose of a toxic substance, heat or blast overpressure exceeds 10.0E-6 per year.

- Residential developments for more than about 75 people, if the individual risk of receiving a defined dangerous dose of a toxic substance, heat or blast overpressure exceeds $1.0\text{E-}6$ per year.
- Moderately sized developments where the calculated individual risk exceeds $10.0\text{E-}6$ per year.
- Large sized developments where the calculated individual risk exceeds $1.0\text{E-}6$ per year.

Another important factor that needs to be taken into consideration within the South African context is that formal development, whether it is residential or otherwise, can be controlled and managed by planning authorities. However, due to a chronic scarcity of residential land, informal settlements are a reality. It is therefore quite possible that vacant land around the Vortum Energy (Pty) Ltd site could be occupied by informal dwellers, which would be very difficult to control and manage by both Vortum Energy (Pty) Ltd and the authorities.

It must further be borne in mind that whatever decision is taken regarding future land development, will remain in force for at least 50 years.

Annexure 3

Risk Criteria

1. Introduction

The risks identified in this assessment can only be interpreted meaningfully if it is compared with internationally acceptable risk criteria. The UK Health and Safety Executive (HSE) is regarded [1] as a world leader as far as occupational and public health and safety are concerned. The risk criteria applied by the HSE are therefore used as benchmarks in this report.

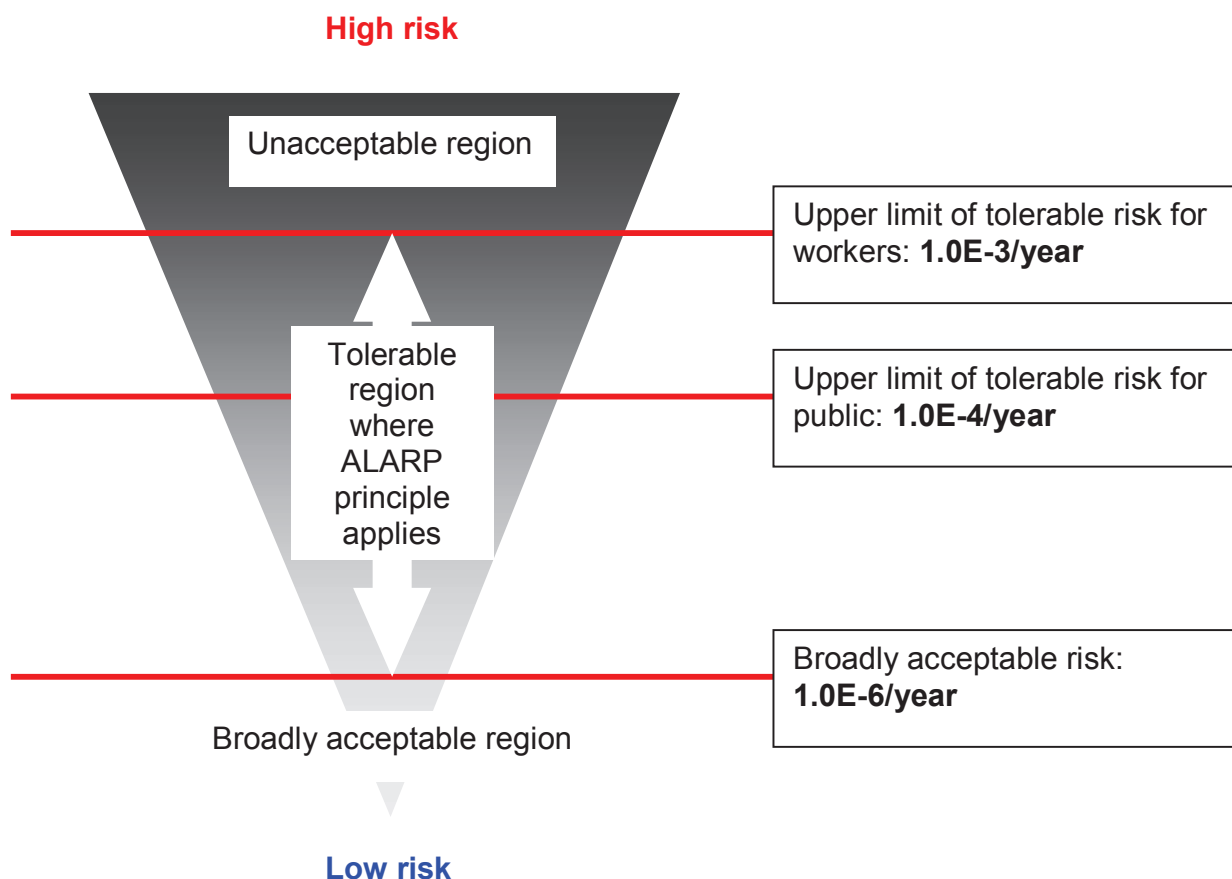
The HSE refers to two types of risk criteria, namely individual risk and societal risk.

2. Individual risk criteria

The HSE risk criteria framework [26] is represented by a triangle as shown in Figure A3.1. The risk increases from the bottom part of the triangle to the top. The framework suggests that there is an upper limit to individual risk, above which the risk is regarded as **unacceptable**, whatever the benefits. Any activity or practice that falls into this region (the dark section at the top of the triangle) would normally be ruled out (not allowed). Action needs to be taken to reduce the risk so that it can fall into one of the regions lower down in the triangle.

Figure A3.1

HSE framework for individual risk criteria



The zone at the bottom part of the triangle represents a **broadly acceptable** risk region. Activity risks that fall into this region are regarded as insignificant and adequately controlled. Further action to reduce the risk would normally not be required, unless there are obvious, reasonable practicable measures available. The levels of risk within this region are comparable to those that people regard as trivial or insignificant in their daily lives.

The middle region of the triangle (between the unacceptable and broadly acceptable regions) represents a region of **tolerable** risk. Within this region the risks must be controlled to a level that is as low as reasonably practicable (ALARP).

3. Societal risk criteria

The Dutch Advisory Committee on Dangerous Substances (ACDS) developed risk criteria that are applicable to societies at large. These criteria are shown in Figure A3.2.

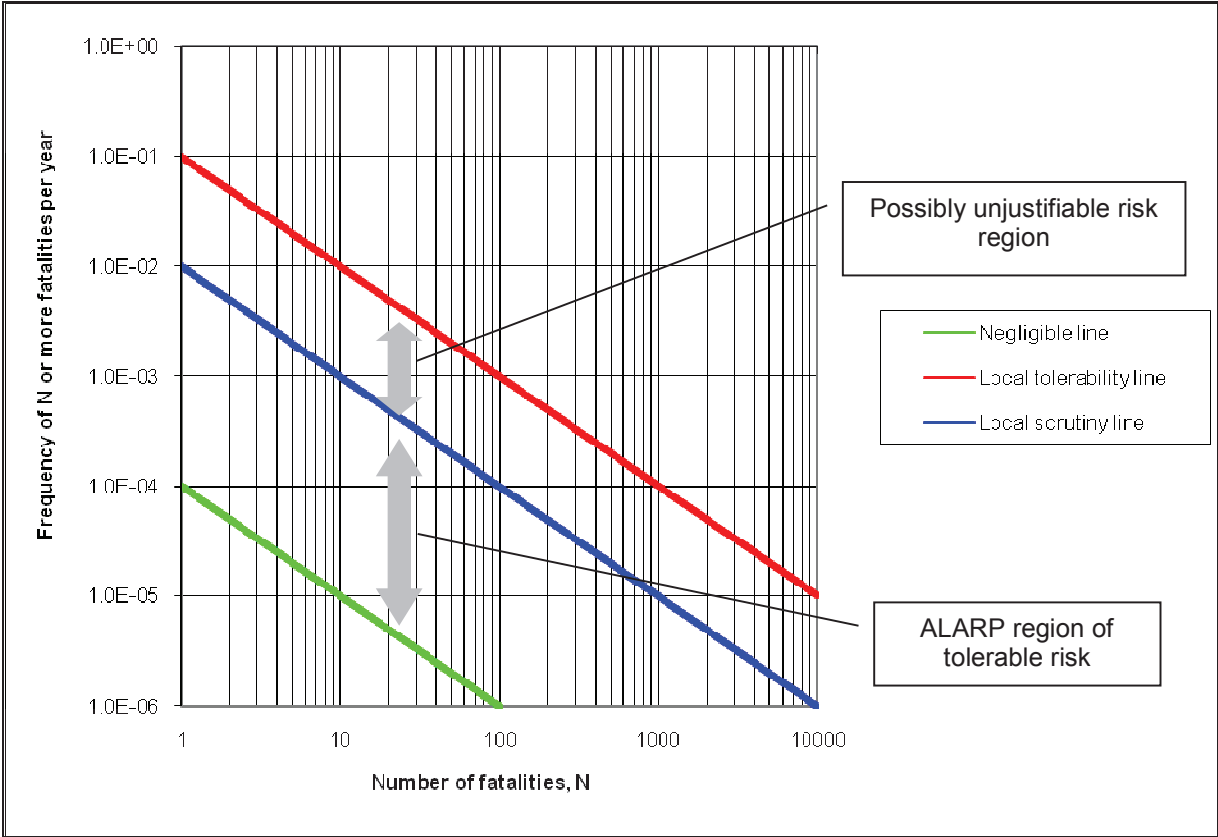
The intolerable region above the local tolerability line on the FN-curve is defined as activities that must be avoided.

Below the negligible line lies a region where risks are **negligible** and no further action is required to reduce the risk level.

The middle region, above the negligible line and below the local tolerability line, is a region of **possibly unjustifiable** risk. The ALARP principle is applicable in this region.

Figure A3.2

Dutch criteria for societal risk



4. The ALARP principle

The ALARP (as low as reasonably practicable) principle arises from the fact that it would theoretically be possible to spend an infinite amount of resources such as time, effort and money in an attempt to reduce a particular risk to a level of zero. It will be a never-ending process.

The objective of risk management is to reduce the risks associated with a particular activity to such a level that nothing else can be done further without serious cost or other disadvantages. These disadvantages may be of such a magnitude that it is not worthwhile to pursue the activity anymore. It means that all reasonably practicable mitigation measures have been taken to reduce the level of the residual risk. The risk is then low enough so that any attempt to reduce it further would be more costly than the costs that may be incurred due to the risk *per se*. The residual risk is then called **tolerable risk**, as shown in Figure A3.2.

Annexure 4**Material Safety Data Sheet**

The following Material Safety Data Sheet (MSDS) are enclosed in this report and must be kept on site:

1. Diesel.
 2. Natural gas.
-

Material Safety Data Sheet

SECTION 1 PRODUCT AND COMPANY IDENTIFICATION

DIESEL FUEL No. 2

Product Use: Fuel

Product Number(s): CPS220122 [See Section 16 for Additional Product Numbers]

Synonyms: 15 S Diesel Fuel 2, Alternative Low Aromatic Diesel (ALAD), Calco LS Diesel 2, Calco ULS DF2, Calco ULS Diesel 2, Chevron LS Diesel 2, Chevron ULS Diesel 2, Diesel Fuel Oil, Diesel Grade No. 2, Diesel No. 2-D S15, Diesel No. 2-D S500, Diesel No. 2-D S5000, Distillates, straight run, Gas Oil, HS Diesel 2, HS Heating Fuel 2, Light Diesel Oil Grade No. 2-D, LS Diesel 2, LS Heating Fuel 2, Marine Diesel, RR Diesel Fuel, Texaco Diesel, Texaco Diesel No. 2, Ultra Low Sulfur Diesel 2

Company Identification

Chevron Products Company
Marketing, MSDS Coordinator
6001 Bollinger Canyon Road
San Ramon, CA 94583
United States of America

Transportation Emergency Response

CHEMTREC: (800) 424-9300 or (703) 527-3887

Health Emergency

ChevronTexaco Emergency Information Center: Located in the USA. International collect calls accepted. (800) 231-0623 or (510) 231-0623

Product Information

MSDS Requests: (800) 689-3998 Technical Information: (510) 242-5357

SPECIAL NOTES: This MSDS covers all Chevron and Calco non-CARB Diesel No. 2 Fuels. The sulfur content is less than 0.5% (mass). Red dye is added to non-taxable fuel. (MSDS 6894)

SECTION 2 COMPOSITION/ INFORMATION ON INGREDIENTS

COMPONENTS	CAS NUMBER	AMOUNT
Diesel Fuel No. 2	68476-34-6	100 %wt/wt
Distillates, hydrodesulfurized, middle	64742-80-9	0 - 100 %wt/wt
Distillates, straight run middle (gas oil, light)	64741-44-2	0 - 100 %wt/wt
Kerosine	8008-20-6	0 - 25 %wt/wt
Kerosine, hydrodesulfurized	64742-81-0	0 - 25 %wt/wt
Distillates (petroleum), light catalytic cracked	64741-59-9	0 - 50 %wt/wt
Naphthalene	91-20-3	0.02 - 0.2 %wt/wt
Total sulfur	None	0 - 0.5 %wt/wt

SECTION 3 HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

- COMBUSTIBLE LIQUID AND VAPOR
- HARMFUL OR FATAL IF SWALLOWED - MAY CAUSE LUNG DAMAGE IF SWALLOWED
- CAUSES SKIN IRRITATION
- MAY CAUSE CANCER BASED ON ANIMAL DATA
- TOXIC TO AQUATIC ORGANISMS

IMMEDIATE HEALTH EFFECTS

Eye: Not expected to cause prolonged or significant eye irritation.

Skin: Contact with the skin causes irritation. Skin contact may cause drying or defatting of the skin. Symptoms may include pain, itching, discoloration, swelling, and blistering. Contact with the skin is not expected to cause an allergic skin response. Not expected to be harmful to internal organs if absorbed through the skin.

Ingestion: Because of its low viscosity, this material can directly enter the lungs, if swallowed, or if subsequently vomited. Once in the lungs it is very difficult to remove and can cause severe injury or death. May be irritating to mouth, throat, and stomach. Symptoms may include pain, nausea, vomiting, and diarrhea.

Inhalation: Mists of this material may cause respiratory irritation. Symptoms of respiratory irritation may include coughing and difficulty breathing. Breathing this material at concentrations above the recommended exposure limits may cause central nervous system effects. Central nervous system effects may include headache, dizziness, nausea, vomiting, weakness, loss of coordination, blurred vision, drowsiness, confusion, or disorientation. At extreme exposures, central nervous system effects may include respiratory depression, tremors or convulsions, loss of consciousness, coma or death.

DELAYED OR OTHER HEALTH EFFECTS:

Cancer: Prolonged or repeated exposure to this material may cause cancer. Whole diesel engine exhaust has been classified as a Group 2A carcinogen (probably carcinogenic to humans) by the International Agency for Research on Cancer (IARC). Diesel exhaust particulate has been classified as reasonably anticipated to be a human carcinogen in the National Toxicology Program's Ninth Report on Carcinogens. The National Institute of Occupational Safety and Health (NIOSH) has recommended that whole diesel exhaust be regarded as potentially causing cancer. Diesel engine exhaust is known to the State of California to cause cancer. Contains naphthalene, which has been classified as a Group 2B carcinogen (possibly carcinogenic to humans) by the International Agency for Research on Cancer (IARC).

See Section 11 for additional information. Risk depends on duration and level of exposure.

SECTION 4 FIRST AID MEASURES

Eye: No specific first aid measures are required. As a precaution, remove contact lenses, if worn, and flush eyes with water.

Skin: Wash skin with water immediately and remove contaminated clothing and shoes. Get medical attention if any symptoms develop. To remove the material from skin, use soap and water. Discard contaminated clothing and shoes or thoroughly clean before reuse.

Ingestion: If swallowed, get immediate medical attention. Do not induce vomiting. Never give

anything by mouth to an unconscious person.

Inhalation: Move the exposed person to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention if breathing difficulties continue.

Note to Physicians: Ingestion of this product or subsequent vomiting may result in aspiration of light hydrocarbon liquid, which may cause pneumonitis.

SECTION 5 FIRE FIGHTING MEASURES

See Section 7 for proper handling and storage.

FIRE CLASSIFICATION:

OSHA Classification (29 CFR 1910.1200): Combustible liquid.

NFPA RATINGS: Health: 0 Flammability: 2 Reactivity: 0

FLAMMABLE PROPERTIES:

Flashpoint: (Pensky-Martens Closed Cup) 52 °C (125 °F) (Min)

Autoignition: 257 °C (494 °F)

Flammability (Explosive) Limits (% by volume in air): Lower: 0.6 Upper: 4.7

EXTINGUISHING MEDIA: Use water fog, foam, dry chemical or carbon dioxide (CO₂) to extinguish flames.

PROTECTION OF FIRE FIGHTERS:

Fire Fighting Instructions: For fires involving this material, do not enter any enclosed or confined fire space without proper protective equipment, including self-contained breathing apparatus.

Combustion Products: Highly dependent on combustion conditions. A complex mixture of airborne solids, liquids, and gases including carbon monoxide, carbon dioxide, and unidentified organic compounds will be evolved when this material undergoes combustion.

SECTION 6 ACCIDENTAL RELEASE MEASURES

Protective Measures: Eliminate all sources of ignition in the vicinity of the spill or released vapor. If this material is released into the work area, evacuate the area immediately. Monitor area with combustible gas indicator.

Spill Management: Stop the source of the release if you can do it without risk. Contain release to prevent further contamination of soil, surface water or groundwater. Clean up spill as soon as possible, observing precautions in Exposure Controls/Personal Protection. Use appropriate techniques such as applying non-combustible absorbent materials or pumping. All equipment used when handling the product must be grounded. A vapor suppressing foam may be used to reduce vapors. Use clean non-sparking tools to collect absorbed material. Where feasible and appropriate, remove contaminated soil. Place contaminated materials in disposable containers and dispose of in a manner consistent with applicable regulations.

Reporting: Report spills to local authorities and/or the U.S. Coast Guard's National Response Center at (800) 424-8802 as appropriate or required.

SECTION 7 HANDLING AND STORAGE

Precautionary Measures: Liquid evaporates and forms vapor (fumes) which can catch fire and burn with explosive force. Invisible vapor spreads easily and can be set on fire by many sources such as pilot lights, welding equipment, and electrical motors and switches. Fire hazard is greater as liquid temperature rises above 29°C (85°F). Do not get in eyes, on skin, or on clothing. Do not

taste or swallow. Do not breathe vapor or fumes. Do not breathe mist. Wash thoroughly after handling. Keep out of the reach of children.

Unusual Handling Hazards: WARNING! Do not use as portable heater or appliance fuel. Toxic fumes may accumulate and cause death.

General Handling Information: Avoid contaminating soil or releasing this material into sewage and drainage systems and bodies of water.

Static Hazard: Electrostatic charge may accumulate and create a hazardous condition when handling this material. To minimize this hazard, bonding and grounding may be necessary but may not, by themselves, be sufficient. Review all operations which have the potential of generating and accumulating an electrostatic charge and/or a flammable atmosphere (including tank and container filling, splash filling, tank cleaning, sampling, gauging, switch loading, filtering, mixing, agitation, and vacuum truck operations) and use appropriate mitigating procedures. For more information, refer to OSHA Standard 29 CFR 1910.106, 'Flammable and Combustible Liquids', National Fire Protection Association (NFPA 77, 'Recommended Practice on Static Electricity', and/or the American Petroleum Institute (API) Recommended Practice 2003, 'Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents'.

General Storage Information: DO NOT USE OR STORE near heat, sparks, flames, or hot surfaces. USE AND STORE ONLY IN WELL VENTILATED AREA. Keep container closed when not in use.

Container Warnings: Container is not designed to contain pressure. Do not use pressure to empty container or it may rupture with explosive force. Empty containers retain product residue (solid, liquid, and/or vapor) and can be dangerous. Do not pressurize, cut, weld, braze, solder, drill, grind, or expose such containers to heat, flame, sparks, static electricity, or other sources of ignition. They may explode and cause injury or death. Empty containers should be completely drained, properly closed, and promptly returned to a drum reconditioner or disposed of properly.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

GENERAL CONSIDERATIONS:

Consider the potential hazards of this material (see Section 3), applicable exposure limits, job activities, and other substances in the work place when designing engineering controls and selecting personal protective equipment. If engineering controls or work practices are not adequate to prevent exposure to harmful levels of this material, the personal protective equipment listed below is recommended. The user should read and understand all instructions and limitations supplied with the equipment since protection is usually provided for a limited time or under certain circumstances.

ENGINEERING CONTROLS:

Use process enclosures, local exhaust ventilation, or other engineering controls to control airborne levels below the recommended exposure limits.

PERSONAL PROTECTIVE EQUIPMENT

Eye/Face Protection: No special eye protection is normally required. Where splashing is possible, wear safety glasses with side shields as a good safety practice.

Skin Protection: Wear protective clothing to prevent skin contact. Selection of protective clothing may include gloves, apron, boots, and complete facial protection depending on operations conducted. Suggested materials for protective gloves include: Chlorinated Polyethylene (or Chlorosulfonated Polyethylene), Nitrile Rubber, Polyurethane, Viton.

Respiratory Protection: Determine if airborne concentrations are below the recommended occupational exposure limits for jurisdiction of use. If airborne concentrations are above the acceptable limits, wear an approved respirator that provides adequate protection from this material, such as: Air-Purifying Respirator for Organic Vapors. When used as a fuel, this material can produce carbon monoxide in the exhaust. Determine if airborne concentrations are below the occupational exposure limit for carbon monoxide. If not, wear an approved positive-pressure air-

SECTION 11 TOXICOLOGICAL INFORMATION

IMMEDIATE HEALTH EFFECTS

Eye Irritation: The eye irritation hazard is based on evaluation of data for similar materials or product components.

Skin Irritation: The skin irritation hazard is based on evaluation of data for similar materials or product components.

Skin Sensitization: This material did not cause skin sensitization reactions in a Buehler guinea pig test.

Acute Dermal Toxicity: LD50: >5ml/kg (rabbit).

Acute Oral Toxicity: LD50: > 5 ml/kg (rat)

Acute Inhalation Toxicity: 4 hour(s) LC50: > 5mg/l (rat).

ADDITIONAL TOXICOLOGY INFORMATION:

This product contains gas oils.

CONCAWE (product dossier 95/107) has summarized current health, safety and environmental data available for a number of gas oils, typically hydrodesulfurized middle distillates, CAS 64742-80-9, straight-run middle distillates, CAS 64741-44-2, and/or light cat-cracked distillate CAS 64741-59-9. **CARCINOGENICITY:** All materials tested have caused the development of skin tumors in mice, but all featured severe skin irritation and sometimes a long latency period before tumors developed. Straight-run and cracked gas oil samples were studied to determine the influence of dermal irritation on the carcinogenic activity of middle distillates. At non-irritant doses the straight-run gas oil was not carcinogenic, but at irritant doses, weak activity was demonstrated. Cracked gas oils, when diluted with mineral oil, demonstrated carcinogenic activity irrespective of the occurrence of skin irritation. Gas oils were tested on male mice to study tumor initiating/promoting activity. The results demonstrated that while a straight-run gas oil sample was neither an initiator or promotor, a blend of straight-run and FCC stock was both a tumor initiator and a promoter.

GENOTOXICITY: Hydrotreated & hydrodesulfurized gas oils range in activity from inactive to weakly positive in in-vitro bacterial mutagenicity assays. Mouse lymphoma assays on straight-run gas oils without subsequent hydrodesulfurization gave positive results in the presence of S9 metabolic activation. In-vivo bone marrow cytogenetics and sister chromatid exchange assay exhibited no activity for straight-run components with or without hydrodesulfurization. Thermally or catalytically cracked gas oils tested with in-vitro bacterial mutagenicity assays in the presence of S9 metabolic activation were shown to be mutagenic. In-vitro sister chromatid exchange assays on cracked gas oil gave equivocal results both with and without S9 metabolic activation. In-vivo bone marrow cytogenetics assay was inactive for two cracked gas oil samples. Three hydrocracked gas oils were tested with in-vitro bacterial mutagenicity assays with S9, and one of the three gave positive results. Twelve distillate fuel samples were tested with in-vitro bacterial mutagenicity assays & with S9 metabolic activation and showed negative to weakly positive results. In one series, activity was shown to be related to the PCA content of samples tested. Two in-vivo studies were also conducted. A mouse dominant lethal assay was negative for a sample of diesel fuel. In the other study, 9 samples of No 2 heating oil containing 50% cracked stocks caused a slight increase in the number of chromosomal aberrations in bone marrow cytogenetics assays. **DEVELOPMENTAL TOXICITY:** Diesel fuel vapor did not cause fetotoxic or teratogenic effects when pregnant rats were exposed on days 6-15 of pregnancy. Gas oils were applied to the skin of pregnant rats daily on days 0-19 of gestation. All but one (cooker light gas oil) caused fetotoxicity (increased resorptions, reduced litter weight, reduced litter size) at dose levels that were also maternally toxic.

This product contains naphthalene. **GENERAL TOXICITY:** Exposure to naphthalene has been reported to cause methemoglobinemia and/or hemolytic anemia, especially in humans deficient in the enzyme glucose-6-phosphate dehydrogenase. Laboratory animals given repeated oral doses of naphthalene have developed cataracts. **REPRODUCTIVE TOXICITY AND BIRTH DEFECTS:**

Naphthalene did not cause birth defects when administered orally to rabbits, rats, and mice during pregnancy, but slightly reduced litter size in mice at dose levels that were lethal to the pregnant females. Naphthalene has been reported to cross the human placenta. **GENETIC TOXICITY:** Naphthalene caused chromosome aberrations and sister chromatid exchanges in Chinese hamster ovary cells, but was not a mutagen in several other in-vitro tests. **CARCINOGENICITY:** In a study conducted by the National Toxicology Program (NTP), mice exposed to 10 or 30 ppm of naphthalene by inhalation daily for two years had chronic inflammation of the nose and lungs and increased incidences of metaplasia in those tissues. The incidence of benign lung tumors (alveolar/bronchiolar adenomas) was significantly increased in the high-dose female group but not in the male groups. In another two-year inhalation study conducted by NTP, exposure of rats to 10, 30, and 60 ppm naphthalene caused increases in the incidences of a variety of nonneoplastic lesions in the nose. Increases in nasal tumors were seen in both sexes, including olfactory neuroblastomas in females at 60 ppm and adenomas of the respiratory epithelium in males at all exposure levels. The relevance of these effects to humans has not been established. No carcinogenic effect was reported in a 2-year feeding study in rats receiving naphthalene at 41 mg/kg/day.

This product may contain significant amounts of Polynuclear Aromatic Hydrocarbons (PAH's) which have been shown to cause skin cancer after prolonged and frequent contact with the skin of test animals. Brief or intermittent skin contact with this product is not expected to have serious effects if it is washed from the skin. While skin cancer is unlikely to occur in human beings following use of this product, skin contact and breathing, of mists, vapors or dusts should be reduced to a minimum.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY

96 hour(s) LC50: 21-210 mg/l (*Salmo gairdneri*)
 48 hour(s) EC50: 20-210 mg/l (*Daphnia magna*)
 72 hour(s) EC50: 2.6-25 mg/l (*Raphidocellus subcapitata*)
 This material is expected to be toxic to aquatic organisms.

ENVIRONMENTAL FATE

On release to the environment the lighter components of diesel fuel will generally evaporate but depending on local environmental conditions (temperature, wind, mixing or wave action, soil type, etc.) the remainder may become dispersed in the water column or absorbed to soil or sediment. Diesel fuel would not be expected to be readily biodegradable. In a modified Strum test (OECD method 301B) approximately 40% biodegradation was recorded over 28 days. However, it has been shown that most hydrocarbon components of diesel fuel are degraded in soil in the presence of oxygen. Under anaerobic conditions, such as in anoxic sediments, rates of biodegradation are negligible.

SECTION 13 DISPOSAL CONSIDERATIONS

Use material for its intended purpose or recycle if possible. This material, if it must be discarded, may meet the criteria of a hazardous waste as defined by US EPA under RCRA (40 CFR 261) or other State and local regulations. Measurement of certain physical properties and analysis for regulated components may be necessary to make a correct determination. If this material is classified as a hazardous waste, federal law requires disposal at a licensed hazardous waste disposal facility.

SECTION 14 TRANSPORT INFORMATION

The description shown may not apply to all shipping situations. Consult 49CFR, or appropriate Dangerous Goods Regulations, for additional description requirements (e.g., technical name) and mode-specific or quantity-specific shipping requirements.

DOT Shipping Description: GAS OIL, Combustible Liquid, UN1202,III

IMO/IMDG Shipping Description: GAS OIL,3,UN1202,III, FLASH POINT SEE SECTION 5

ICAO/IATA Shipping Description: GAS OIL,3,UN1202,III,

SECTION 15 REGULATORY INFORMATION

EPCRA 311/312 CATEGORIES:

1. Immediate (Acute) Health Effects: YES 2. Delayed (Chronic) Health Effects: YES
3. Fire Hazard: YES 4. Sudden Release of Pressure Hazard: NO 5. Reactivity Hazard: NO

REGULATORY LISTS SEARCHED:

01-1=IARC Group 1	03=EPCRA 313
01-2A=IARC Group 2A	04=CA Proposition 65
01-2B=IARC Group 2B	05=MA RTK
02=NTP Carcinogen	06=NJ RTK
	07=PA RTK

The following components of this material are found on the regulatory lists indicated.

Diesel Fuel No. 2	07
Distillates, straight run middle (gas oil, light)	06
Kerosine	05, 06, 07
Naphthalene	01-2B, 02, 03, 04, 05, 06, 07

CERCLA REPORTABLE QUANTITIES(RQ)/EPCRA 302 THRESHOLD PLANNING QUANTITIES(TPQ):

Component	Component RQ	Component TPQ	Product RQ
Naphthalene	100 lbs	None	55556 lbs

CHEMICAL INVENTORIES:

All components comply with the following chemical inventory requirements: AICS (Australia), DSL (Canada), EINECS (European Union), IECSC (China), KECI (Korea), PICCS (Philippines), TSCA (United States).

NEW JERSEY RTK CLASSIFICATION:

Refer to components listed in Section 2. Under the New Jersey Right-to-Know Act L. 1983 Chapter 315 N.J.S.A. 34:5A-1 et. seq., the product is to be identified as follows: DIESEL FUEL

WHMIS CLASSIFICATION:

Class B, Division 3: Combustible Liquids
Class D, Division 2, Subdivision A: Very Toxic Material -
Carcinogenicity
Class D, Division 2, Subdivision B: Toxic Material -
Skin or Eye Irritation

SECTION 16 OTHER INFORMATION

NFPA RATINGS: Health: 0 Flammability: 2 Reactivity: 0

(0-Least, 1-Slight, 2-Moderate, 3-High, 4-Extreme, PPE:- Personal Protection Equipment Index recommendation, *- Chronic Effect Indicator). These values are obtained using the guidelines or published evaluations prepared by the National Fire Protection Association (NFPA) or the National Paint and Coating Association (for HMIS ratings).

Additional Product Number(s): CPS225114, CPS225115, CPS225150, CPS266176, CPS270005, CPS270094, CPS270095, CPS270096, CPS271006, CPS272093, CPS272102, CPS272126, CPS272152, CPS272185, CPS272190, CPS272195, CPS272593, CPS272601, CPS272693, CPS272793, CPS273003, CPS273030, CPS273053, CPS275000

REVISION STATEMENT: This revision updates the following sections of this Material Safety Data Sheet: 1,8

Revision Date: 02/14/2006

ABBREVIATIONS THAT MAY HAVE BEEN USED IN THIS DOCUMENT:

TLV - Threshold Limit Value	TWA - Time Weighted Average
STEL - Short-term Exposure Limit	PEL - Permissible Exposure Limit
	CAS - Chemical Abstract Service Number
ACGIH - American Conference of Government Industrial Hygienists	IMO/IMDG - International Maritime Dangerous Goods Code
API - American Petroleum Institute	MSDS - Material Safety Data Sheet
CVX - ChevronTexaco	NFPA - National Fire Protection Association (USA)
DOT - Department of Transportation (USA)	NTP - National Toxicology Program (USA)
IARC - International Agency for Research on Cancer	OSHA - Occupational Safety and Health Administration

Prepared according to the OSHA Hazard Communication Standard (29 CFR 1910.1200) and the ANSI MSDS Standard (Z400.1) by the Chevron Texaco Energy Research & Technology Company, 100 Chevron Way, Richmond, California 94802.

The above information is based on the data of which we are aware and is believed to be correct as of the date hereof. Since this information may be applied under conditions beyond our control and with which we may be unfamiliar and since data made available subsequent to the date hereof may suggest modifications of the information, we do not assume any responsibility for the results of its use. This information is furnished upon condition that the person receiving it shall make his own determination of the suitability of the material for his particular purpose.

sasol
reaching new frontiers



Material Safety Data Sheet

Natural Gas

1 Chemical product and company identification

Common name	: Natural Gas	Code	:
Supplier	: Sasol Oil (Pty) Ltd. P.O. Box 4211 Randburg 2125 Republic of South Africa TEL: +27 11 889 7600 FAX: +27 11 889 7979	MSDS#	:
Synonym	: Marsh gas	Validation date	: 2003/02/20.
Trade name	: Natural gas	Print date	: 2003/02/20.
Material uses	: Petrochemical industry; Petrochemicals	Prepared by	: Boni Mhlokomakulu
Manufacturer	: Sasol Synthetic Fuels Private Bag X1000 Secunda 2302 Republic of South Africa TEL: +27 17 610-1111	In case of emergency	: SASOL GAS ALRODE DEPOT +27 11 9081010 OR +27 11 8543960 SOUTH AFRICA: 0800 11 28 90 INTERNATIONAL: +27 17 610 4444

2 Composition / Information on ingredients

Name	CAS #	% by weight	Exposure limits
Methane	74-82-8	87.6 (94.3 mole %)	Simple asphyxiant.
Ethane	74-84-0	3.7 (2.1 mole %)	Simple asphyxiant.
NITROGEN GAS	7727-37-9	2.8 (1.7 mole %)	Simple asphyxiant.
PROPANE	74-98-6	2.6 (1.0 mole %)	ACGIH TLV (United States, 2002). TWA: 1800 ppm 8 hour(s). OSHA (United States, 2002). TWA: 1000 ppm 8 hour(s). RQMT (United States, 2002). TWA: 1800 ppm 8 hour(s).

3 Hazards identification

Physical state and appearance	: Gas.
Emergency overview	: DANGER! FLAMMABLE GAS MAY CAUSE FLASH FIRE GAS REDUCES OXYGEN AVAILABLE FOR BREATHING Hazardous gas under pressure. Keep away from heat, sparks and flame. Do not puncture or incinerate container. Keep container closed. Use only with adequate ventilation. Do not enter storage areas and confined spaces unless adequately ventilated.

Continued on Next Page

Natural Gas		Page: 2/6
Routes of entry	: Inhalation.	
Potential acute health effects		
Eyes	: Not considered to be a hazard.	
Skin	: Not considered to be a hazard.	
Inhalation	: Hazardous in case of inhalation. Asphyxiant.	
Ingestion	: Not applicable (Gas).	
Potential chronic health effects	: CARCINOGENIC EFFECTS: Not listed. MUTAGENIC EFFECTS: Not listed. TERATOGENIC EFFECTS: Not listed.	
Medical conditions aggravated by overexposure:	: Repeated or prolonged exposure is not known to aggravate medical condition.	
Overexposure /signs/symptoms	: Asphyxiation.	
See toxicological information (section 11)		
4 First aid measures		
Eye contact	: First aid is normally not required.	
Skin contact	: First aid is normally not required. Dermal contact with a rapidly expanding gas could result in frosting of the tissues or frostbite. Try to warm up the frozen tissues and seek medical attention.	
Inhalation	: If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.	
Ingestion	: Not applicable (gas).	
Notes to physician	: Support respiratory and cardiovascular function.	
5 Fire fighting measures		
Flammability of the product	: Flammable.	
Autoignition temperature	: 650°C (1202°F)	
Flash points	: Closed cup: Lower than -18°C (0°F).	
Flammable limits	: LOWER: 5% UPPER: 15%	
Products of combustion	: These products are carbon oxides (CO, CO ₂), nitrogen oxides (NO, NO ₂ ...).	
Fire hazards in presence of various substances	: Flammable in presence of open flames, sparks, static discharge, heat.	
Explosion hazards in presence of various substances	: Explosive in presence of oxidizing materials.	
Fire fighting media and instructions	: SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use fog or foam. Do not use water jet. Move containing vessels from fire area if without risk. Cool containing vessels with flooding quantities of water until well after fire is out. Cool containing vessels with water jet in order to prevent pressure build-up, autoignition or explosion. Do not extinguish a leaking gas flame unless leak can be stopped. Extinguish secondary fire. Handle damaged cylinders with extreme care.	
Protective clothing (fire)	: Be sure to use an approved/certified respirator or equivalent.	
Special remarks on fire hazards	: No additional remark.	
Special remarks on explosion hazards	: No additional remark.	

Continued on Next Page

6 Accidental release measures

- Small spill and leak** : Try to stop the gaseous leak by taping the container with an appropriate material (tape, stretched plastic).
- Large spill and leak** : Do not direct water at spill or source. Use water spray curtain to divert gas drift. Prevent entry into sewers, basements or confined areas. Eliminate all ignition sources.

7 Handling and storage

- Handling** : Keep away from heat, sparks and flame. Do not puncture or incinerate. Keep container closed. Use only with adequate ventilation. To avoid fire, minimize ignition sources. Use explosion-proof electrical (ventilating, lighting and material handling) equipment.
- Storage** : Keep container in a cool, well-ventilated area. Keep container tightly closed and sealed until ready for use. Segregate from oxidizing materials. Avoid all possible sources of ignition (spark or flame).

8 Exposure controls, personal protection

- Engineering controls** : Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of gases below their respective threshold limit value.

Personal protection

- Eyes** : Splash goggles.
- Body** : Overalls.
- Respiratory** : Wear appropriate respirator when ventilation is inadequate.
- Hands** : Gloves.
- Feet** : Boots.

Protective clothing (pictograms)



- Personal protection in case of a large spill** : Wear appropriate respirator when ventilation is inadequate. Suggested protective clothing might not be sufficient, consult a specialist BEFORE handling this product.

Product name	Exposure limits
Methane	Simple asphyxiant.
Ethane	Simple asphyxiant.
Nitrogen	Simple asphyxiant.
Propane	Simple asphyxiant.
	ACGIH TLV (United States, 2002).
	TWA: 1800 ppm 8 hour(s).
	OSHA (United States, 2002).
	TWA: 1000 ppm 8 hour(s).
	RQMT (United States, 2002).
	TWA: 1800 ppm 8 hour(s).

9 Physical and chemical properties

- Physical state and appearance** : Gas.
- Color** : Colourless.
- Odor** : Odourless.
- Taste** : No data available.
- Molecular weight** : Not applicable.
- Molecular formula** : Not applicable.
- pH (1% soln/water)** : No data available.
- Boiling/condensation point** : -160°C (-256°F)
- Melting/freezing point** : -172°C (-277.6°F) based on data for: Ethane. Weighted average: -183.39°C (-298.1°F)
- Critical temperature** : No data available.

Continued on Next Page

Natural Gas	Page: 4/6
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Specific gravity	: 0.73 (with reference to air)
Vapor pressure	: Not applicable.
Vapor density	: No data available.
Volatility	: 100% (w/w).
Odor threshold	: The lowest known value is 200 ppm (Methane) Weighted average: 338.36 ppm
Evaporation rate	: Not applicable.
VOC	: Not applicable.
Viscosity	: Dynamic: 0.011731 cP

LogK_{ow}	: Not applicable.
Ionicity (in water)	: Not applicable.
Dispersion properties	: Not applicable.
Solubility	: Slightly soluble in cold water, acetone.
Physical chemical comments	: No additional remark.

10 Stability and reactivity

Stability and reactivity	: The product is stable.
Conditions of instability	: Heat and in the presence of oxidizing agents.
Incompatibility with various substances	: Reactive or incompatible with oxidizing agents.
Hazardous decomposition products	: No data available.
Hazardous polymerization	: Will not occur.

11 Toxicological information

Toxicity to Animals	: No data available.
Chronic effects on humans	: No additional remark.
Other toxic effects on humans	: No specific information is available in our database regarding the other toxic effects of this material for humans.
Special remarks on toxicity to animals	: No additional remark.
Special remarks on chronic effects on humans	: No additional remark.
Special remarks on other toxic effects on humans	: No additional remark.

12 Ecological information

Ecotoxicity	: No data available.
BOD and COD	: No data available.
Biodegradable/OECD	: Easily biodegradable.
Mobility	: No data available.
Products of degradation	: These products are Carbon oxides (CO, CO ₂) and water, nitrogen oxides (NO, NO ₂ ...).
Toxicity of the products of biodegradation	: No data available.
Special remarks on the products of biodegradation	: No additional remark.

Continued on Next Page





13 Disposal considerations

Waste information : Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Waste stream : Not data available.

Consult your local or regional authorities.

14 Transport information

Regulatory information	UN number	Proper shipping name	Class	Packing group	Label	Additional information
DOT Classification	UN 1971	NATURAL GAS, COMPRESSED, with high methane content.	DOT Class 2.1: Flammable gas.			-
TDG Classification	UN 1971	NATURAL GAS, COMPRESSED, with high methane content.	TDG Class 2.1: Flammable gas.			
IMDG Class	UN 1971	NATURAL GAS, COMPRESSED, with high methane content.	IMDG Class 2.1: Flammable gas.			-
IATA-DGR Class	UN 1971	NATURAL GAS, COMPRESSED, with high methane content.	IATA Class 2.1: Flammable gas.			-

15 Regulatory information

HCS classification : Class: Flammable gas.

U.S. Federal regulations : TSCA 8(b) inventory: Methane; Ethane; Nitrogen; Propane

SARA 302/304/311/312 extremely hazardous substances: No products were found.

SARA 302/304 emergency planning and notification: No products were found.

SARA 302/304/311/312 hazardous chemicals: No products were found.

SARA 311/312 MSDS distribution - chemical inventory - hazard identification: No products were found.

SARA 313 toxic chemical notification and release reporting: No products were found.

Clean Water Act (CWA) 307: No products were found.

Clean Water Act (CWA) 311: No products were found.

Clean air act (CAA) 112 accidental release prevention: Methane; Ethane; Propane

Clean air act (CAA) 112 regulated flammable substances: Methane; Ethane; Propane

Clean air act (CAA) 112 regulated toxic substances: No products were found.

State regulations

: Rhode Island RTK hazardous substances: Methane; Ethane; Nitrogen; Propane

Pennsylvania RTK: Methane; Ethane; Nitrogen; Propane

Florida: Nitrogen

Minnesota: Methane; Ethane; Nitrogen; Propane

Massachusetts RTK: Methane; Ethane; Nitrogen; Propane


New Jersey: Methane; Ethane; Propane

New Jersey spill list: Methane; Ethane; Nitrogen; Propane

California prop. 65: No products were found.

EU Regulations

Continued on Next Page

Natural Gas		Page: 6/6
Hazard symbol(s)		
Classification	: Extremely flammable	
Risk phrases	: R12- Extremely flammable	
Safety phrases	: S9- Keep container in a well-ventilated place. : S16- Keep away from sources of ignition - No smoking. : S33- Take precautionary measures against static discharges.	
EINECS Number	: 200-812-7 (Methane), 200-814-8 (Ethane), 231-783-9 (Nitrogen gas) and 200-827-9 (Propane).	

16 Other information

**National Fire
Protection
Association
(U.S.A.)**



References

- : -Hawley, G.G., The Condensed Chemical Dictionary, 11e ed., New York N.Y., Van Nostrand Reinold, 1987.
- SAX, N.I. Dangerous Properties of Industrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984.
- The Sigma-Aldrich Library of Chemical Safety Data, Edition II.
- Guide de la loi et du règlement sur le transport des marchandises dangereuses au Canada. Centre de conformité international Ltée. 1986.
- Chemical Hazards Response Information System.
- Hazardous Substances Data Bank.

Other special considerations

- : No additional remark.

Date of printing

- : 2003/02/20.

Date of issue

- : 2003/02/20.

Date of previous issue

- : No Previous Validation.

Version

- : 3

Verified by

- : Albert George.

Notice to reader

This MSDS summarizes at the date of issue our best knowledge of the health, safety and environmental hazard information related to the product, and in particular how to safely handle, use, store and transport the product in the workplace. Since SASOL and its subsidiaries cannot anticipate or control the conditions under which the product may be handled, used, stored or transported, each user must, prior to usage, review this MSDS in the context of how the user intends to handle, use, store or transport the product in the workplace and beyond, and communicate such information to all relevant parties. If clarification or further information is needed to ensure that an appropriate assessment can be made, the user should contact this company.

We shall not assume any liability for the accuracy or completeness of the information contained herein or any advice given unless there has been gross negligence on our part. In such event our liability shall be limited only to direct damages suffered. Our responsibility for product as sold is subject to our standard terms and conditions, a copy of which is sent to our customers and is also available upon request. All risk associated with the possession and application of the product passes on delivery.

Annexure 5 Certificates of Accreditation and Registration



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 schedule 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 17020:1998

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 R Josias
Chief Executive Officer

Effective Date: **08 August 2013**
Certificate Expires: **07 August 2017**

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 Labour.

ANNEXURE A

SCHEDULE OF ACCREDITATION

Facility Number: MHI0004

TYPE A

Permanent Address: Nature & Business Alliance Africa (Pty) Ltd No. 13 Sedona Complex Flora Haase Street Amarosa Roodepoort 1725 Tel: (011) 958-2132 Fax: 086 502 4381 Cell: 083 225 4426 E-mail: admin@natbus-alliance.co.za		Postal Address: P O Box 6756 Westgate 1734 Issue No.: 06 Date of Issue: 08 August 2013 Expiry date: 07 August 2017
Nominated Representative: Mr A Niemand Quality Manager: Ms A Duff	Technical Manager: Mr A Niemand	Technical Signatory: Mr 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	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 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


 Field Manager

Republic of South Africa



Department of Labour

Certificate

This is to certify that

NATURE & BUSINESS ALLIANCE AFRICA (PTY) LTD

Has been approved as an

APPROVED INSPECTION AUTHORITY

Type A; Explosive chemicals, Gases, Flammable Gases, Non-Flammable, Non toxic gases (asphyxiants), Toxic gases, Flammable liquids, Flammable solids, Substances liable to spontaneous combustion, Substances that on contact with water release flammable gasses, Oxidizing substances and organic peroxides, Toxic liquids and Solids.
In terms of the Occupational Health and Safety Act, 1993, read with the Major Hazard Installation Regulations 5(5) (a) regarding risk assessments


.....
Chief Inspector

Valid From: 19 August 2013

Expires: 07 August 2017

MHI 0002

.....
Certificate Number



THE SOUTH AFRICAN COUNCIL
FOR
NATURAL SCIENTIFIC PROFESSIONS

herewith certifies that

Alfonso Niemand

Registration number
200026/04

has been registered as a

Certificated Natural Scientist

in terms of section 20(3)(c) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)

in the following field(s) of practice
(Schedule I of the Act)

Environmental Science

25 November 2004

Pretoria


President


Chief Executive Officer

References

- [1] American Institute of Chemical Engineers. Center for Chemical Process Safety. *Guidelines for Chemical Process Quantitative Risk Analysis*. Second Edition. 2000.
- [2] US Environmental Protection Agency (EPA). US federal Emergency Management Agency (FEMA). US Department of Transportation. *Automated Resource for Chemical Hazard Incident Evaluation used in conjunction with the Handbook of Chemical Hazard Analysis Procedures, Volume 1 and 2*. 1987.
- [3] 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.
- [4] US Arizona Emergency Response Commission. *Cameo Companion Procedure for the Management of Hazardous Situations*. October 2004.
- [5] Site plan for the Vortum Energy (Pty) Ltd site.
- [6] Sam Mannan. Lee's Loss Prevention in the Process Industries. Hazard Identification, Assessment and Control. Volume 1. Third Edition. 2005.
- [7] Sam Mannan. Lee's Loss Prevention in the Process Industries. Hazard Identification, Assessment and Control. Volume 2. Third Edition. 2004.
- [8] Sam Mannan. Lee's Loss Prevention in the Process Industries. Hazard Identification, Assessment and Control. Volume 3. Third Edition. 2004.
- [9] Robert H Perry and Cecil H Chilton. *Chemical Engineer's Handbook*. Fifth Edition. 1973.
- [10] A C Valsamakis, R W Vivian and G S du Toit. *Risk Management*. Second Edition. 1999.
- [11] J D Andrews and T R Moss. *Reliability and Risk Assessment*. Second Edition. 2002.
- [12] Dennis P Nolan. *Handbook of Fire and Explosion Protection Engineering Principles for Oil, Gas, Chemical and related Facilities*. Noyes Publications. 1996.
- [13] CRC Press. *Handbook of Chemistry and Physics*. 61st Edition. 1980.
- [14] RSA Occupational Health and Safety Act (Act No 85 of 1993).
- [15] RSA Major Hazard Installation Regulations R.692 of 30 July 2001.
- [16] RSA Development Facilitation Act (Act No 67 of 1995).

- [17] UK Health and Safety Executive. *Risk Criteria for Land-use Planning in the Vicinity of Major Industrial Hazards*. 1989.
- [18] Milton R Beychok. *Fundamentals of Stack Gas Dispersion*. Third Edition. 1995.
- [19] RSA Weather Service. A C Kruger. *Climate of South Africa: Surface Winds*. Publication No WS-43. 2002.
- [20] RSA Weather Bureau. Climate of South Africa. Climate Statistics up to 1984. Publication WB-40.
- [21] RSA Weather Bureau. Climate of South Africa Part 8. General Survey. Publication WB-28.
- [22] RSA National Nuclear Regulator. *A Guideline Document for the Release of Contaminated Sites from Regulatory Control*. July 2002.
- [23] RSA Environment Conservation Act (Act No 73 of 1989).
- [24] RSA National Environmental Management Second Amendment Act (Act No 8 of 2004).
- [25] Internet web site for Vortum Energy (Pty) Ltd and the Vortum Energy (Pty) Ltd group.
- [26] UK Health and Safety Executive. *Lines of Defence / Layers of Protection Analysis in the COMAH (Control of Major Accident Hazards regulations of 1999) Context*. 1999.
- [27] Digital Globe, National Geographic and Google Earth Plus. Global satellite image mapping. 2005.
- [28] The Concise Oxford Dictionary. 1983.
- [29] UK Health and Safety Executive. *Reducing Risks, Protecting People*. 2001.
- [30] D van Zyl. *South African Weather and Atmospheric Phenomena*. Briza Publications. 2003.
- [31] South African Weather Service. *Climate of South Africa – Surface Winds*. Publication WS43. 2002.
- [32] Weather Bureau of South Africa. *Climate of South Africa Part 8 WB28*. 1994.
- [33] Weather Bureau of South Africa. *Climate of South Africa WB40*. 1988.
- [34] Statistics South Africa. Data sets for the census survey in 2001.
- [35] American Heritage Dictionary of the English Language. Fourth Edition, 2004. Houghton Mifflin Company.

- [36] A Garrett, W T Lippincott, F Verhoek. *Chemistry – A study of Matter*. Ohio State University. 1972.
- [37] European Gas Pipeline Incident Data Group (EGIG). *Sixth Incident Report*. Nederlandse Gasunie. December 2005.
- [38] Australian Liquefied Petroleum Gas Association Ltd. *Material Safety Data Sheet for liquefied petroleum gas (LPG)*. 2002.
- [39] 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.
- [40] USA Environmental Protection Agency. *RMP Comp software programme for the calculation of overpressure safety distances*. 2006.
- [41] US Department of Labour. Occupational Safety and Health Administration (OSHA). Fact sheet on hazard alert for combustible dust explosions. 2009.
- [42] American Institute of Chemical Engineers. Center for Chemical Process Safety. *Guidelines for Process Equipment Reliability Data*. New York. 1989.
- [43] RSA Hazardous Chemical Substances Regulations R.1179 of 25 August 1995.
- [44] US National Library of Medicine, 8600 Rockville Pike, Bethesda, MD 20894 1-888-FIND-NLM
- [45] US Environmental Protection Agency (EPA).
- [46] Material Safety data Sheet (MSDS) released by TotalGaz for liquefied petroleum gas (LPG).
- [47] Supplement to South African National Standard (SANS) 10234 Edition 1: 2008. *List of Classification and Labelling of Chemicals in Accordance with the Globally Harmonized System (GHS)*.

Raw Data:

*Mr. Bill Eloff - 0824489767 / 071 603 8053.
Site co-ordinates: 32° 58' 00" S; 18° 04' 46" E.
Six diesel storage tanks, 5 400 m3 each
Natural gas pipeline at 2 890 tons per day*

*Alfonso Niemand
Nature & Business Alliance Africa (Pty) Ltd
Cell 083 225 4426*