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# QUANTITATIVE RISK ASSESSMENT FOR THE PROPOSED NEWCASTLE GAS ENGINE POWER PLANT AT NEWCASTLE IN THE KWAZULU NATAL PROVINCE

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RISCOM (PTY) LTD is a consulting company that specialises in process safety. Further to this, RISCOM* is an approved inspection authority (AIA) for conducting Major Hazard Installation (MHI) risk assessments in accordance with the OHS Act 85 of 1993 and its Major Hazard Installation regulations (July 2001). In order to maintain the status of approved inspection authority, RISCOM is accredited by the South African National Accreditation System (SANAS) in accordance with the IEC/ISO 17020:2012 standard.

The accreditation consists of a number of elements, including technical competence and third-party independence.

The independence of RISCOM is demonstrated by the following:

RISCOM does not sell or repair equipment that can be used in the process industry;

RISCOM does not have any shareholding in processing companies nor companies performing risk assessment functions;

RISCOM does not design equipment or processes.

Mike Oberholzer is a professional engineer, holds a Bachelor of Science in Chemical Engineering and is an approved signatory for MHI risk assessments, thereby meeting the competency requirements of SANAS for assessment of the risks of hazardous components, including fires, explosions and toxic releases.

Opinions and interpretations expressed herein this report are outside the scope of SANAS accreditation.

M P Oberholzer Pr. Eng. BSc (Chem. Eng.) MIChemE MSAIChE



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# QUANTITATIVE RISK ASSESSMENT FOR THE PROPOSED NEWCASTLE GAS ENGINE POWER PLANT AT NEWCASTLE IN THE KWAZULU NATAL PROVINCE

# EXECUTIVE SUMMARY

## 1 INTRODUCTION

Newcastle Energy (Pty) Ltd. (Newcastle Energy), a subsidiary of Vutomi Energy (Pty) Ltd. (Vutomi), own an 18.5-megawatt (MW) capacity gas fired cogeneration (stream and power) plant within the Karbochem Industrial Complex in Newcastle, KwaZulu-Natal.

Through the Newcastle Gas Engine Power Plant (hereinafter referred to as NGEPP) Independent Power Producer (IPP) project, Newcastle Energy proposes to increase its electricity generation capacity to approximately 100 MW and intends to submit a bid for the above RM IPP Procurement Programme Tender.

The LNG installations, including offloading, storage and regasification (vaporisers) will be located within the Karbochem site with natural gas being transported across the fence into the NGEPP facility. Thus, the risk assessment covers sections of the Karbochem Industrial Complex, as well as the NGEPP facility

### 1.1 Terms of Reference

The main aim of the investigation was to quantify the risks to employees, neighbours and the public with regard to the proposed NGEPP facility within the Karbochem Industrial Complex.

The scope of the risk assessment included:

1. Development of accidental spill and fire scenarios for the facility;
2. Using generic failure rate data (for tanks, pressure vessels, pipelines/ pipework, valves, flanges, and so forth), determination of the probability of each accident scenario;
3. For each incident developed in Step 2, determination of consequences (such as thermal radiation, domino effects, toxic-cloud formation and so forth);
4. For scenarios with off-site consequences (greater than 1% fatality off-site), calculation of maximum individual risk (MIR), taking into account all generic failure rates, initiating events (such as ignition), meteorological conditions and lethality.

### 1.2 Purpose and Main Activities

The main activity of the power plant would be the generation of mid-merit power supply to the South African electricity grid. The fuel used to generate power would be natural gas, with diesel proposed as a back-up fuel.

## 1.3 Main Hazards Due to Substance and Process

The main hazards that would occur with a loss of containment of hazardous components at the proposed NGEPP facility with in Karbochem Industrial Complex include exposure to:

- Thermal radiation from fires;
- Overpressure from explosions.

## 1.4 Assumptions and Limitations

The risk assessment was developed based on the information provided by NGEPP, and its engineering suppliers. These designs are conceptual and does not include detailed designs, which will be completed before construction. Thus, some information, as required by the risk assessment simulations, were assumed and based on similar installations. However, it is assumed that the relatively large storage tanks, will determine the endpoints from a release and will be the major contributor towards the risks generated. To this end the results obtained in this report may lack the accuracy of a detailed engineered plant. However, the risk generated are expected to represent the facility, provided the vessel size and inventory are not increased.

Part of the risk assessment is within the Karbochem Industrial Complex and thus this risk assessment was limited to the area LNG installation and did not other facilities within the Karbochem Industrial Complex. Should the project proceed, the risk assessment for the Karbochem Industrial Complex should be reviewed, as required by law.

# 2 ENVIRONMENT

The NGEPP, as shown in Figure 2-1, is located on the southern portion of the Karbochem Industrial Complex. The site is situated about 4.5 km southeast of the central business district of Newcastle and about 1.0 km southeast of the N11 highway.

The land use surrounding Karbochem Industrial Complex:

- To the north is the Newcastle airport;
- To the east, south and west is agricultural land.

There are some widely spaced residential properties to the west of site with the closest located about 375 m from the site boundary. The nearest suburban residential area is Arbor Park that is located about 1.2 km northwest of the site. No vulnerable facilities such as schools, hospitals and old age homes were identified within a 1.0 km radius of the site.

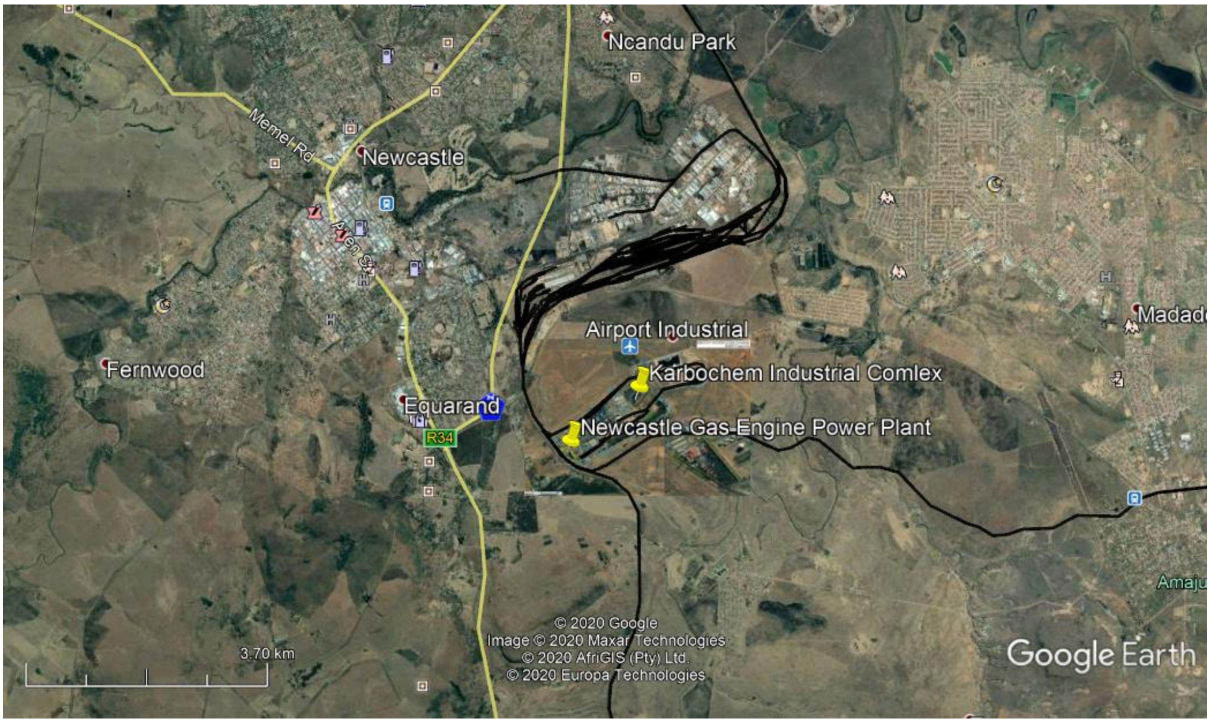



**Figure 2-1: Location of the NGEPP facility in Newcastle**

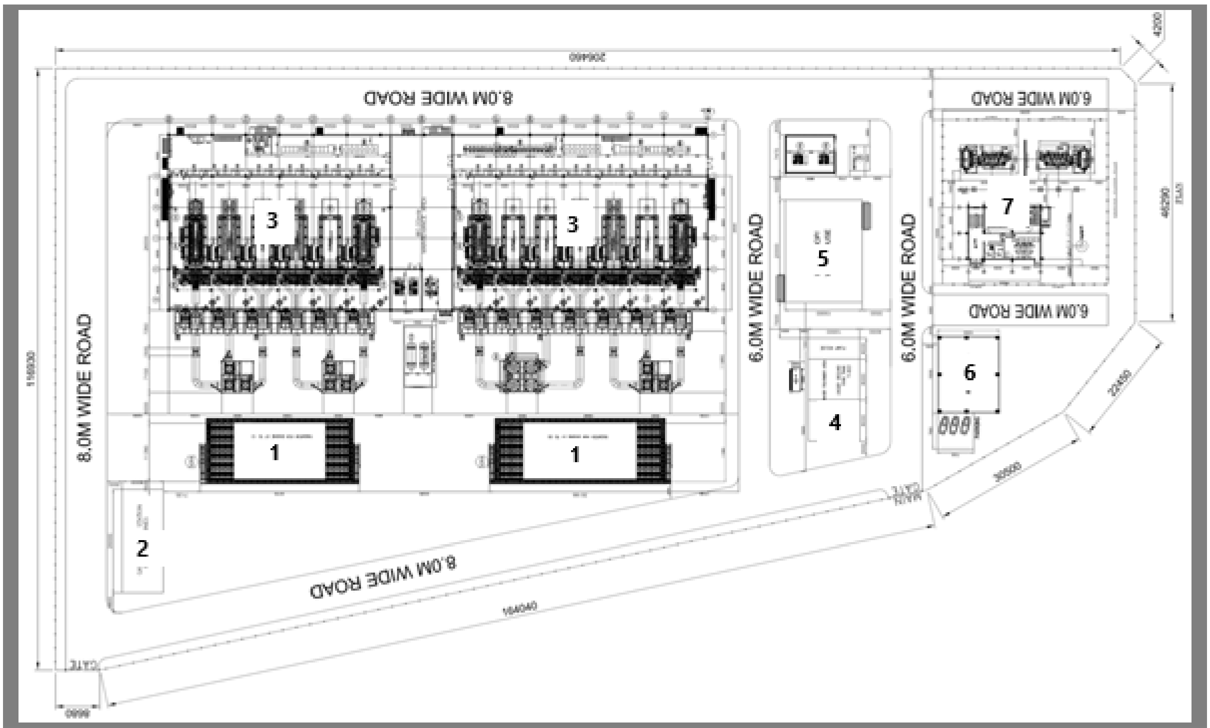
# 3 PROCESS DESCRIPTION

## 3.1 Site

The NGEPP would be located on the current site and will be erected after demolition of the current infrastructure. The LNG offloading, storge and vaporisers will be located to the east of NGEPP in the Karbochem tank farm area, as shown in Figure 3-1.


**Figure 3-1: Location of the LNG facility and the new NGEPP power plant**

The proposed layout of the power plant is shown in Figure 3-2 and consists of gas to power engines, as well as workshops, administration buildings and a sub-station.




| No. | Description | No. | Description |
|---|---|---|---|
| 1 | Engine radiator | 2 | Gas receiving station |
| 3 | Engine room | 4 | Fire fighting |
| 5 | Workshop / warehouse | 7 | Admin building |
| 15 | Sub station | | |

**Figure 3-2: Site layout of NGEPP power plant**

The layout of the LNG facility including; offloading, storage and regasification section, located in the position, are shown in Figure 3-3.

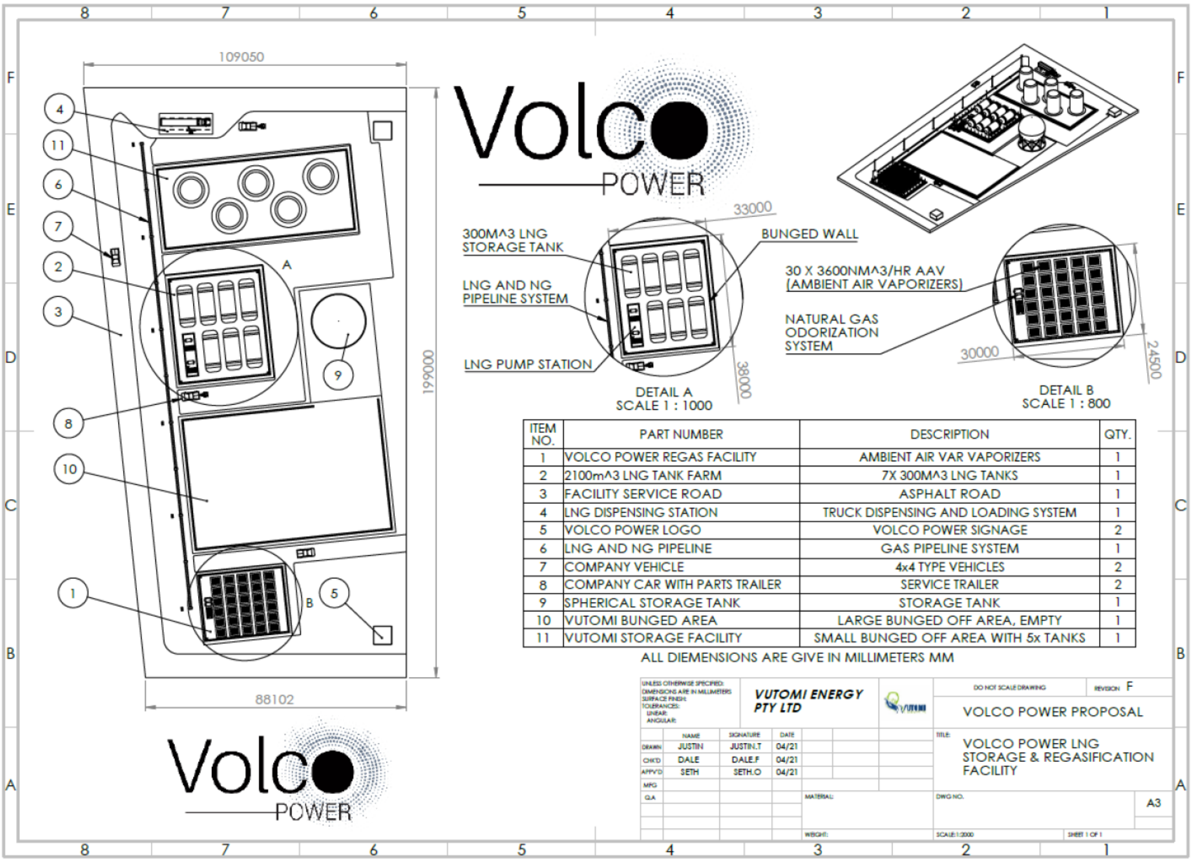



**Figure 3-3: Layout of the LNG facility**

## 3.2 Process Description

The proposed NGEPP project entails the construction of a gas fired open cycle thermal power generating plant, with a nominal generation capacity of approximately 100 MWe.

The 100 MWe capacity will be achieved via 13 Rolls-Royce (Bergen B3540V20) gas engines of 8.8 MWe each. The operating hours of the facility is based on 16.5 hours a day or 5 840 hours per year.

[Note: Although the directly calculated output would be around 121 MW, one engine will always be on stand-by, while the 12 others will output the nominal 100 MWe, with allowance made for a 2.5% parasitic plan loss which would bring the output capacity down to approximately 100 MWe.]

The fuel interface point for the new plant will be located at the existing gas metering station, supplying methane rich gas to the existing cogeneration plant (i.e., Spring Lights Gas / Sasol Gas transported via Lily Pipeline). For the electricity produced, the connection to the grid is proposed to be via the existing 132 kV switchyard, located within the Karbochem Industrial Complex where it interconnects with the external Eskom Grid system, making use of existing servitudes (note: the feasibility of using the existing 132 kV switchyard is still to be confirmed).

A conceptual block diagram showing what infrastructure will be within the site boundary (i.e., inside battery limits (IBL)) and what infrastructure will be outside of the site boundary (i.e., outside battery limits (OBL)), as shown in Figure 3-4.

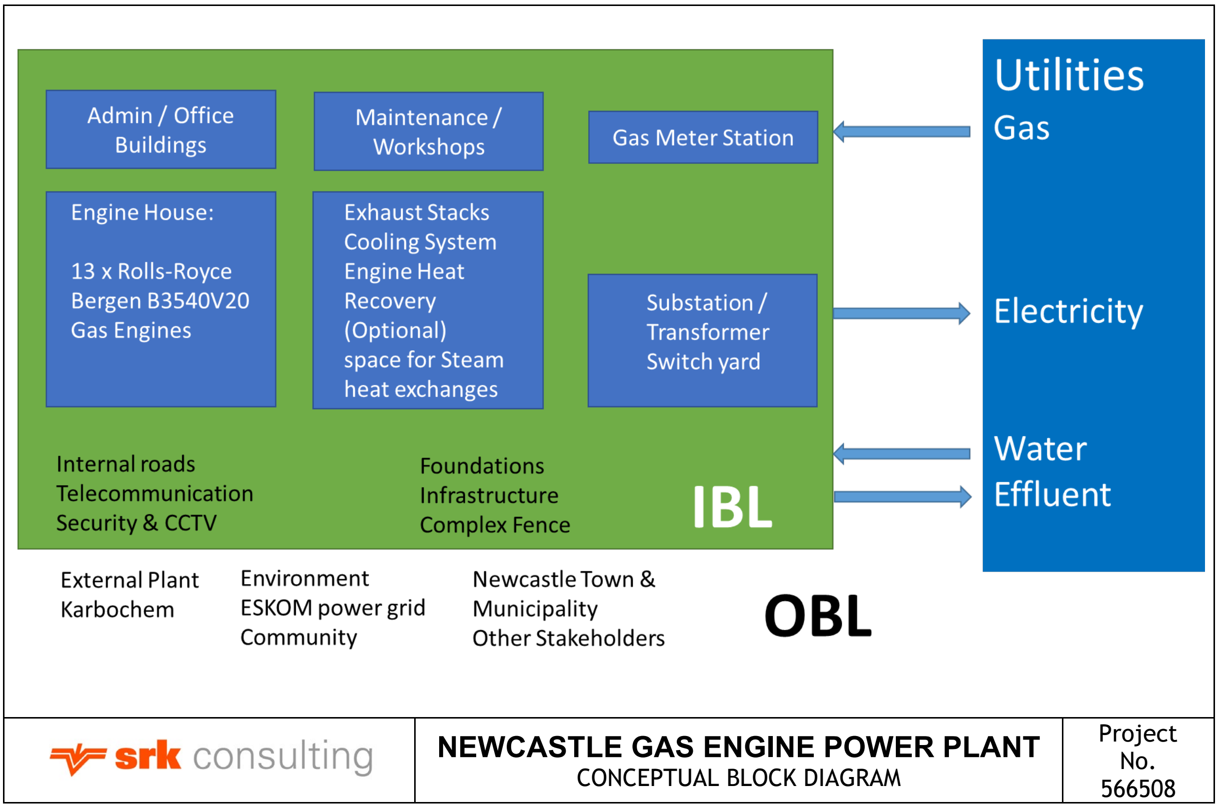



**Figure 3-4: Conceptual block diagram for the NGEPP**

A back-up of fuel, equal to three-day supply, will be achieved with 7 x 300 m3 LNG bullets located in the Karbochem tank farm area. The LNG would be transported to site in 20 or 40 ft ISO containers and offloaded into the LNG bullets. Each 40 ft ISO container would hold 37 m3 LNG at 93 % capacity. Acceptable ISO Containers will conform to ASME regulations;

therefore, each container will have a minimum of 80-day hold time before evaporation (boil-off) occurs, thereafter 0.20% evaporations occur per day.

The initial first fill of the LNG storage facility will require 63 LNG ISO containers to be delivered and offloaded over the course of a month, allowing for testing and commissioning. At the full commercial operating date, the LNG storage will be fully operational, boil off will only incur 130 days from the first fill, and from that point, an LNG ISO container delivered and offloaded once every 10 days to replenish the boil-off gas consumed by the power plant.

When required, the LNG will be sent to 30 air vaporing (AAV's) units of a combined capacity of 3600 Nm3 an hour, where the LNG will be converted to the gaseous phase and transported to the gensets at approximately 1 meter per second flow rate at between 1.74 and 2.74 barg of pressure.

## 3.3 Summary of Bulk Materials stored on Site

A summary of bulk materials that can give hazardous effects that are to be stored or conveyed and used on-site, is given in Table 3-1.

**Table 3-1: Summary of hazardous components to be stored / conveyed / used on site**

| No. | Component | CAS No. | Inventory |
|---|---|---|---|
| 1 | Natural Gas (predominantly methane) | 74-82-8 | 7 x 300 $m^3$ |

# 4 METHODOLOGY

The first step in any risk assessment is to identify all hazards. The merit of including a hazard for further investigation is then determined by how significant it is, normally by using a cut-off or threshold value.

Once a hazard has been identified, it is necessary to assess it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequence should be considered, but there are occasions where, if either the probability or the consequence can be shown to be sufficiently low or sufficiently high, decisions can be made based on just one factor.

During the hazard identification component of the report, the following considerations are taken into account:

- Chemical identities;
- Location of on-site installations that use, produce, process, transport or store hazardous components;
- Type and design of containers, vessels or pipelines;
- Quantity of material that could be involved in an airborne release;
- Nature of the hazard most likely to accompany hazardous materials spills or releases, e.g., airborne toxic vapours or mists, fires or explosions, large quantities to be stored and certain handling conditions of processed components.

The evaluation methodology assumes that the facility will perform as designed in the absence of unintended events such as component and material failures of equipment, human errors, external events and process unknowns.

The SANS 1461 standard is the requirement for performing MHI risk assessments in South Africa and is primarily based on the Dutch RIVM (2009). The evaluation of the acceptability of the risks is done in accordance with the UK Health and Safety Executive (HSE) ALARP criteria that clearly cover land use criteria, based on the determined risks.

This report is based on SANS 1461 with the exclusion of elements specific to the Occupational Health and Safety Act 85 of 1993 and its MHI regulation, as well as specific requirements not suitable for this report. This would include, but not limited to the requirements of emergency plan etc.

The QRA process is summarised with the following steps:

1. Identification of components that are flammable, toxic, reactive or corrosive and that have potential to result in a major incident from fires, explosions or toxic releases;
2. Development of accidental loss of containment (LOC) scenarios for equipment containing hazardous components (including release rate, location and orientation of release);
3. For each incident developed in Step 2, determination of consequences (such as thermal radiation, domino effects, toxic-cloud formation and so forth);
4. For scenarios with off-site consequences (greater than 1% fatality off-site), calculation of maximum individual risk (MIR), taking into account all generic failure rates, initiating events (such as ignition), meteorological conditions and lethality.

Scenarios included in this QRA have impacts external to the establishment. The 1% fatality from acute affects (thermal radiation, blast overpressure and toxic exposure) is determined as the endpoint (RIVM 2009). Thus, a scenario producing a fatality of less than 1% at the establishment boundary under worst-case meteorological conditions would be excluded from the QRA.

# 5 CONCLUSIONS

Risk calculations are not precise. Accuracy of predictions is determined by the quality of base data and expert judgements.

This risk assessment included the consequences of fires and explosions as well as toxic releases at the NGEPP gas to power facility in Newcastle. A number of well-known sources of incident data were consulted and applied to determine the likelihood of an incident to occur.

This risk assessment was performed with the assumption that the site would be maintained to an acceptable level and that all statutory regulations would be applied. It was also assumed that the detailed engineering designs would be done by competent people and would be correctly specified for the intended duty. For example, it was assumed that tank wall thicknesses have been correctly calculated, that vents have been sized for emergency conditions, that instrumentation and electrical components comply with the specified electrical area classification, that material of construction is compatible with the products, etc.

It is the responsibility of the owners and their contractors to ensure that all engineering designs would have been completed by competent persons and that all pieces of equipment would have been installed correctly. All designs should be in full compliance with (but not limited to) the Occupational Health and Safety Act 85 of 1993 and its regulations, the National Buildings Regulations and the Buildings Standards Act 107 of 1977 as well as local by-laws.

A number of incident scenarios were simulated, taking into account the prevailing meteorological conditions, and described in the report.

The following installations were considered for analysis in the QRA:

- Sasol methane rich gas;
- LNG.

## 5.1 Notifiable Substances

The General Machinery Regulation 8 and its Schedule A on notifiable substances, requires any employer who has a substance equal to or exceeding the quantity listed in the regulation to notify the divisional director. A site is classified as a Major Hazard Installation if it contains one or more notifiable substances or if the off-site risk is sufficiently high. The latter can only be determined from a quantitative risk assessment.

Methane (compressed) is listed as a notifiable substance at a threshold value of 15 t stored in a single vessel. As the LNG is not a compressed gas, LNG will not be classified as notifiable substance.

## 5.2 Sasol Gas

The Sasol gas would be the main source of energy to the NGEPP gas to power facility in Newcastle and would be supplied to gensets at approximately 8 bar(g). A loss of containment could result in las fires, jet fires and explosions. The maximum damage would result from large jet fires that could extend beyond the site boundary, but would not reach residential or vulnerable populations.

### 5.3 LNG Installation

The LNG installation consisting of ISO Container offloading storage, regasifier / vaporiser with associated pumping and pipelines transporting the LNG to the gensets.

The maximum extent from a large release of LNG at the storage area, could extend over 1 km downwind to the 1% fatality.

The risk of $1x10^{-6}$ fatalities per person per year isopleth, would extend beyond the Karbochem Industrial Complex site boundary, and **that alone qualifies the Karbochem Industrial Complex as a Major Hazard Installation.** The risks from the LNG facility would not impact any residential areas or vulnerable populations.

The risks to the public would be within the ALARP range and considered tolerable to the general public.

### 5.4 Impacts onto Neighbouring Properties and Residential Areas

While the large releases can extend just over 940 m downwind from the release. Large releases would mostly be within the Karbochem Industrial Complex, but could extend into the airfield to the north.

Residential vulnerable populations would not be impacted from this development.

### 5.5 Major Hazard Installation

This investigation concluded that under typical design conditions, assuming conservative design options and inventories, the proposed power plant **could be considered as a Major Hazard Installation**, depending on the hazardous chemicals used on site as well as the layout of the power station. Furthermore, the risks of the LNG installation alone would classify the **Karbochem Industrial Complex as a Major Hazardous Installation**

**This study is not intended to replace the Major Hazard Installation risk assessment which should be completed prior to construction of the facility**.

# 6 RECOMMENDATIONS

RISCOM did not find any fatal flaws with the proposed NGEPP that would prevent the project proceeding to the detailed engineering phase of the project.

RISCOM would support the project with the following conditions:

- Compliance with all statutory requirements, i.e., pressure vessel designs;
- Compliance with applicable SANS codes, i.e., SANS 1461, SANS 10087, SANS 10089, SANS 10108, etc.;
- Incorporation of applicable guidelines or equivalent international recognised codes of good design and practice into the designs;
- Completion of a recognised process hazard analysis (such as a HAZOP study, FMEA, etc.) on the proposed facility prior to construction to ensure design and operational hazards have been identified and adequate mitigation put in place;
- Full compliance with IEC 61508 and IEC 61511 (Safety Instrument Systems) standards or equivalent to ensure that adequate protective instrumentation is included in the design and would remain valid for the full life cycle of the tank farm:
    - Including demonstration from the designer that sufficient and reliable instrumentation would be specified and installed at the facility;
- Preparation and issue of a safety document detailing safety and design features reducing the impacts from fires, explosions and flammable atmospheres to the MHI assessment body at the time of the MHI assessment:
    - Including compliance to statutory laws, applicable codes and standards and world's best practice;
    - Including the listing of statutory and non-statutory inspections, giving frequency of inspections;
    - Including the auditing of the built facility against the safety document;
    - Noting that codes such as IEC 61511 can be used to achieve these requirements;
- Demonstration by NGEPP or their contractor that the final designs would reduce the risks posed by the installation to internationally acceptable guidelines;
- Signature of all terminal designs by a professional engineer registered in South Africa in accordance with the Professional Engineers Act, who takes responsibility for suitable designs;
- Completion of an emergency preparedness and response document for on-site and off-site scenarios prior to initiating the MHI risk assessment (with input from local authorities);
- Permission not being granted for increases to the product list or product inventories without redoing part of or the full EIA;
- The Karbochem Industrial Complex must review the MHI requirements with regards to the new LNG installation, as required by the MHI regulation
- Final acceptance of the facility risks with an MHI risk assessment that must be completed in accordance to the MHI regulations:
    - Basing such a risk assessment on the final design and including engineering mitigation.

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## 1 INTRODUCTION

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### 1.1 Legislation

Legislation discussed in this sub-section is limited to the health and safety of employees and the public.

Risk assessments are conducted when required to do so by law or by companies wishing to determine the risks of the facility for other reasons, such as insurance. In South Africa, risk assessments are carried out under the legislation of two separate acts, each with different requirements. These are discussed in the sub-sections that follow.

#### 1.1.1 National Environmental Management Act (No. 107 of 1998) (NEMA) and its Regulations

The National Environmental Management Act (NEMA) contains South Africa’s principal environmental legislation. It has as its primary objective to make provision for cooperative governance by establishing principles for decision making on matters affecting the environment, on the formation of institutions that will promote cooperative governance and on establishing procedures for co-ordinating environmental functions exercised by organs of state as well as to provide for matters connected therewith (Government Gazette 1998).

Section 30 of the NEMA act deals with the control of emergency incidents where an "*incident*" is defined as an "*unexpected sudden occurrence, including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment, whether immediate or delayed*".

The act defines "*pollution*" as *"any change in the environment caused by:*

*(i) Substances;*
*(ii) Radioactive or other waves; or,*
*(iii) Noise, odours, dust or heat…*

*Emitted from any activity, including the storage or treatment of waste or substances, construction and the provision of services, whether engaged in by any person or an organ of state, where that change has an adverse effect on human health or wellbeing or on the composition, resilience and productivity of natural or managed ecosystems, or on materials useful to people, or will have such an effect in the future... "*

**"*Serious*" is not fully defined but would be accepted as having long lasting effects that could pose a risk to the environment or to the health of the public that is not immediately reversible.**

This is similar to the definition of a MHI as defined in the Occupational Health and Safety Act (OHS Act) 85 of 1993 and the associated MHI regulations.

Section 28 of NEMA makes provision for anyone who causes pollution or degradation of the environment being made responsible for the prevention of the occurrence, continuation or re-occurrence of related impacts and for the costs of repair of the environment. In terms of the provisions under Section 28 that are stated as:

*" Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped… "*

### 1.1.2 The Occupational Health and Safety Act No. 85 of 1993

The Occupation Health and Safety Act 85 (1993) is primarily intended for the health and safety of the employees, whereas the associated MHI regulations are intended for the health and safety of the public.

The OHS Act shall not apply in respect of:

" a) *A mine, a mining area or any works as defined in the Minerals Act, 1991 (Act No. 50 of 1991), except in so far as that Act provides otherwise;*

b) *Any load line ship (including a ship holding a load line exemption certificate), fishing boat, sealing boat and whaling boat as defined in Section 2 (1) of the Merchant Shipping Act, 1951 (Act No. 57 of 1951), or any floating crane, whether or not such ship, boat or crane is in or out of the water within any harbour in the Republic or within the territorial waters thereof, (date of commencement of paragraph (b) to be proclaimed.), or in respect of any person present on or in any such mine, mining area, works, ship, boat or crane.* "

#### *1.1.2.1 Major Hazard Installation Regulations*

The MHI regulations (July 2001) published under Section 43 of the OHS Act require employers, self-employed persons and users who have on their premises, either permanently or temporarily, a major hazard installation or a quantity of a substance which may pose a **risk** (our emphasis) that could affect the health and safety of employees and the public, to conduct a risk assessment in accordance with the legislation.

In accordance with legislation, the risk assessment must be done **prior to construction of the facility** by an approved inspection authority (AIA; see Appendix B and Appendix D), registered with the Department of Labour and accredited by the South African Accreditation Systems (SANAS).

Similar to Section 30 of NEMA as it relates to the health and safety of the public, the MHI regulations are applicable to the health and safety of employees and the public in relation to the operation of a facility and specifically in relation to sudden or accidental major incidents involving substances that could pose a risk to the health and safety of employees and the public.

It is important to note that the MHI regulations are applicable to the risks posed and not merely the consequences. This implies that both the consequence and likelihood of an event need to be evaluated, with the classification of an installation being determined on the risk posed to the employees and the public.

The notification of the MHI is described in the regulations as an advertisement placement and specifies the timing of responses from the advertisement. It should be noted that the regulation does not require public participation.

The regulations, summarised in Appendix D, essentially consists of six parts, namely:

1. The duties for notification of a MHI (existing or proposed), including:
    a. Fixed;
    b. Temporary installations;
2. The minimum requirements for a quantitative risk assessment (QRA);
3. The requirements for an on-site emergency plan;
4. The reporting steps for risk and emergency occurrences;
5. The general duties required of suppliers;
6. The general duties required of local government.

As this is not an MHI risk assessment, the application of the above legislation is not mandatory but the legislation is described to give a background to this report.

## 1.2 Terms of Reference

The main aim of the investigation was to quantify the risks to employees, neighbours and the public with regard to the proposed NGEPP facility within the Karbochem Industrial Complex.

The scope of the risk assessment included:

1. Development of accidental spill and fire scenarios for the facility;
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The main hazards that would occur with a loss of containment of hazardous components at the proposed NGEPP facility with in Karbochem Industrial Complex include exposure to:

- Thermal radiation from fires;
- Overpressure from explosions.

## 1.5 Software

Physical consequences were calculated with TNO's EFFECTS v.9.0.26 and the data derived was entered into TNO's RISKCURVES v. 9.0.23. All calculations were performed by Mr M P Oberholzer.

## 1.6 Limitations and Assumptions

The risk assessment was developed based on the information provided by NGEPP, and its engineering suppliers. These designs are conceptual and does not include detailed designs, which will be completed before construction. Thus, some information, as required by the risk assessment simulations, were assumed and based on similar installations. However, it is assumed that the relatively large storage tanks, will determine the endpoints from a release and will be the major contributor towards the risks generated. To this end the results obtained in this report may lack the accuracy of a detailed engineered plant. However, the risk generated are expected to represent the facility, provided the vessel size and inventory are not increased.

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# 2 ENVIRONMENT

## 2.1 General Background

The NGEPP, as shown in Figure 2-1, is located on the southern portion of the Karbochem Industrial Complex. The site is situated about 4.5 km southeast of the central business district of Newcastle and about 1.0 km southeast of the N11 highway.

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- To the north is the Newcastle airport;
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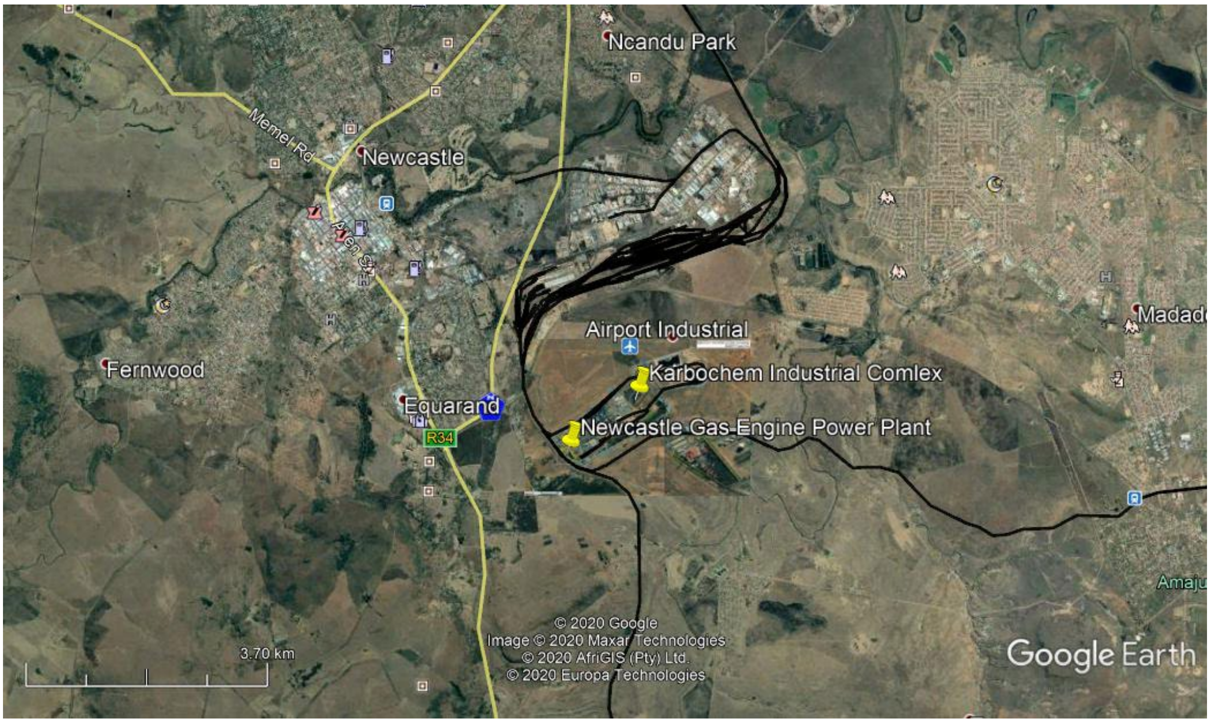



**Figure 2-1: Location of the NGEPP facility in Newcastle**

## 2.2 Meteorology

Meteorological mechanisms govern dispersion, transformation and eventual removal of hazardous vapours from the atmosphere. The extent to which hazardous vapours will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer.

Dispersion comprises of vertical and horizontal components of motion. The stability and the depth of the atmosphere from the surface (known as the mixing layer) define the vertical component. The horizontal dispersion of hazardous vapours in the atmospheric boundary layer is primarily a function of wind field. Wind speed determines both the distance of downwind transport and the rate of dilution as a result of stretching of the plume, and generation of mechanical turbulence is a function of the wind speed in combination with surface roughness. Wind direction and variability in wind direction, both determine the general path hazardous vapours will follow and the extent of crosswind spreading.

Concentration levels of hazardous vapours therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing layer depth and to shifts in the wind field.

For this report, the meteorological conditions at Newcastle, as measured by the South African Weather Service, were used as the basis of wind speed and direction, temperature, precipitation and atmospheric humidity and stability.

### 2.2.1 Surface Winds

Hourly averages of wind speed and direction recorded at Newcastle were obtained from the South African Weather Service for the period from January 2010 to December 2014. Currently, the South African Weather Service does not record meteorological data at Newcastle and thus the indicated data is the best available data.

The wind roses as shown in Figure 2-2, depict seasonal variances of measured wind speed and direction. In summer months, wind blows predominantly from the south eastern quadrant with variable wind speeds up to 8.7 m/s. During the winter months, the wind is predominantly from the north western quadrant with variable wind speeds up to 8.7 m/s and south eastern quadrant with variable wind speeds up to 5.6 m/s. On rare occasions the winds will reach higher speeds. Calm conditions vary from 8.4 –14.3% from summer to winter.

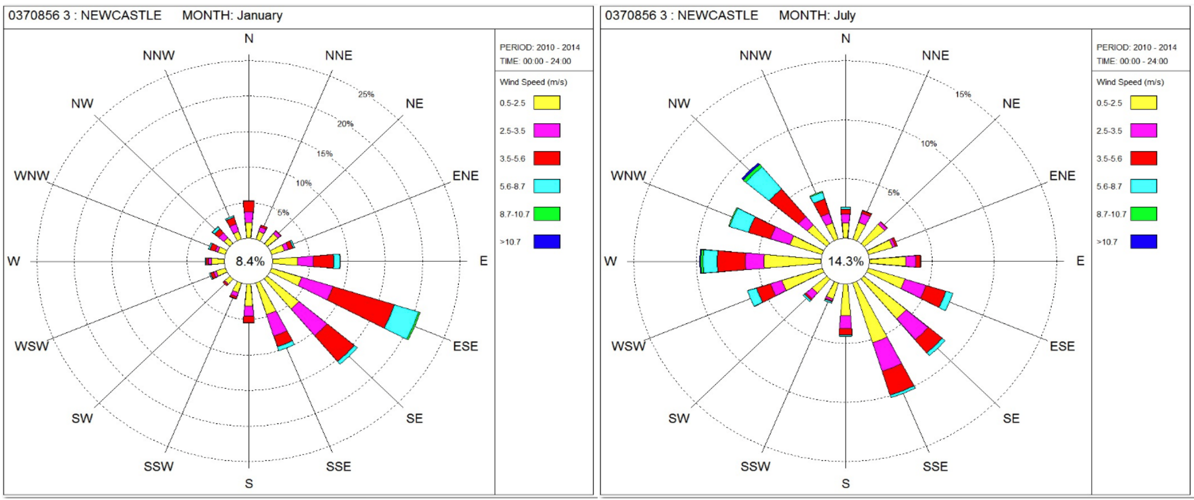



**Figure 2-2: Seasonal wind speed as a function of wind direction at Newcastle for the period from 2010 to 2014**

### 2.2.2 Precipitation and Relative Humidity

The long-term rainfall and relative humidity recorded at Newcastle was obtained from the South African Weather Service for the period from 1961 to 1990, as given in Table 2-1.

In Newcastle, there is an average annual rainfall of 801 mm with the maximum rainfall ranging from December to February. Whereas summer months receive about 49.8% of the rainfall, winter months are normally dry.

The relative humidity typically ranges from 43% (comfortable) to 81% (humid) over the course of the year, rarely dropping below 20% (dry) and reaching as high as 100% (very humid).

**Table 2-1: Long-term rainfall and relative humidity at Newcastle**

| Month | Relative Humidity (%) | | Precipitation | | |
|---|---|---|---|---|---|
| | Average Maximum | Average Minimum | Average Monthly (mm) | Average No. of Days with Less than 1 mm | Highest 24-hour Rainfall (mm) |
| January | 81 | 51 | 145 | 11.4 | 250 |
| February | 86 | 53 | 126 | 9.3 | 245 |
| March | 88 | 49 | 78 | 6.8 | 185 |
| April | 89 | 45 | 41 | 4.5 | 136 |
| May | 85 | 38 | 14 | 2.1 | 65 |
| June | 84 | 35 | 8 | 1.3 | 35 |
| July | 81 | 33 | 6 | 1.0 | 31 |
| August | 76 | 34 | 25 | 2.4 | 80 |
| September | 75 | 37 | 40 | 3.9 | 235 |
| October | 75 | 43 | 82 | 8.4 | 185 |
| November | 77 | 48 | 108 | 10.8 | 224 |
| December | 77 | 47 | 128 | 9.8 | 764 |
| **Year** | **81** | **43** | **801** | **72** | **764** |

### 2.2.3 Temperature

The long-term temperatures recorded at Newcastle were obtained from the South African Weather Service for the period from 1961 to 1990, as given in Table 2-2.

The surrounding region has a temperate climate with the average daily maximum between 20.0°C and 29.1°C. Temperatures rarely extend below freezing, with the mean average of the daily temperature at 17.8°C.

**Table 2-2: Long-term temperatures measured at Newcastle**

| Month | Temperature (°C) | | | |
|---|---|---|---|---|
| | Highest Recorded | Average Daily Mean | Average Daily Maximum | Average Daily Minimum |
| January | 38.0 | 22.7 | 29.1 | 16.3 |
| February | 38.3 | 21.7 | 27.9 | 15.5 |
| March | 35.0 | 20.7 | 27.4 | 14.0 |
| April | 33.7 | 17.6 | 24.8 | 10.3 |
| May | 32.0 | 14.4 | 22.6 | 6.2 |
| June | 28.5 | 11.1 | 20.0 | 2.2 |
| July | 27.5 | 11.8 | 20.7 | 2.8 |
| August | 31.2 | 14.4 | 23.0 | 5.8 |
| September | 35.0 | 17.6 | 25.3 | 9.8 |
| October | 37.5 | 19.1 | 26.2 | 12.0 |
| November | 38.5 | 20.6 | 27.4 | 13.8 |
| December | 37.2 | 22.3 | 29.0 | 15.4 |
| **Year** | **38.5** | **17.8** | **25.3** | **10.3** |

### 2.2.4 Atmospheric Stability

Atmospheric stability is frequently categorised into one of six stability classes. These are briefly described in Table 2-3. Atmospheric stability, in combination with wind speed, is important in determining the extent of a particular hazardous vapour release.

A very stable atmospheric condition, typically at night, would have low wind speeds and produce the greatest endpoint for a dense gas. Conversely, a buoyant gas would have the greatest endpoint distance at high wind speeds.

**Table 2-3: Classification scheme for atmospheric stability**

| Stability Class | Stability Classification | Description |
|---|---|---|
| A | Very unstable | Calm wind, clear skies, hot conditions during the day |
| B | Moderately unstable | Clear skies during the day |
| C | Unstable | Moderate wind, slightly overcast conditions during the day |
| D | Neutral | Strong winds or cloudy days and nights |
| E | Stable | Moderate wind, slightly overcast conditions at night |
| F | Very stable | Low winds, clear skies, cold conditions at night |

The atmospheric stability for Newcastle, as a function of the wind class, was calculated from hourly weather values supplied by the South African Weather Service from January 2010 to the December 2014, as given in Figure 2-3.

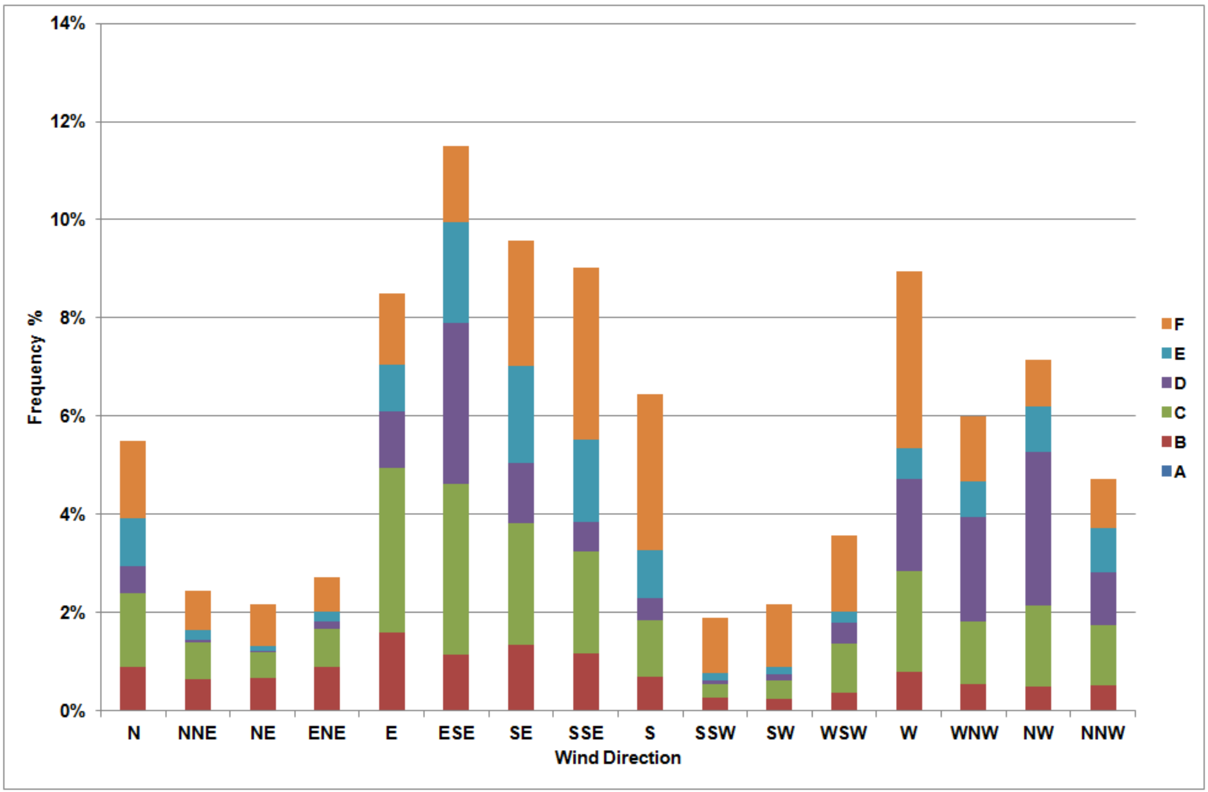



**Figure 2-3: Atmospheric stability as a function of wind direction**

Calculations for this risk assessment are based on six representative weather classes covering stability conditions of stable, neutral and unstable as well as low and high wind speeds. In terms of Pasquill classes, representative conditions are given in Table 2-4.

**Table 2-4: Representative weather classes**

| Stability Class | Wind (m/s) |
|---|---|
| B | 3 |
| D | 1.5 |
| D | 5 |
| D | 9 |
| E | 5 |
| F | 1.5 |

As wind velocities are vector quantities (having speed and direction) and blow preferentially in certain directions, it is mathematically incorrect to give an average wind speed over 360° of wind direction; the result would be incorrect risk calculations.

It would also be incorrect to base risk calculations on one wind category, such as 1.5/F for example. In order to obtain representative risk calculations, hourly weather data for wind speed and direction was analysed over a five-year period and categorised into the six wind classes for day and night conditions and 16 wind directions. The risk was then determined using contributions from each wind class in various wind directions.

The allocation of observations into the six weather classes is summarised in Table 2-5, with the representative weather classes given in Figure 2-4.

**Table 2-5: Allocation of observations into six weather classes**

<table>
<tr><th>Wind Speed</th><th>A</th><th>B</th><th>B/C</th><th>C</th><th>C/D</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td>< 2.5 m/s</td><td colspan="3" rowspan="3">B 3 m/s</td><td colspan="3">D 1.5 m/s</td><td colspan="2">F 1.5 m/s</td></tr>
<tr><td>2.5 - 6 m/s</td><td colspan="3">D 5 m/s</td><td colspan="2" rowspan="2">E 5 m/s</td></tr>
<tr><td>> 6 m/s</td><td colspan="3">D 9 m/s</td></tr>
</table>

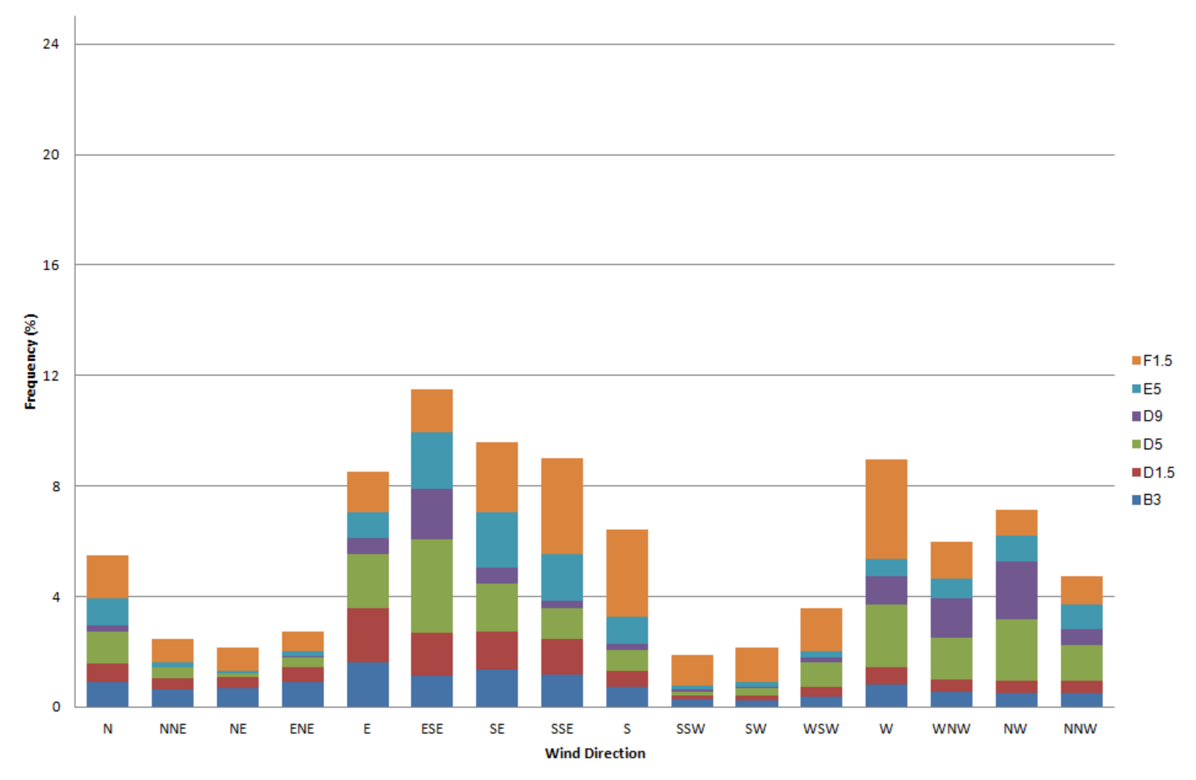



**Figure 2-4: Representative weather classes for Newcastle**

### 2.2.5 Default Meteorological Values

Default meteorological values used in simulations, based on local conditions, are given in Table 2-6.

**Table 2-6: Default meteorological values used in simulations, based on local conditions**

| Parameter | Default Value (Day) | Default Value (Night) |
|---|---|---|
| Ambient temperature (°C) | 25.3 | 10.3 |
| Substrate or bund temperature (°C) | 17.8 | 17.8 |
| Water temperature (°C) | 17.8 | 17.8 |
| Air pressure (bar) | 0.92 | 0.92 |
| Humidity (%) | 43 | 81 |
| Fraction of a 24-hour period | 0.5 | 0.5 |
| Mixing height | 2 | 1 |

2 The default values for the mixing height, which are included in the model, are: 1500 m for Weather Category B3; 300 m for Weather Category D1.5; 500 m for Weather Category D5 and Weather Category D9; 230 m for Weather Category E5; and, 50 m for Weather Category F1.5.

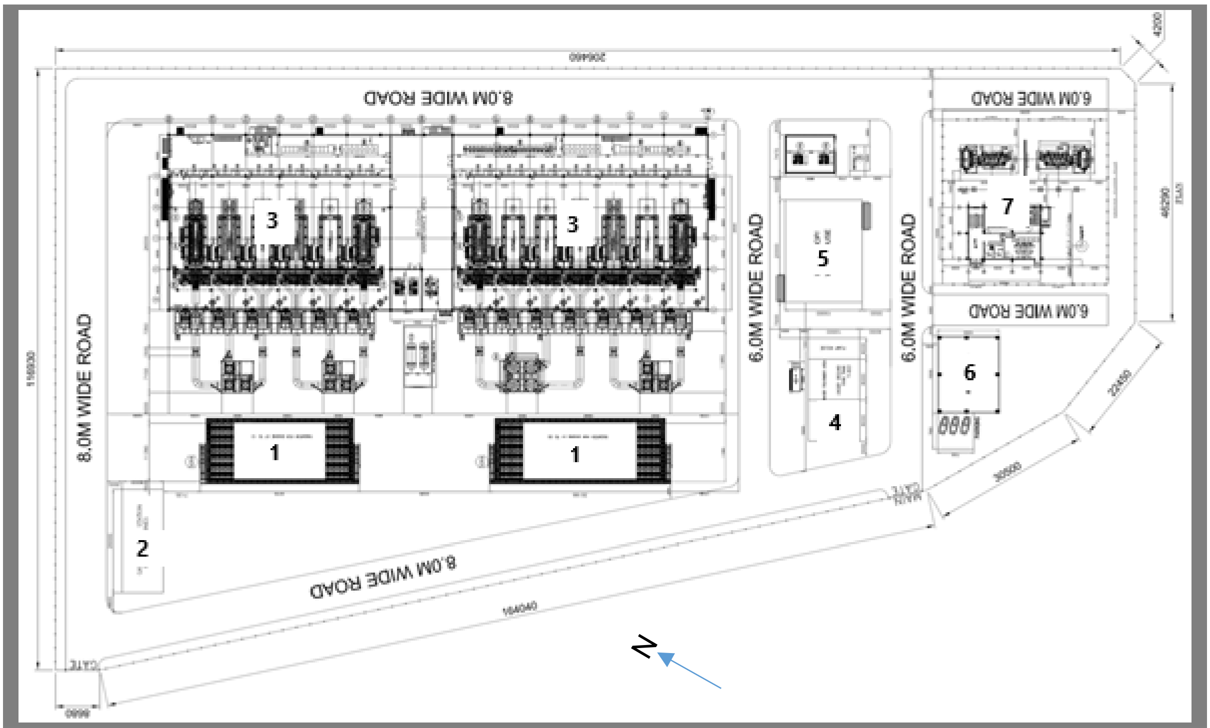
# 3 PROJECT DESCRIPTION

## 3.1 Site

The NGEPP would be located on the current site and will be erected after demolition of the current infrastructure. The LNG offloading, storge and vaporisers will be located to the east of NGEPP in the Karbochem tank farm area, as shown in Figure 3-1.


**Figure 3-1: Location of the LNG facility and the new NGEPP power plant**

The proposed layout of the power plant is shown in Figure 3-2 and consists of gas to power engines, as well as workshops, administration buildings and a sub-station.




| No. | Description | No. | Description |
|---|---|---|---|
| 1 | Engine radiator | 2 | Gas receiving station |
| 3 | Engine room | 4 | Fire fighting |
| 5 | Workshop / warehouse | 7 | Admin building |
| 15 | Sub station | | |

**Figure 3-2: Site layout of NGEPP power plant**

The layout of the LNG facility including; offloading, storage and regasification section, located in the position, are shown in Figure 3-3.

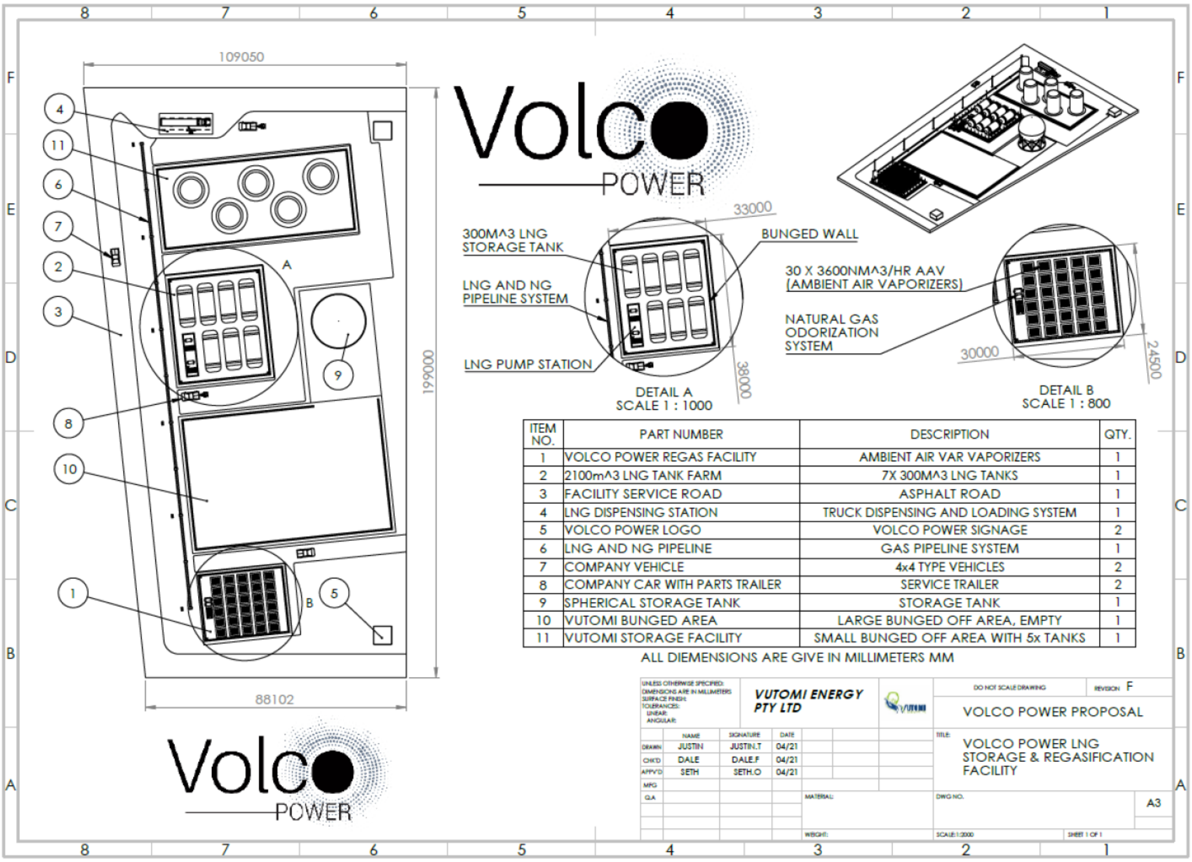



**Figure 3-3: Layout of the LNG facility**

### 3.2 Process Description

The proposed NGEPP project entails the construction of a gas fired open cycle thermal power generating plant, with a nominal generation capacity of approximately 100 MWe.

The 100 MWe capacity will be achieved via 13 Rolls-Royce (Bergen B3540V20) gas engines of 8.8 MWe each. The operating hours of the facility is based on 16.5 hours a day or 5 840 hours per year.

[Note: Although the directly calculated output would be around 121 MW, one engine will always be on stand-by, while the 12 others will output the nominal 100 MWe, with allowance made for a 2.5% parasitic plan loss which would bring the output capacity down to approximately 100 MWe.]

The fuel interface point for the new plant will be located at the existing gas metering station, supplying methane rich gas to the existing cogeneration plant (i.e., Spring Lights Gas / Sasol Gas transported via Lily Pipeline). For the electricity produced, the connection to the grid is proposed to be via the existing 132 kV switchyard, located within the Karbochem Industrial Complex where it interconnects with the external Eskom Grid system, making use of existing servitudes (note: the feasibility of using the existing 132 kV switchyard is still to be confirmed).

A conceptual block diagram showing what infrastructure will be within the site boundary (i.e., inside battery limits (IBL)) and what infrastructure will be outside of the site boundary (i.e., outside battery limits (OBL)), as shown in Figure 3-4.

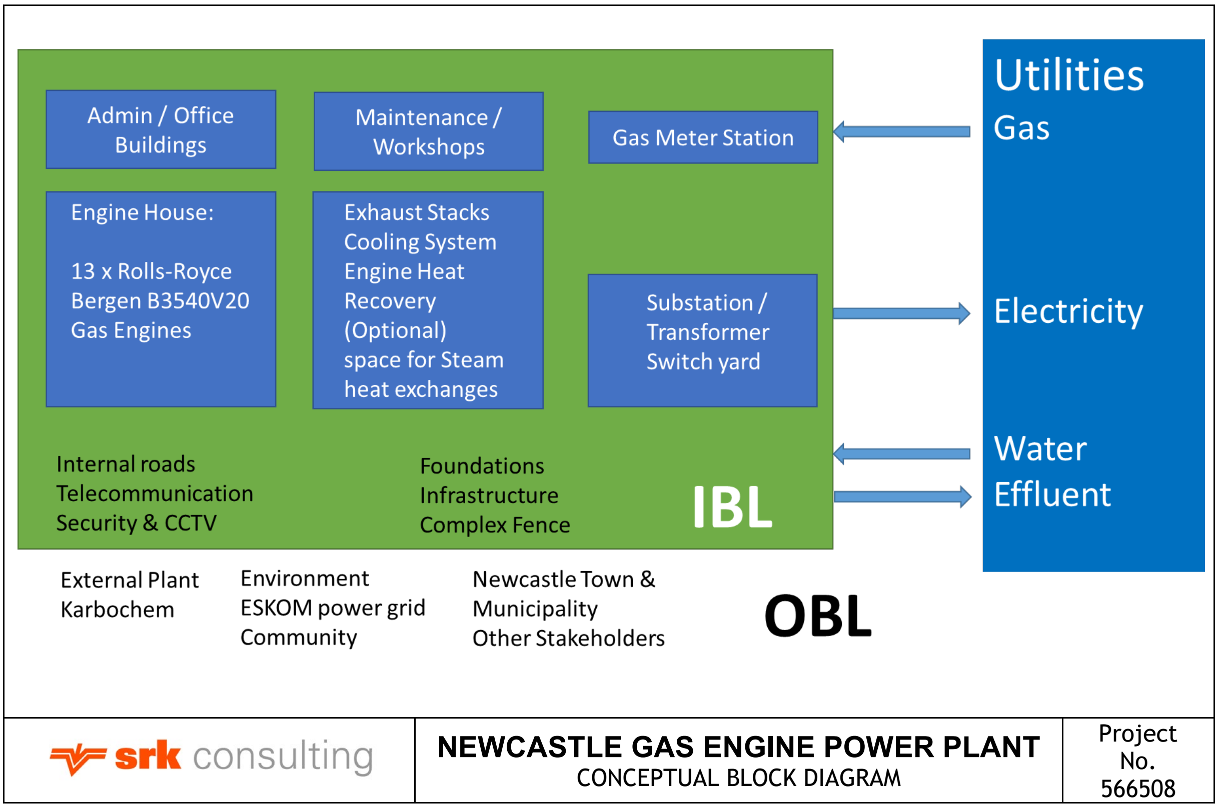



**Figure 3-4: Conceptual block diagram for the NGEPP**

A back-up of fuel, equal to three-day supply, will be achieved with 7 x 300 m$^3$ LNG bullets located in the Karbochem tank farm area. The LNG would be transported to site in 20 or 40 ft ISO containers and offloaded into the LNG bullets. Each 40 ft ISO container would hold 37 m$^3$ LNG at 93 % capacity. Acceptable ISO Containers will conform to ASME regulations;

therefore, each container will have a minimum of 80-day hold time before evaporation (boil-off) occurs, thereafter 0.20% evaporations occur per day.

The initial first fill of the LNG storage facility will require 63 LNG ISO containers to be delivered and offloaded over the course of a month, allowing for testing and commissioning. At the full commercial operating date, the LNG storage will be fully operational, boil off will only incur 130 days from the first fill, and from that point, an LNG ISO container delivered and offloaded once every 10 days to replenish the boil-off gas consumed by the power plant.

When required, the LNG will be sent to 30 air vaporing (AAV's) units of a combined capacity of 3600 $Nm^3$ an hour, where the LNG will be converted to the gaseous phase and transported to the gensets at approximately 1 meter per second flow rate at between 1.74 and 2.74 barg of pressure.

It is important to note that the LNG offloading, storage and vaporisers will be located within the Karbochem site and that the vaporised gas will be transported across the fence into the NGEPP site.

### 3.3 Summary of Bulk Materials to be Stored on Site

A summary of bulk materials that can give hazardous effects that are to be stored or conveyed and used on-site, is given in Table 3-1.

**Table 3-1: Summary of hazardous components to be stored / conveyed / used on site**

| No. | Component | CAS No. | Inventory |
|---|---|---|---|
| 1 | Natural Gas (predominantly methane) | 74-82-8 | 7 x 300 $m^3$ |

# 4 METHODOLOGY

## 4.1 Hazard Identification

The first step in any risk assessment is to identify all hazards. The merit of including a hazard for further investigation is then determined by how significant it is, normally by using a cut-off or threshold value.

Once a hazard has been identified, it is necessary to assess it in terms of the risk it presents to the employees and the neighbouring community. In principle, both probability and consequence should be considered but there are occasions where, if either the probability or the consequence can be shown to be sufficiently low or sufficiently high, decisions can be made based on just one factor.

During the hazard identification component of the report, the following considerations are taken into account:

- Chemical identities;
- Location of on-site installations that use, produce, process, transport or store hazardous components;
- Type and design of containers, vessels or pipelines;
- Quantity of material that could be involved in an airborne release;
- Nature of the hazard most likely to accompany hazardous materials spills or releases, e.g., airborne toxic vapours or mists, fires or explosions, large quantities to be stored and certain handling conditions of processed components.

The evaluation methodology assumes that the facility will perform as designed in absence of unintended events, such as component and material failures of equipment, human errors, external events and process unknowns.

## 4.2 Notifiable Substances

The General Machinery Regulation 8 and its Schedule A on notifiable substances, requires any employer who has a substance equal to or exceeding the quantity listed in the regulation to notify the divisional director. A site is classified as a Major Hazard Installation if it contains one or more notifiable substances or if the off-site risk is sufficiently high. The latter can only be determined from a quantitative risk assessment.

Methane (compressed) is listed as a notifiable substance at a threshold value of 15 t stored in a single vessel. As the LNG is not a compressed gas, LNG will not be classified as notifiable substance.

## 4.3 Substance Hazards

All components on site were assessed for potential hazards according to the criteria discussed in this section.

### 4.3.1 Chemical Properties

A short description of bulk hazardous components to be stored on, produced at or delivered to site is given in the following subsections. The material safety data sheets (MSDSs) of the respective materials are attached in Appendix F.

#### *4.3.1.1 Natural Gas*

The composition of natural gas is primarily methane (±95% v/v), with other components including ethane, propane and nitrogen.

Given the flammable and potentially explosive nature of natural gas, fires and VCEs represent the primary hazards associated with transfer of the gas. The gas is a fire and explosion hazard when it is exposed to heat and flame. The lower explosive limit (LEL) is 5% v/v (meaning 5% gas to 95% air, measured by volume) and the higher explosive limit (HEL) is 15% v/v. In unconfined atmospheric conditions, the likelihood of an explosion is expected to be small.

It is not compatible with strong oxidants and could result in fires and explosions in the presence of such materials.

It is non-toxic and would be considered as an asphyxiant only. Chronic and long-term effects are low and are not listed.

It is in the gaseous state at atmospheric temperatures and pressures. Economical transportation would require either liquefying or compressing the gas so that it would occupy less volume per weight. LNG has a low temperature of -162°C (at atmospheric pressure). The critical pressure of methane is 46 bar; compressed natural gas (CNG) would be above the critical pressure and would be a supercritical gas having a density similar to that of the liquid.

### 4.3.2 Flammable and Combustible Components

Flammable and combustible components are those that can ignite and give a number of hazardous effects, depending on the nature of the component and conditions. These effects may include pool fires, jet fires and flash fires as well as explosions and fireballs.

The flammable and combustible components to be stored on, produced at or delivered to site, are listed in Table 4-1. These components have been analysed for fire and explosion risk.

**Table 4-1: Flammable and combustible components to be stored on, produced at or delivered to site**

| Component | Flashpoint (°C) | Boiling Point (°C) | LFL (vol. %) | UFL (vol. %) |
|---|---|---|---|---|
| Natural gas | -188 | -161 | 5 | 15 |

### 4.3.3 Toxic and Asphyxiant Components

Toxic or asphyxiant components of interest to this study are those that could produce dispersing vapour clouds upon release into the atmosphere. These could subsequently cause harm through inhalation or absorption through the skin. Typically, the hazard posed by toxic or asphyxiant components will depend on both concentration of the material in the air and the exposure duration.

No bulk toxic or asphyxiant materials would be stored or processed on site. All combustion products are hot and released via stacks and will be dispersed adequately before reaching the ground and can be ignored (BEVI (2009)).

## 4.4 Physical Properties

For this study, LPG, natural gas and diesel were modelled as pure components, as given in Table 4-2. The physical properties used in the simulations were based on the DIPPR[1] data base.

**Table 4-2: Representative components**

| Component | Modelled as |
|---|---|
| Natural gas / Sasol gas | Modelled as methane |

## 4.5 Components Excluded from the Study

The following installations were not considered in this study, as the site inventories would be very small in comparison to the relatively large natural gas:

- Workshop gases;
- Flammable store;
- Laboratory reagents.

1 Design Institute for Physical Properties

Turbine oil, lube oils and greases were excluded from the study as they have very high flashpoints making ignition extremely remote.

It is assumed that corrosive liquids would be stored sufficiently far from the site boundary so that a release would not affect the public. The toxic effects of vapours released from sulphuric acid were not considered, due its low vapour pressure.

# 5 CONSEQUENCE ANALYSIS

## 5.1 Physical and Consequence Modelling

In order to establish which impacts follow an accident, it is first necessary to estimate the physical process of the spill (i.e. rate and size), spreading of the spill, evaporation from the spill, subsequent atmospheric dispersion of the airborne cloud and, in the case of ignition, the burning rate and resulting thermal radiation from a fire and the overpressures from an explosion.

The second step is then to estimate the consequences of a release on humans, fauna, flora and structures in terms of the significance and extent of the impact in the event of a release. The consequences could be due to toxic or asphyxiant vapours, thermal radiation or explosion overpressures. They may be described in various formats.

The simplest methodology would show a comparison of predicted concentrations, thermal radiation or overpressures to short-term guideline values.

In a different but more realistic fashion, the consequences may be determined by using a dose-response analysis. Dose-response analysis aims to relate the intensity of the phenomenon that constitutes a hazard to the degree of injury or damage that it can cause. Probit analysis is possibly the method mostly used to estimate probability of death, hospitalisation or structural damage. The probit is a lognormal distribution and represents a measure of the percentage of the vulnerable resource that sustains injury or damage. The probability of injury or death (i.e., the risk level) is in turn estimated from this probit (risk characterisation).

Consequence modelling gives an indication of the extent of the impact for selected events and is used primarily for emergency planning. A consequence that would not cause irreversible injuries would be considered insignificant, and no further analysis would be required. The effects from major incidents are summarised in the following sub-sections.

## 5.2 Fires

Combustible and flammable components within their flammable limits may ignite and burn if exposed to an ignition source of sufficient energy. On process plants, releases with ignition normally occur as a result of a leakage or spillage. Depending on the physical properties of the component and the operating parameters, combustion may take on a number of forms, such as pool fires, jet fires, flash fires and so forth.

### 5.2.1 Thermal Radiation

The effect of thermal radiation is very dependent on the type of fire and duration of exposure. Certain codes, such as the American Petroleum Institute API 520 and API 2000 codes, suggest values for the maximum heat absorbed by vessels to facilitate adequate relief designs in order to prevent failure of the vessel. Other codes, such as API 510 and the British Standards BS 5980 code, give guidelines for the maximum thermal radiation intensity and act as a guide to equipment layout, as shown in Table 5-1.

The effect of thermal radiation on human health has been widely studied, relating injuries to the time and intensity of exposure.

**Table 5-1: Thermal radiation guidelines (BS 5980 of 1990)**

| Thermal Radiation Intensity ($kW/m^2$) | Limit |
|---|---|
| 1.5 | Will cause no discomfort for long exposure. |
| 2.1 | Sufficient to cause pain if unable to reach cover within 40 seconds. |
| 4.5 | Sufficient to cause pain if unable to reach cover within 20 seconds. |
| 12.5 | Minimum energy required for piloted ignition of wood and melting of plastic tubing. |
| 25 | Minimum energy required to ignite wood at indefinitely long exposures. |
| 37.5 | Sufficient to cause serious damage to process equipment. |

For pool fires, jet fires and flash fires CPR 18E (Purple Book; 1999) suggests the following thermal radiation levels be reported:

4 $kW/m^2$, the level that glass can withstand, preventing the fire entering a building, and that should be used for emergency planning;

10 $kW/m^2$, the level that represents the 1% fatality for 20 seconds of unprotected exposure and at which plastic and wood may start to burn, transferring the fire to other areas;

35 $kW/m^2$, the level at which spontaneous ignition of hair and clothing occurs, with an assumed 100% fatality, and at which initial damage to steel may occur.

### 5.2.2 Bund and Pool Fires

Pool fires, either tank or bund fires, consist of large volumes of a flammable liquid component burning in an open space at atmospheric pressure.

The flammable component will be consumed at the burning rate, depending on factors including prevailing winds. During combustion, heat will be released in the form of thermal radiation. Temperatures close to the flame centre will be high but will reduce rapidly to tolerable temperatures over a relatively short distance. Any building or persons close to the fire or within the intolerable zone will experience burn damage with severity depending on the distance from the fire and time exposed to the heat of the fire.

In the event of a pool fire, the flames will tilt according to the wind speed and direction. The flame length and tilt angle affect the distance of thermal radiation generated.

#### *5.2.2.1 Jet Fires*

Jet fires occur when a flammable component is released with high exit velocity ignites.

In process industries this may be due to design (such as flares) or due to accidental releases. Ejection of a flammable component from a vessel, pipe or pipe flange may give rise to a jet fire and in some instances the jet flame could have substantial ‘reach’.

Depending on wind speed, the flame may tilt and impinge on other pipelines, equipment or structures. The thermal radiation from these fires may cause injury to people or damage equipment some distance away from the source of the flame.

#### *5.2.2.2 Flash Fires*

A loss of containment of a flammable component may mix with air, forming a flammable mixture. The flammable cloud would be defined by the lower flammable limit (LFL) and the upper flammable limit (UFL). The extent of the flammable cloud would depend on the quantity of the released and mixed component, physical properties of the released component, wind speed and weather stability. An ignition within a flammable cloud can result in an explosion if the front is propagated by pressure. If the front is propagated by heat, then the fire moves across the flammable cloud at the flame velocity and is called a flash fire. Flash fires are characterised by low overpressure, and injuries are caused by thermal radiation. The effects of overpressure due to an exploding cloud are covered in the subsection dealing with vapour cloud explosions (VCEs).

A flash fire would extend to the lower flammable limit; however, due to the formation of pockets, it could extend beyond this limit to the point defined as the ½ LFL. It is assumed that people within the flash fire would experience lethal injuries, while people outside of the flash fire would remain unharmed. The ½ LFL is used for emergency planning to evacuate people to a safe distance in the event of a release.

### 5.2.3 Explosions

The concentration of a flammable component would decrease from the point of release to below the lower explosive limits (LEL), at which concentration the component can no longer ignite. The sudden detonation of an explosive mass would cause overpressures that could result in injury or damage to property.

Such an explosion may give rise to any of the following effects:

Blast damage;
Thermal damage;
Missile damage;
Ground tremors;
Crater formation;
Personal injury.

Obviously, the nature of these effects depends on the pressure waves and the proximity to the actual explosion. Of concern in this investigation are the 'far distance effects', such as limited structural damage and the breakage of windows, rather than crater formations.

Table 5-2 and Table 5-3 give a more detailed summary of the damage produced by an explosion due to various overpressures.

CPR 18E (Purple Book; 1999) suggests the following overpressures be determined:

- 0.03 bar overpressure, corresponding to the critical overpressure causing windows to break;
- 0.1 bar overpressure, corresponding to 10% of the houses being severely damaged and a probability of death indoors equal to 0.025:
  - No lethal effects are expected below 0.1 bar overpressure on unprotected people in the open;
- 0.3 bar overpressure, corresponding to structures being severely damaged and 100% fatality for unprotected people in the open;
- 0.7 bar overpressure, corresponding to an almost entire destruction of buildings.

**Table 5-2: Summary of consequences of blast overpressure (Clancey 1972)**

| Pressure (Gauge) | | Damage |
|---|---|---|
| Psi | kPa | |
| 0.02 | 0.138 | Annoying noise (137 dB), if of low frequency (10 – 15 Hz). |
| 0.03 | 0.207 | Occasional breaking of large glass windows already under strain. |
| 0.04 | 0.276 | Loud noise (143 dB); sonic boom glass failure. |
| 0.1 | 0.69 | Breakage of small under strain windows. |
| 0.15 | 1.035 | Typical pressure for glass failure. |
| 0.3 | 2.07 | ‘Safe distance’ (probability 0.95; no serious damage beyond this value); missile limit; some damage to house ceilings; 10% window glass broken. |
| 0.4 | 2.76 | Limited minor structural damage. |
| 0.5–1.0 | 3.45–6.9 | Large and small windows usually shattered; occasional damage to window frames. |
| 0.7 | 4.83 | Minor damage to house structures. |
| 1.0 | 6.9 | Partial demolition of houses, made uninhabitable. |
| 1.0–2.0 | 6.9–13.8 | Corrugated asbestos shattered; corrugated steel or aluminium panels, fastenings fail, followed by buckling; wood panels (standard housing) fastenings fail, panels blown in. |
| 1.3 | 8.97 | Steel frame of clad building slightly distorted. |
| 2.0 | 13.8 | Partial collapse of walls and roofs of houses. |
| 2.0–3.0 | 13.8–20.7 | Concrete or cinderblock walls (not reinforced) shattered. |
| 2.3 | 15.87 | Lower limit of serious structural damage. |
| 2.5 | 17.25 | 50% destruction of brickwork of house. |
| 3.0 | 20.7 | Heavy machines (1.4 t) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations. |
| 3.0–4.0 | 20.7–27.6 | Frameless, self-framing steel panel building demolished. |
| 4.0 | 27.6 | Cladding of light industrial buildings demolished. |
| 5.0 | 34.5 | Wooden utilities poles (telegraph, etc.) snapped; tall hydraulic press (18 t) in building slightly damaged. |
| 5.0–7.0 | 34.5–48.3 | Nearly complete destruction of houses. |
| 7.0 | 48.3 | Loaded train wagons overturned. |
| 7.0–8.0 | 48.3–55.2 | Brick panels (20 – 30 cm) not reinforced fail by shearing or flexure. |
| 9.0 | 62.1 | Loaded train boxcars completely demolished. |
| 10.0 | 69.0 | Probable total destruction buildings; heavy (3 t) machine tools moved and badly damaged; very heavy (12 000 lb. / 5443 kg) machine tools survived. |
| 300 | 2070 | Limit of crater lip. |

**Table 5-3: Damage caused by overpressure effects of an explosion (Stephens 1970)**

| Equipment | Overpressure (psi) | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0.5** | **1** | **1.5** | **2** | **2.5** | **3** | **3.5** | **4** | **4.5** | **5** | **5.5** | **6** | **6.5** | **7** | **7.5** | **8** | **8.5** | **9** | **9.5** | **10** | **12** | **14** | **16** | **18** | **20** |
| Control house steel roof | A | C | V | | | | N | | | | | | | | | | | | | | | | | | |
| Control house concrete roof | A | E | P | D | | | N | | | | | | | | | | | | | | | | | | |
| Cooling tower | B | | | F | | | O | | | | | | | | | | | | | | | | | | |
| Tank: cone roof | | D | | | | K | | | | | | | U | | | | | | | | | | | | |
| Instrument cubicle | | | A | | | LM | | | | | | T | | | | | | | | | | | | | |
| Fire heater | | | | G | I | | | | | T | | | | | | | | | | | | | | | |
| Reactor: chemical | | | | A | | | | I | | | | P | | | | | | T | | | | | | | |
| Filter | | | | H | | | | | F | | | | | | | | | V | | | T | | | | |
| Regenerator | | | | | | I | | | | IP | | | | | T | | | | | | | | | | |
| Tank: floating roof | | | | | | K | | | | | | | U | | | | | | | | | | | | D |
| Reactor: cracking | | | | | | | I | | | | | | | I | | | | | | | T | | | | |
| Pine supports | | | | | | | P | | | | | SO | | | | | | | | | | | | | |
| Utilities: gas meter | | | | | | | | | Q | | | | | | | | | | | | | | | | |
| Utilities: electric transformer | | | | | | | | | H | | | | | I | | | | | | T | | | | | |
| Electric motor | | | | | | | | | | H | | | | | | | | I | | | | | | | V |
| Blower | | | | | | | | | | Q | | | | | | | | | | T | | | | | |
| Fractionation column | | | | | | | | | | | R | | | T | | | | | | | | | | | |
| Pressure vessel horizontal | | | | | | | | | | | | PI | | | | | | T | | | | | | | |
| Utilities: gas regulator | | | | | | | | | | | | I | | | | | | | | MQ | | | | | |
| Extraction column | | | | | | | | | | | | | I | | | | | | | V | T | | | | |
| Steam turbine | | | | | | | | | | | | | | | I | | | | | | M | S | | | V |
| Heat exchanger | | | | | | | | | | | | | | | I | | | T | | | | | | | |
| Tank sphere | | | | | | | | | | | | | | | | I | | | | | | I | T | | |
| Pressure vessel vertical | | | | | | | | | | | | | | | | | | | | | I | T | | | |
| Pump | | | | | | | | | | | | | | | | | | | | | I | | Y | | |

| | |
|---|---|
| A | Windows and gauges break |
| B | Louvers fall at 0.3–0.5 psi |
| C | Switchgear is damaged from roof collapse |
| D | Roof collapses |
| E | Instruments are damaged |
| F | Inner parts are damaged |
| G | Bracket cracks |
| H | Debris-missile damage occurs |
| I | Unit moves and pipes break |
| J | Bracing fails |
| K | Unit uplifts (half filled) |
| L | Power lines are severed |
| M | Controls are damaged |
| N | Block wall fails |
| O | Frame collapses |
| P | Frame deforms |
| Q | Case is damaged |
| R | Frame cracks |
| S | Piping breaks |
| T | Unit overturns or is destroyed |
| U | Unit uplifts (0.9 filled) |
| V | Unit moves on foundations |

#### *5.2.3.1 Vapour Cloud Explosions (VCEs)*

The release of a flammable component into the atmosphere could result in formation of a flash fire, as described in the subsection on flash fires, or a vapour cloud explosion (VCE). In the case of a VCE, an ignited vapour cloud between the higher explosive limits (HEL) and the lower explosive limit (LEL) could form a fireball with overpressures that could result in injury or damage to property.

#### *5.2.3.2 Boiling Liquid Expanding Vapour Explosions (BLEVEs)*

A boiling liquid expanding vapour explosion (BLEVE) can occur when a flame impinges on a pressure cylinder, particularly in the vapour space region where cooling by evaporation of the contained material does not occur; the cylinder shell would weaken and rupture with a total loss of the contents, and the issuing mass of material would burn as a massive fireball.

The major consequences of a BLEVE are \ intense thermal radiation from the fireball, a blast wave and propelled fragments from the shattered vessel. These fragments may be projected to considerable distances. Analyses of the travel range of fragment missiles from a number of BLEVEs suggest that the majority land within 700 m from the incident. A blast wave from a BLEVE is fairly localised but can cause significant damage to immediate equipment.

A BLEVE occurs sometime after the vessel has been engulfed in flames. Should an incident occur that could result in a BLEVE, people should be evacuated to beyond the 1% fatality line.

## 5.3 Risk Analysis

### 5.3.1 Background

It is important to understand the difference between hazard and risk.

A hazard is anything that has the potential to cause damage to life, property and the environment. Furthermore, it has constant parameters (like those of petrol, chlorine, ammonia, etc.) that pose the same hazard wherever present.

On the other hand, risk is the probability that a hazard will actually cause damage, and goes along with how severe that damage will be (consequence). Risk is therefore the probability that a hazard will manifest itself. For instance, the risks of a chemical accident or spill depends upon the amount present, the process the chemical is used in, the design and safety features of its container, the exposure, the prevailing environmental and weather conditions and so on.

Risk analysis consists of a judgement of probability based on local atmospheric conditions, generic failure rates and severity of consequences, based on the best available technological information.

Risks form an inherent part of modern life. Some risks are readily accepted on a day-to-day basis, while certain hazards attract headlines even when the risk is much smaller, particularly in the field of environmental protection and health. For instance, the risk of one-in-ten-thousand chance of death per year associated with driving a car is acceptable to most people, whereas the much lower risks associated with nuclear facilities (one-in-ten-million chance of death per year) are deemed unacceptable.

A report by the British Parliamentary Office of Science and Technology (POST), entitled ‘Safety in Numbers? Risk Assessment and Environmental Protection’, explains how public perception of risk is influenced by a number of factors in addition to the actual size of the risk. These factors were summarised as follows in Table 5-4.

**Table 5-4: Influence of public perception of risk on acceptance of that risk, based on the POST report**

| | |
|---|---|
| **Control** | People are more willing to accept risks they impose upon themselves or they consider to be ‘natural’ than to have risks imposed upon them. |
| **Dread and Scale of Impact** | Fear is greatest where the consequences of a risk are likely to be catastrophic rather than spread over time. |
| **Familiarity** | People appear more willing to accept risks that are familiar rather than new risks. |
| **Timing** | Risks seem to be more acceptable if the consequences are immediate or short term, rather than if they are delayed (especially if they might affect future generations). |
| **Social Amplification and Attenuation** | Concern can be increased because of media coverage, graphic depiction of events or reduced by economic hardship. |
| **Trust** | A key factor is how far the public trusts regulators, policy makers or industry; if these bodies are open and accountable (being honest as well as admitting mistakes and limitations and taking account of differing views without disregarding them as emotive or irrational), then the public is more likely consider them credible. |

A risk assessment should be seen as an important component of ongoing preventative action, aimed at minimising or hopefully avoiding accidents. Re-assessments of risks should therefore follow at regular intervals and after any changes that could alter the nature of the hazard, so contributing to an overall prevention programme and emergency response plan of the facility. Risks should be ranked with decreasing severity and the top risks reduced to acceptable levels.

Procedures for predictive hazard evaluation have been developed for the analysis of processes when evaluating very low probability accidents with very high consequences (for which there is little or no experience), as well as more likely releases with fewer consequences (for which there may be more information available). These addresses both the probability of an accident, as well as the magnitude and nature of undesirable consequences of that accident. Risk is usually defined as some simple function of both the probability and consequence.

### 5.3.2 Predicted Risk

Physical and consequence modelling addresses the impact of a release of a hazardous component without taking into account probability of occurrence. This merely illustrates the significance and the extent of the impact in the event of a release. Modelling should also analyse cascading or knock-on effects due to incidents in the facility and the surrounding industries and suburbs.

During a risk analysis, the likelihood of various incidents is assessed, the consequences calculated and finally the risk for the facility is determined.

### 5.3.3 Generic Equipment Failure Scenarios

Because of the coarse nature of this study and the general lack of detailed information, only major failures of equipment were included, and pig receiver, pump / compressor and transport scenarios such as road tanker failures were not included due to their effects likely being surpassed by those of the larger vessels on-site. Unless otherwise stated, analysis was completed using published failure rate data (RIVM 2009). Equipment failures can occur in tanks, pipelines and other items handling hazardous chemical components. These failures may result in:

Release of combustible, flammable and explosive components with fires or explosions upon ignition;

Release of toxic or asphyxiant components.

#### *5.3.3.1 Storage Vessels*

Scenarios involving storage vessels can include catastrophic failures that would lead to leakage into the bund with a possible bund fire. The fracture of a nozzle or transfer pipeline could also result in leakage into the bund.

Typical failure frequencies for atmospheric and pressure vessels are listed, respectively, in Table 5-5 and Table 5-6.

**Table 5-5: Failure frequencies for atmospheric vessels**

| Event | Leak Frequency (per item per year) |
|---|---|
| Small leaks | $1 \times 10^{-4}$ |
| Severe leaks | $3 \times 10^{-5}$ |
| Catastrophic failure | $5 \times 10^{-6}$ |

**Table 5-6: Failure frequencies for pressure vessels**

| Event | Failure Frequency (per item per year) |
|---|---|
| Small leaks | $1 \times 10^{-5}$ |
| Severe leaks | $5 \times 10^{-7}$ |
| Catastrophic failure | $5 \times 10^{-7}$ |

#### *5.3.3.2 Process Piping*

Piping may fail as a result of corrosion, erosion, mechanical impact damage, pressure surge (water hammer) or operation outside the design limitations for pressure and temperature. Failures caused by corrosion and erosion usually result in small leaks, which are easily detected and corrected quickly. For significant failures, the leak duration may be from 10 – 30 minutes before detection.

Generic data for leak frequency for process piping is generally expressed in terms of the cumulative total failure rate per year for a 10 m section of pipe for each pipe diameter.

Furthermore, failure frequency normally decreases with increasing pipe diameter. Scenarios and failure frequencies for a pipeline apply to pipelines with connections, such as flanges, welds and valves.

The failure data given in Table 5-7 represents the total failure rate, incorporating all failures of whatever size and due to all probable causes. These frequencies are based on an assumed environment where no excessive vibration, corrosion, erosion or thermal cyclic stresses are expected. For incidents causing significant leaks (such as corrosion), the failure rate will be increased by a factor of 10.

**Table 5-7: Failure frequencies for process pipes**

| Description | Frequencies of Loss of Containment for Process Pipes (per meter per year) | |
|---|---|---|
| | Full Bore Rupture | Leak |
| Nominal diameter < 75 mm | $1x10^{-6}$ | $5x10^{-6}$ |
| 75 mm < nominal diameter < 150 mm | $3x10^{-7}$ | $2x10^{-6}$ |
| Nominal diameter > 150 mm | $1x10^{-7}$ | $5x10^{-7}$ |

#### *5.3.3.3 Ignition Probability of Flammable Gases and Liquids*

Estimation of probability of an ignition is a key step in assessment of risk for installations where flammable liquids or gases are stored. There is a reasonable amount of data available relating to characteristics of ignition sources and effects of release type and location.

Probability of ignition for stationary installations, is given in Table 5-8 (along with classification of flammable substances in Table 5-9). These can be replaced with ignition probabilities related to surrounding activities. For example, probability of a fire from a flammable release at an open flame would increase to a value of 1.

**Table 5-8: Probability of direct ignition for stationary installations (RIVM 2009)**

| Substance Category | Source-Term Continuous | Source-Term Instantaneous | Probability of Direct Ignition |
|---|---|---|---|
| Category 0<br>Average to high reactivity | < 10 kg/s<br>10 – 100 kg/s<br>> 100 kg/s | < 1000 kg<br>1000 – 10 000 kg<br>> 10 000 kg | 0.2<br>0.5<br>0.7 |
| Category 0<br>Low reactivity | < 10 kg/s<br>10 – 100 kg/s<br>> 100 kg/s | < 1000 kg<br>1000 – 10 000 kg<br>> 10 000 kg | 0.02<br>0.04<br>0.09 |
| Category 1 | All flow rates | All quantities | 0.065 |
| Category 2 | All flow rates | All quantities | 0.0043[1] |
| Category 3<br>Category 4 | All flow rates | All quantities | 0 |

1 This value is taken from the CPR 18E (Purple Book; 1999). RIVM (2009) gives the value of delayed ignition as zero. RISCOM (PTY) LTD believes the CPR 18E is more appropriate for warmer climates and is a conservative value.

While methane is considered a low reactive gas, the impurities in natural gas will make the nature gas an average reactive gas.

**Table 5-9: Classification of flammable substances**

| Substance Category | Description | Limits |
|---|---|---|
| Category 0 | Extremely flammable | Liquids, substances and preparations that have a flashpoint lower than 0°C and a boiling point (or the start of the boiling range) less than or equal to 35°C Gaseous substances and preparations that may ignite at normal temperature and pressure when exposed to air. |
| Category 1 | Highly flammable | Liquids, substances and preparations that have a flashpoint of below 21°C. |
| Category 2 | Flammable | Liquids, substances and preparations that have a flashpoint equal to 21°C and less than 55°C. |
| Category 3 | | Liquids, substances and preparations that have a flashpoint greater than 55°C and less than or equal to 100°C. |
| Category 4 | | Liquids, substances and preparations that have a flashpoint greater than 100°C. |

# 6 RISK CALCULATIONS

## 6.1 Maximum Individual Risk Parameter

Standard individual risk parameters include: average individual risk; weighted individual risk; maximum individual risk; and, the fatal accident rate. The lattermost parameter is more applicable to occupational exposures.

Only the maximum individual risk (MIR) parameter will be used in this assessment. For this, parameter frequency of fatality is calculated for an individual who is presumed to be present at a specified location. This parameter (defined as the consequence of an event multiplied by the likelihood of the event) is not dependent on knowledge of populations at risk. So, it is an easier parameter to use in the predictive mode than average individual risk or weighted individual risk. The unit of measure is the risk of fatality per person per year.

### 6.1.1 Acceptable Risks

The next step, after having characterised a risk and obtained a risk level, is to recommend whether the outcome is acceptable.

In contrast to the employees at a facility, who may be assumed to be healthy, the adopted exposure assessment applies to an average population group that also includes sensitive sub-populations. Sensitive sub-population groups are those people that for reasons of age or medical condition have a greater than normal response to contaminants. Health guidelines and standards used to establish risk, normally incorporate safety factors that address this group.

Among the most difficult tasks of risk characterisation is the definition of acceptable risk. In an attempt to account for risks in a manner similar to those used in everyday life, the UK Health and Safety Executive (HSE) developed the risk ALARP triangle. Applying the triangle involves deciding:

Whether a risk is so high that something must be done about it;

Whether the risk is or has been made so small that no further precautions are necessary;

If a risk falls between these two states so that it has been reduced to levels as low as reasonably practicable (ALARP).

This is illustrated in Figure 6-1.

ALARP stands for ‘as low as reasonably practicable’. As used in the UK, it is the region between that which is intolerable, at $1x10^{-4}$ per year, and that which is broadly acceptable, at $1x10^{-6}$ per year. A further lower level of risk, at $3x10^{-7}$ per year, is applied to either vulnerable or very large populations for land-use planning.

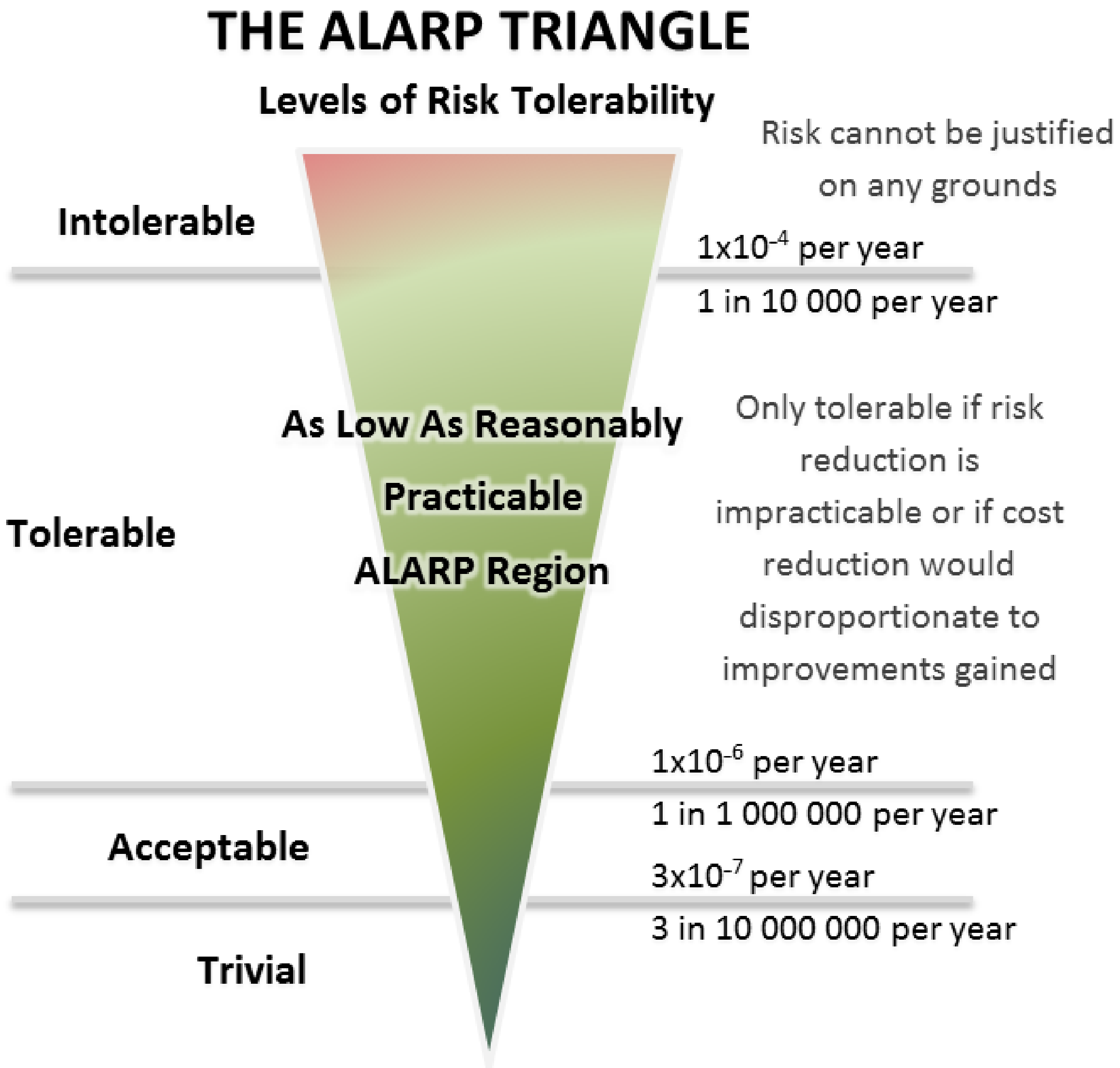



**Figure 6-1: UK HSE decision-making framework**

It should be emphasised that the risks considered acceptable to employees are different to those considered acceptable to the public. This is due to the fact that employees have personal protection equipment (PPE), are aware of the hazards, are sufficiently mobile to evade or escape the hazards and receive training in preventing injuries.

The HSE (UK) gives more detail on the word practicable in the following statement:

" *In essence, making sure a risk has been reduced to ALARP is about weighing the risk against the sacrifice needed to further reduce it. The decision is weighted in favour of health and safety because the presumption is that the duty-holder should implement the risk reduction measure. To avoid having to make this sacrifice, the duty-holder must be able to show that it would be grossly disproportionate to the benefits of risk reduction that would be achieved. Thus, the process is not one of balancing the costs and benefits of measures but, rather, of adopting measures except where they are ruled out because they involve grossly disproportionate sacrifices. Extreme examples might be:*

- *To spend £1m to prevent five staff members suffering bruised knees is obviously grossly disproportionate; but,*
- *To spend £1m to prevent a major explosion capable of killing 150 people is obviously proportionate.*

*Proving ALARP means that if the risks are lower than $1x10^{-4}$ fatalities per person per year, it can be demonstrated that there would be no more benefit from further mitigation, sometimes using cost benefit analysis.* "

### 6.1.2 Land Planning

There are no legislative land-planning guidelines in South Africa and in many parts of the world. Further to this, land-planning guidelines vary from one country to another, and thus it is not easy to benchmark the results of this study to international criteria. In this instance, RISCOM would only advise on applicable land planning and would require governmental authorities to make final decisions.

Land zoning applied in this study follows the HSE (UK) approach of defining the area affected into three zones, consistent to the ALARP approach (HSE 2011).

The three zones are defined as follows:

The inner zone is enclosed by the risk of $1x10^{-5}$ fatalities per person per year isopleth;
The middle zone is enclosed by the risk of $1x10^{-5}$ fatalities per person per year and the risk of $1x10^{-6}$ fatalities per person per year isopleths;
The outer zone is enclosed by the risk $1x10^{-6}$ fatalities per person per year and the risk of $3x10^{-7}$ fatalities per person per year isopleths.

The risks decrease from the inner zone to the outer zone, as shown in Figure 6-2 and Figure 6-3.

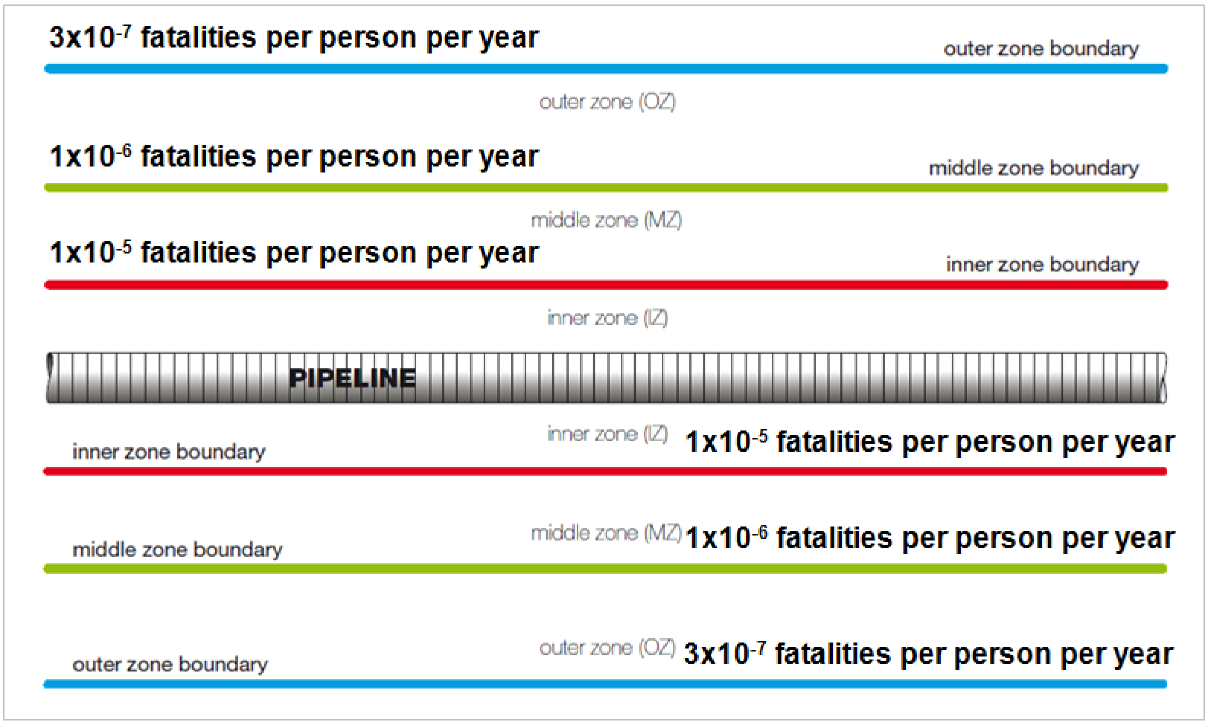



**Figure 6-2: Town-planning zones for pipelines**

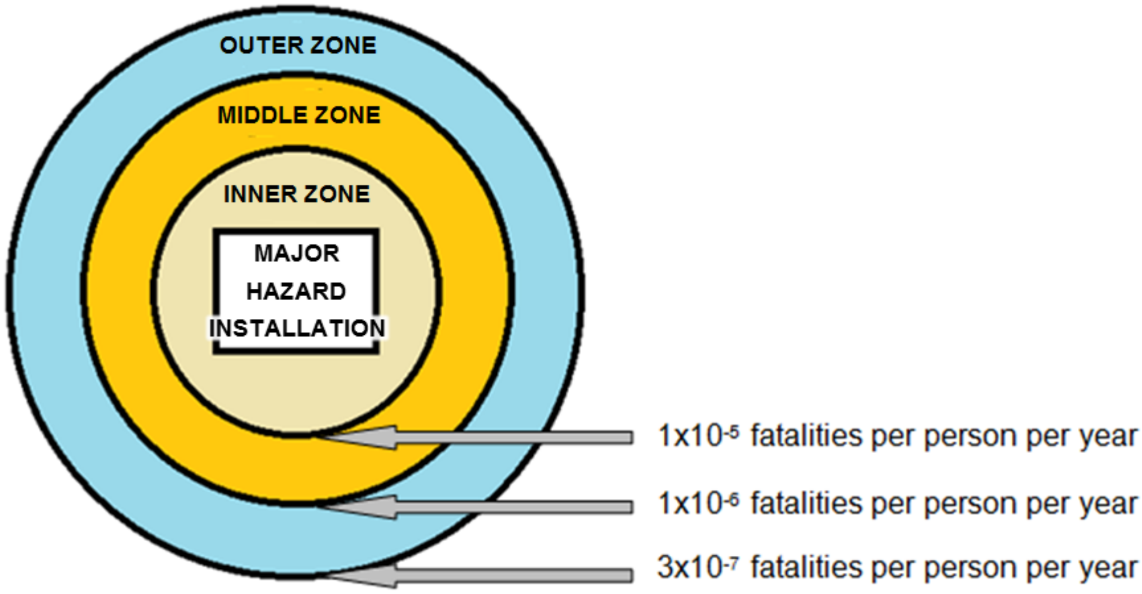



**Figure 6-3: Town-planning zones**

Once the zones are calculated, the HSE (UK) methodology then determines whether a development in a zone should be categorised as ‘advised against’ (AA) or as ‘don’t advise against’ (DAA), depending on the sensitivity of the development, as indicated in Table 6-1. There are no land-planning restrictions beyond the outer zone.

**Table 6-1: Land-use decision matrix**

| Level of Sensitivity | Development in Inner Zone | Development in Middle Zone | Development in Outer Zone |
|---|---|---|---|
| 1 | DAA | DAA | DAA |
| 2 | AA | DAA | DAA |
| 3 | AA | AA | DAA |
| 4 | AA | AA | AA |

The sensitivity levels are based on a clear rationale: progressively more severe restrictions are to be imposed as the sensitivity of the proposed development increases.

There are four sensitivity levels, with the sensitivity for housing defined as follows:

Level 1 is based on workers who have been advised of the hazards and are trained accordingly;

Level 2 is based on the general public at home and involved in normal activities;

Level 3 is based on the vulnerability of certain members of the public (e.g., children, those with mobility difficulties or those unable to recognise physical danger);

Level 4 is based on large examples of Level 2 and of Level 3.

Refer to Appendix E for detailed planning advice for developments near hazardous installations (PADHI) tables. These tables illustrate how the HSE land-use decision matrix, generated using the three zones and the four sensitivity levels, is applied to a variety of development types.

## 6.2 Quantitative Risk Assessment (QRA) Scenarios

### 6.2.1 Methodology

Due to the absence of South African legislation regarding determination methodology for quantitative risk assessment (QRA), the methodology of this assessment is based on the legal requirements of the Netherlands, outlined in CPR 18E (Purple Book; 1999) and RIVM (2009).

The evaluation of the acceptability of the risks is done in accordance with the Health and Safety Executive (HSE; UK) ALARP criteria, which clearly covers land use, based on the determined risks.

The QRA process is summarised with the following steps:

1. Identification of components that are flammable, toxic, reactive or corrosive and that have potential to result in a major incident from fires, explosions or toxic releases;
2. Development of accidental loss of containment (LOC) scenarios for equipment containing hazardous components (including release rate, location and orientation of release);
3. For each incident developed in Step 2, determination of consequences (such as thermal radiation, domino effects, toxic-cloud formation and so forth);
4. For scenarios with off-site consequences (greater than 1% fatality off-site), calculation of maximum individual risk (MIR), taking into account all generic failure rates, initiating events (such as ignition), meteorological conditions and lethality.

Scenarios included in this QRA have impacts external to the establishment. The 1% fatality from acute affects (thermal radiation, blast overpressure and toxic exposure) is determined as the endpoint (RIVM 2009). Thus, a scenario producing a fatality of less than 1% at the establishment boundary under worst-case meteorological conditions would be excluded from the QRA.

### 6.2.2 Scenario Selection

Guidelines for selection of scenarios is given in RIVM (2009) and CPR 18E (Purple Book; 1999). A particular scenario may produce more than one major consequence. In such cases, consequences are evaluated separately and assigned failure frequencies in the risk analysis. Some of these phenomena are described in the subsections that follow.

#### *6.2.2.1 Continuous Release of a Flammable Gas*

The continuous loss of containment of a flammable gas could result in the consequences, given in the event tree of Figure 6-4. Probability of the events occurring is dependent on a number of factors and is determined accordingly. All the scenarios shown in the figure are determined separately and reported in relevant sub-sections of the report.

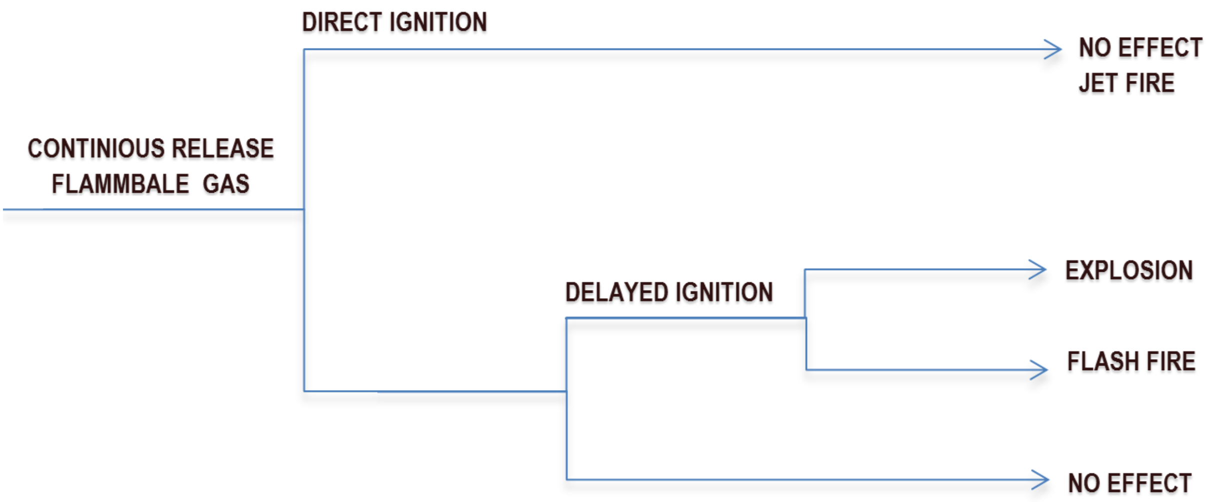



**Figure 6-4: Event tree for a continuous release of a flammable gas**

#### *6.2.2.2 Release of a Flammable Liquid*

The loss of containment of a flammable liquid could result in the consequences, given in the event tree of Figure 6-5. Probability of the events occurring is dependent on a number of factors and is determined accordingly. All the scenarios shown in the figure are determined separately and reported in relevant subsections of the report.

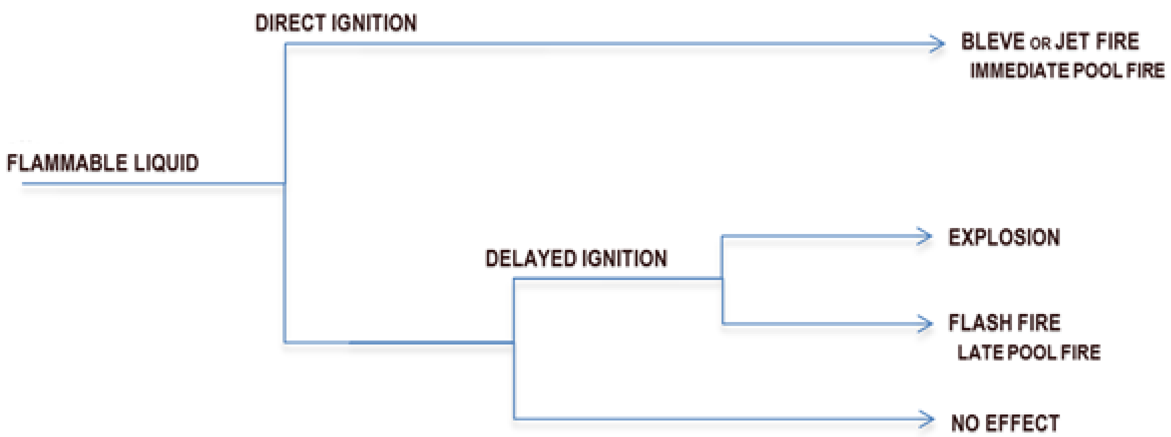



**Figure 6-5: Event tree for a continuous release of a flammable liquid**

# 7 RISK ASSESSMENT

A risk assessment was done of each processing unit by firstly selecting a scenario and then completing consequence and outflow modelling. Consequences with possible impacts beyond the site boundary were retained for risk analysis of the unit.

Finally, the risk of the entire facility is determined as a combination of the risk calculated for each unit.

## 7.1 Power Plant

### 7.1.1 The Purpose of the Processing Unit

LNG would be received from road tankers and stored in 7 x 300 $m^3$ cryogenic tanks. The LNG from the storage will be regasified before being transported to the gensets.

### 7.1.2 Hazardous Components

Methane rich gas (MRG) and LNG will be transported and stored on site. Both these components consist mostly of methane, a flammable gas, as described in Section 4.3.

### 7.1.3 Consequence Modelling

The scenarios modelled for the NGEPP fuels and chemical installations, are listed Table 7-1. Some of these scenarios are discussed further in the sections below.

**Table 7-1: Scenarios modelled**

| Equipment | Scenarios Modelled | Potential Consequences | Comments/assumptions |
|---|---|---|---|
| Sasol gas pipeline | • Failure<br>• Leak | • Jet fires<br>• Flash fires<br>• VCE | • Pressure: 8 Bar(g)<br>• Volume flow rate: 23 000$m^3$/h<br>• Pipeline diameter: 150 mm |
| LNG storage | • Catastrophic failure<br>• Overfill<br>• 10 Minute release<br>• 10 mm Hole | • Pool fire<br>• Flash fires<br>• VCE | • 7x 300 $m^3$ storage<br>• Temp: -162ºC<br>• Press atmospheric<br>• Area of release:33 m x 36m<br>• Overfill protection failure: SIL-2 |
| LNG road tanker | • Tanker failure<br>• Hose failure<br>• Hose leak | • Pool fire<br>• Flash fires<br>• VCE | • 1 Offloading bays<br>• Max tanker size: 37 $m^3$<br>• Area of release: 1200 $m^2$<br>• Frequency 65 days per year |
| LNG offloading pumps | • Pump failure<br>• Pump leak | • Pool fire<br>• Flash fires<br>• VCE | • Pump capacity: 100 $m^3$/h<br>• Pump head: 10 bar |
| Pipeline to storage | • Pipeline failure<br>• Pipeline leak | • Pool fire<br>• Flash fires<br>• VCE | • Pipeline diameter: 50 mm<br>• Pipeline pressure: 10 bar |
| Vaporiser | • Catastrophic failure<br>• 10 mm Hole | • Jet fire<br>• Flash fires<br>• Vapour cloud explosion (VCE) | • Temperature =5ºC<br>• Pressure = 2.7bar(g)<br>• Volume flow rate: 23 000$m^3$/h |

#### *7.1.3.1 Gas Pipeline*

The methane rich gas / natural gas would be transported via a pipeline to the gensets. A large release from the pipeline could result in a flash fire or a jet fire. The maximum effects to the 1% fatality from the loss of containment events, is shown in Figure 7-1. The coloured lines represent a leak in an easterly orientation, while the black line indicates the extent from all directions.

In the event of a large release, jet fires could result in damage to nearby equipment and under worst cases, fatalities beyond the site boundary into the Karbochem complex to the west and into the space occupied by the general public. However, impacts will not extend to residential areas.

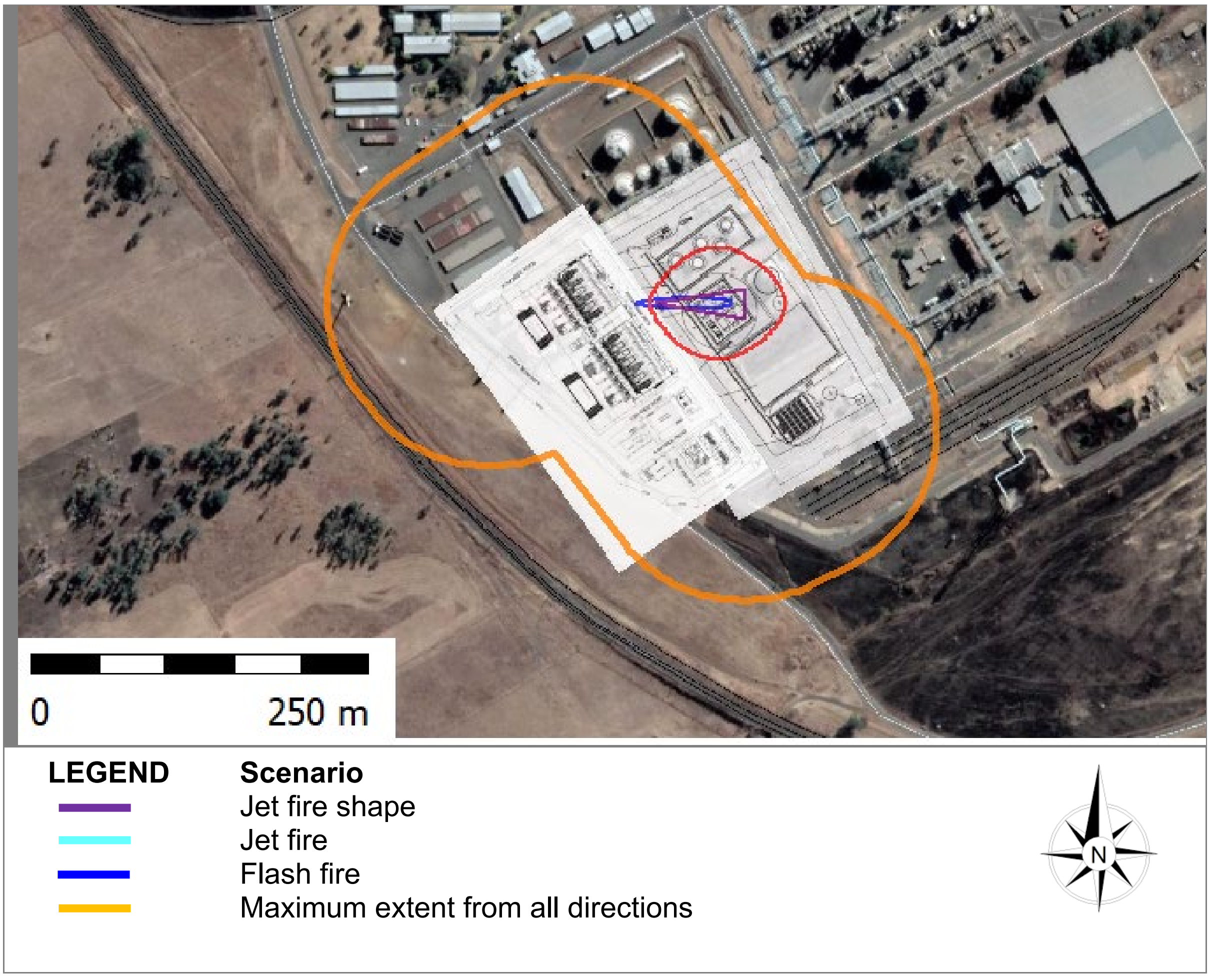



**Figure 7-1: The maximum extent to the 1% fatality from a full-bore failure of the gas pipeline**

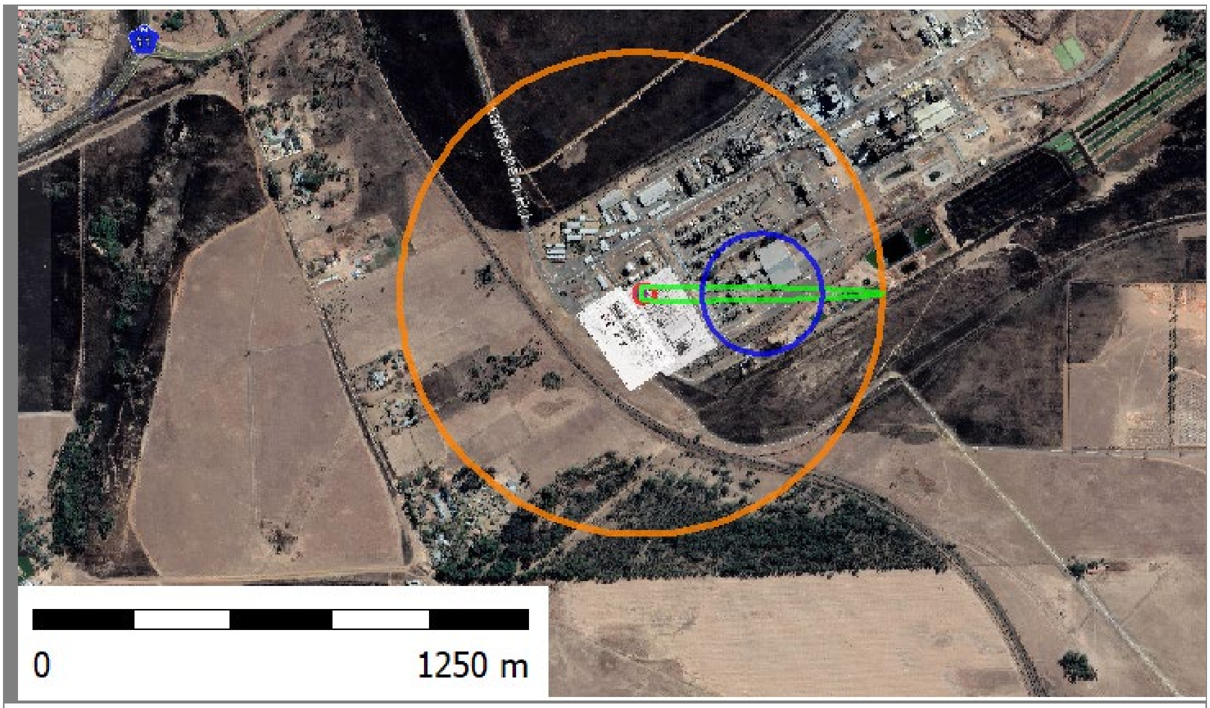
#### *7.1.3.2 LNG Offloading*

The LNG from ISO Containers will be received to replenish the LNG in the storage tanks. It is assumed that there would be a single LNG ISO Container every 10 days.

The maximum extent to the 1% fatality will occur from a loss of containment of a 37 $m^3$ road tanker at low wind speeds, as shown in Figure 7-2. The coloured lines show the maximum extent of the potential effects from a westerly wind direction, while the orange curve indicates the maximum extent from all wind directions.

In this case, the flash fire explosion determines the maximum extent to the 1% fatality. The VCE overpressure for the 1% fatality is equal to 0.1 bar overpressure, that would result in mild damage to the neighbouring property, including damage to the walls and roof.

The impacts from a vapour cloud explosion could result in damage to the LNG storage vessels and piping, that could result in a knock-on effect. However, good engineering of the LNG storage vessels can minimise such events.




**LEGEND** **Scenario**

- Pool fire shape
- Pool fire
- Flash fire
- VCE
- Maximum extent from all directions

N

**Figure 7-2: The maximum extent to the 1% fatality from a catastrophic failure of a 37$m^3$ road tanker**

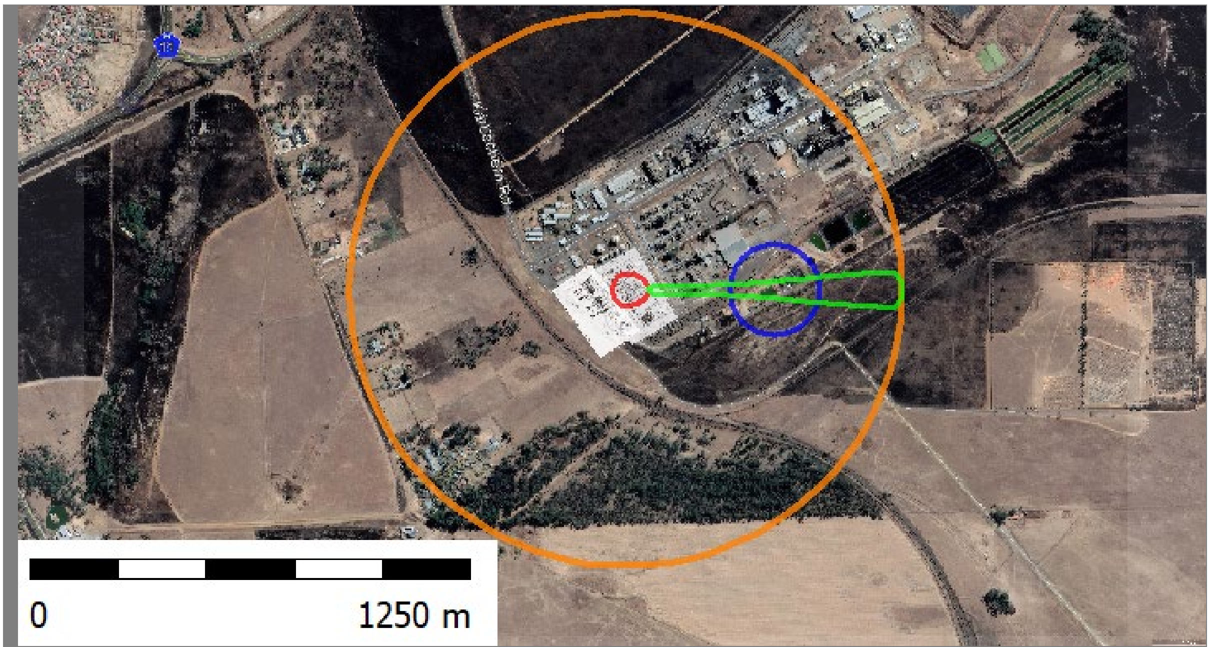
#### *7.1.3.3 LNG Storage*

The LNG will be stored in a maximum of 7 x 300 m$^3$ cryogenic tanks. A loss of containment was assumed to be contained in a 65 x 26.4 m$^2$ area below the storage vessels.

The maximum extent to the 1% fatality will occur from a release of the entire contents of 300 m$^3$ LNG storage tank over 10 minutes, as shown in Figure 7-3. The coloured lines show the maximum extent of the potential effects from a westerly wind direction, while the orange curve indicates the maximum extent from all wind directions.

In this case, the flash fire dominates the impacts and determines the maximum extent to the 1% fatality. People in the open, within the flash fire, are assumed to suffer fatal injuries. The VCE overpressure for the 1% fatality is equal to 0.1 bar overpressure, that would result in mild damage to the neighbouring property, including damage to the walls and roof.

The maximum extent of the 1% fatality could extend beyond the site boundary and into the airport property, but would not reach the runway. Impacts could extend into the farmsteads from the west, but would not extend into the residential areas.




| LEGEND | Scenario |
|---|---|
| (cyan line) | Pool fire shape |
| (red line) | Pool fire |
| (green line) | Flash fire |
| (blue line) | VCE |
| (orange line) | Maximum extent from all directions |

N

**Figure 7-3: The maximum extent to the 1% fatality from a failure of an LNG storage tank.**

#### *7.1.3.4 LNG Vaporisers*

Little detail has been provided regarding the vaporiser, with the exception of the flow rate, temperature and pressure. The worst-case assumptions were made in this instance, and expect the impacts from a vaporiser failure to be less than predicted in this section. The assumptions for the simulations are provided in Section 7.1.3.

The maximum extent to the 1% fatality will occur from a catastrophic failure of the failure of the inlet to the vaporiser at the inlet process conditions, as shown in Figure 7-4. The coloured lines show the maximum extent of the potential effects from a westerly wind direction, while the orange curve indicates the maximum extent from all wind directions.

In this case the vapour cloud explosions determine the maximum extent to the 1% fatality. People in the open, within the flash fire, are assumed to suffer fatal injuries. The VCE overpressure for the 1% fatality is equal to 0.1 bar overpressure, that would result in mild damage to the neighbouring property, including damage to the walls and roof.

The maximum extent of the 1% fatality could extend beyond the site boundary, but would not impact residential areas.

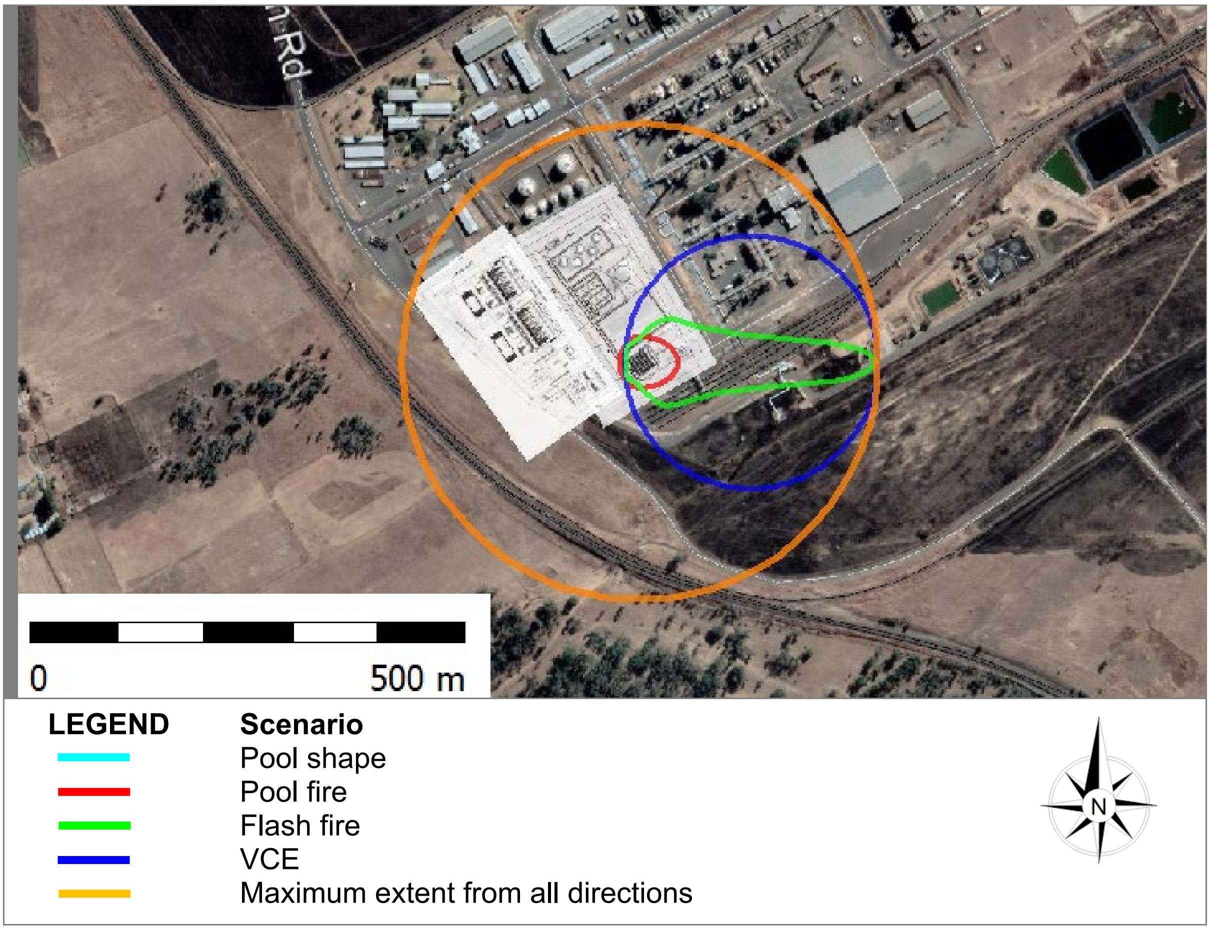



**Figure 7-4: The maximum extent to the 1% fatality from a catastrophic failure of a vaporiser**

#### *7.1.3.5 Summary of Impacts*

Maximum distances from the point of release to the 1% fatality, are summarised for each scenario in Table 7-2.

**Table 7-2: Maximum distance to 1% fatality from the point of release**

| Scenarios | Max. Distance to 1% Fatality (m) |
|---|---|
| **LNG ISO Container Offloading** | |
| LNG ISO Container - Catastrophic failure | 296 |
| LNG ISO Container - Fixed duration leak | 607 |
| LNG ISO Container hose - Failure Set | 5 |
| LNG ISO Container hose - Leak | 5 |
| LNG Offloading pump - Failure | 55 |
| LNG Offloading pump - Leak | 5 |
| | |
| **LNG Storage** | |
| LNG storage - Catastrophic failure | 348 |
| LNG storage - Fixed duration | 780 |
| LNG Storage -10 mm Hole | 11 |
| LNG Storage - Overfill | 0 |
| | |
| **Natural Gas Pipeline to Gensets** | |
| Pipeline - Failure | 112 |
| Pipeline -- Leak | 0 |
| | |
| **Vaporiser** | |
| LNG Vaporiser - Failure | 272 |
| LNG Vaporiser - Single tube failure | 32 |

### 7.1.4 Maximum Individual Risk

#### *7.1.4.1 Sasol Gas Pipeline*

The Sasol pipeline will primary be used for the fuel to the gensets, except for an unexpected loss of supply. The pipeline, from the Sasol gas supply at the western part of the site, will transport methane rich gas to the gensets. The risk of $1 \times 10^{-6}$ fatalities per person per year isopleth, due to a release of the Sasol gas, extended beyond the site boundary, as shown in Figure 7-5 and would **classify the NGEPP as a Major Hazard Installation** As a result, the risks to the public from a release of Sasol gas, would be considered tolerable.

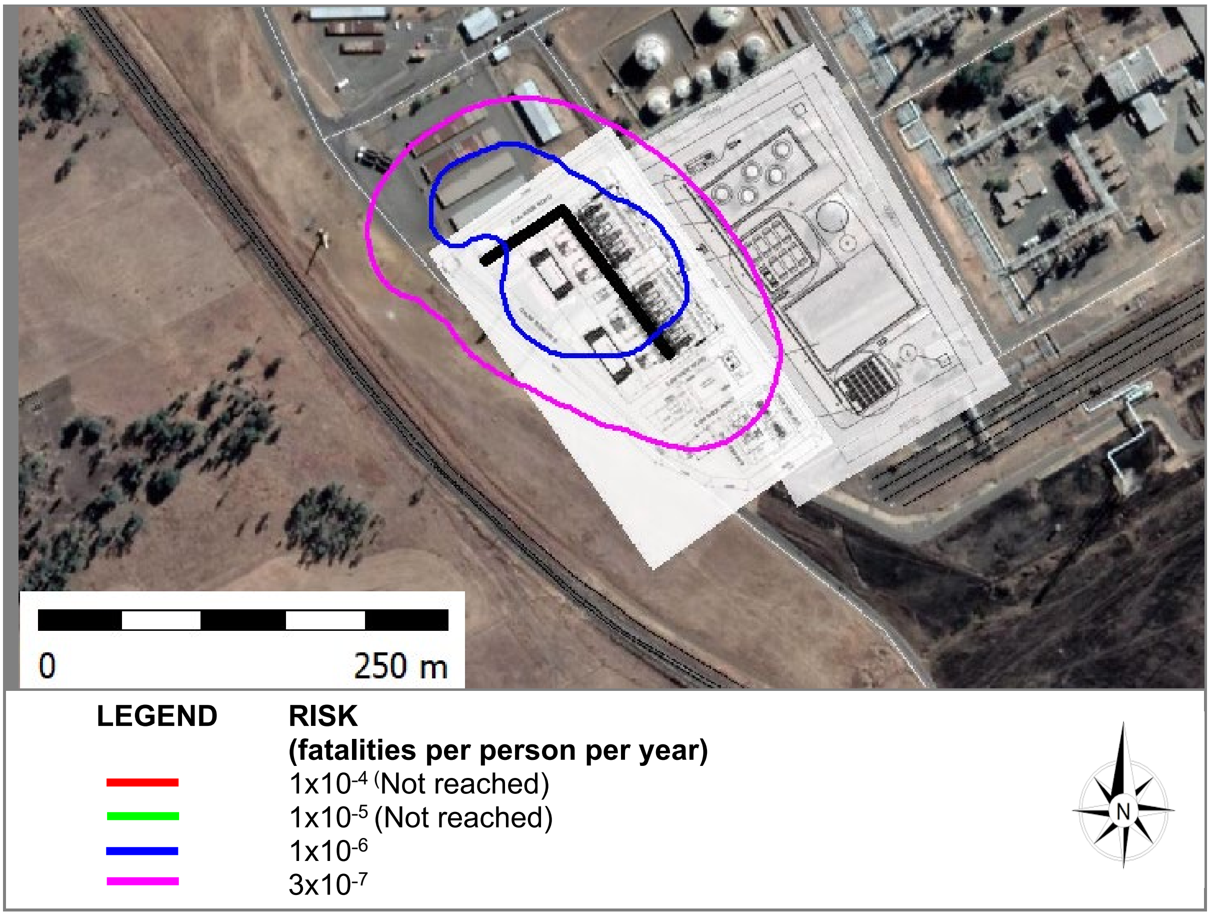
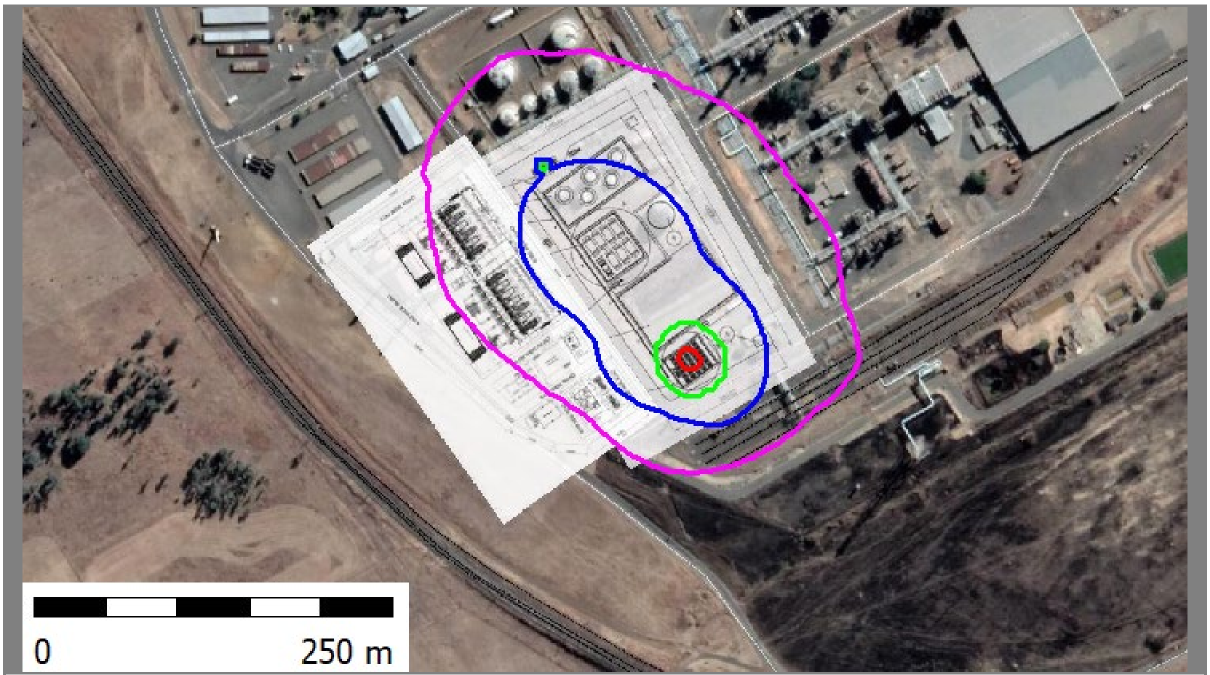



**Figure 7-5 Lethal probability isopleth associated with the loss of containment of the pipeline transporting Sasol gas from the take-off point to gensets**

#### *7.1.4.2 LNG Installation*

The LNG installation consists of the offloading gantry, storage, vaporisers pumps and pipelines.

The risk of $1 \times 10^{-6}$ fatalities per person per year isopleth, due to a release of flammable LNG, extends beyond the Karbochem Industrial Complex site boundary into the to the NGEPP facility, as shown in Figure 7-6. This alone will **classify the Karbochem Industrial Complex as a Major Hazard Installation.** The risk from fires and explosions from the LNG installation on site would be considered tolerable.




| LEGEND | RISK (fatalities per person per year) |
|---|---|
| red line | $1 \times 10^{-4}$ |
| green line | $1 \times 10^{-5}$ |
| blue line | $1 \times 10^{-6}$ |
| magenta line | $3 \times 10^{-7}$ |

**Figure 7-6: Lethal probability isopleth associated with the flammable component X installation**

#### *7.1.4.3 Combined Project Risk*

The combined project risk is the summation of all the individual risks with installations on the Karbochem Industrial Complex as well as on the NGEPP is shown in Figure 7-7.

The combined risk of 1x10$^{-6}$ fatalities per person per year isopleth extends beyond the site boundaries of the Karbochem Industrial Complex as well as on the NGEPP and **would classify both the Karbochem Industrial Complex and the NGEPP facilities as Major Hazard Installations**

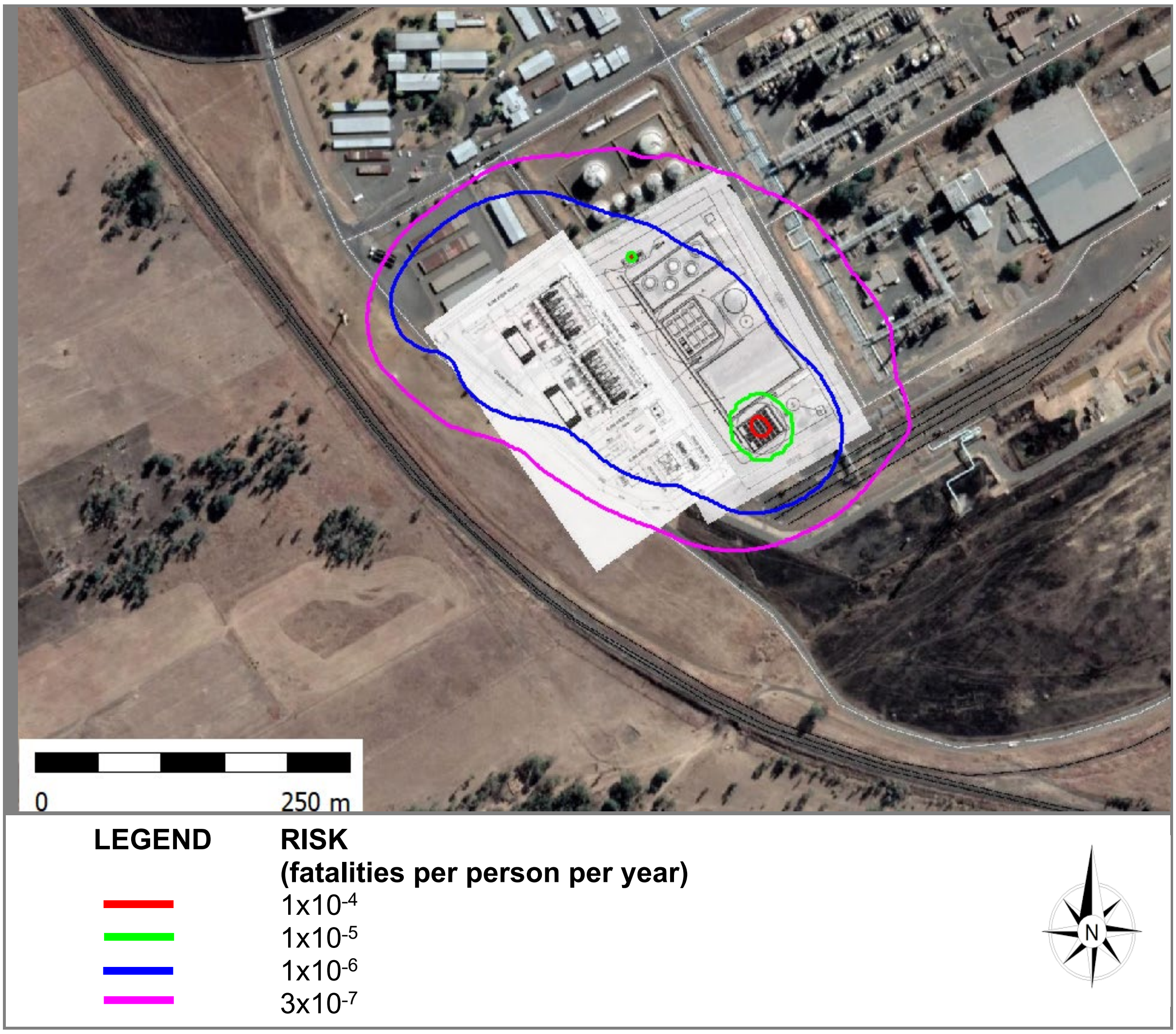



**Figure 7-7: Lethal probability isopleth associated with the project**

Risks greater than 1x10$^{-4}$ fatalities per person per year, considered tolerable for industrial areas but excessive for residential areas, would not extend beyond the project boundary.

The risk of 3x10$^{-7}$ fatalities per person per year isopleth indicates the extent for land-use that would be suitable for vulnerable populations, such as hospitals, retirement homes, nursery schools, prisons, large gatherings in the open, and so forth. As ,no vulnerable people are within the 3x10$^{-7}$ fatalities per person per year isopleth, the project risks would be considered acceptable and with the category ***Do Not Advise Against.***

#### 7.1.5 Risk Ranking

This risk assessment considered numerous scenarios, determining both consequences and a probability of release. Some scenarios have more serious consequences than others. However, the scenarios of particular interest are those with high-risk frequencies extending beyond the boundary of the site.

Figure 7-8 illustrates the comparison of the $1 \times 10^{-6}$ fatalities per person per year isopleth for the various site installations. The red curve represents the total site risk, while the other installations are shown in other colours. The individual risk would remain within the site boundary. However, the combined site boundary would extend beyond the site boundary.

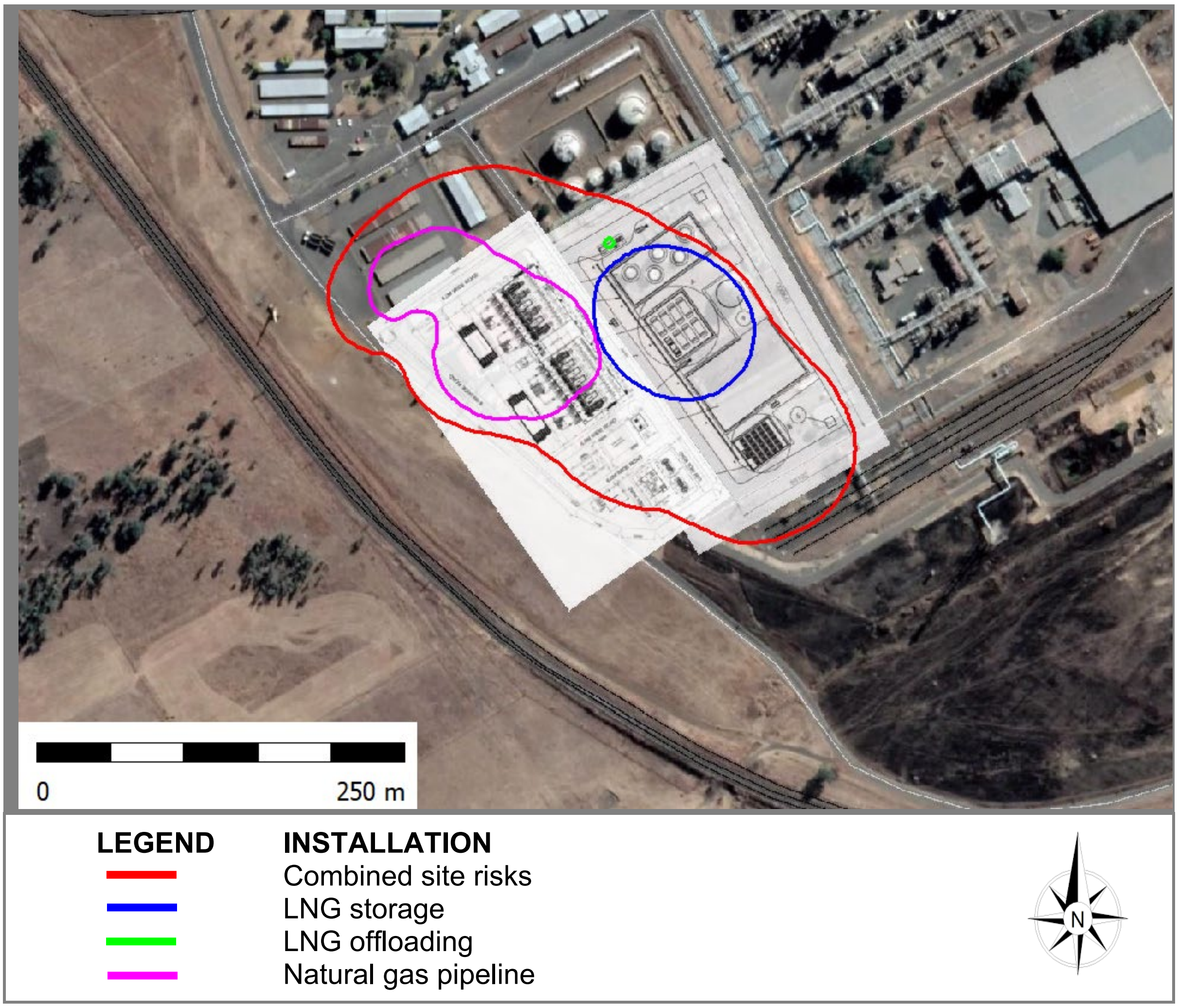



**Figure 7-8: Comparison of the $1 \times 10^{-6}$ fatalities per person per year isopleth for various site installations**

# 8 IMPACT ASSESSMENT

## 8.1 Impact Assessment Methodology

### 8.1.1 Assessment of Potential Impacts

The methodology to be utilised to assess and rank each of the potential environmental impacts and risks identified, has been formulated to comply with the scope of assessment and content of EIA.

Reports as specified in Appendix 3 of the Amended 2014 EIA Regulations (refer to item 3(j) of Appendix 3 in Government Notice R326).

The required scope of assessment is provided in the box below:

> 3. An environmental impact assessment report must contain the information that is necessary for the competent authority to consider and come to a decision on the application, and must include –…………
> (j) an assessment of each identified potentially significant impact and risk, including –
> (ii) cumulative impacts;
> (iii) the nature, significance and consequences of the impact and risk;
> (iv) the extent and duration of the impact and risk;
> (v) the probability of the impact and risk occurring;
> (vi) the degree to which the impact and risk can be reversed;
> (vii) the degree to which the impact and risk may cause irreplaceable loss of resources; and
> (viii) the degree to which the impact and risk can be avoided, managed or mitigated;

In line with the requirements outlined in the box above, each potentially significant impact/risk identified must be assessed in terms of the following:

- **Nature** (description): will the impact have a positive or negative outcome on the biophysical and/or social environment?
- **Extent** (spatial scale): will the impact affect the national, regional or local environment, or only that of the site?
- **Duration** (temporal scale): how long will the impact last?
- **Magnitude** (severity): will the impact be of high, moderate or low severity?
- **Probability** (likelihood of occurring): how likely is it that the impact may occur? The impact assessment is to be based on sound validated scientific information and professional judgement in the context of the specific project and site conditions. To enable a scientific approach for the determination of the environmental consequence and significance (importance) of each identified potential impact, a numerical value must be linked to each factor. The ranking scales below are applicable.

### 8.1.2 Ranking Scales

| | | |
|---|---|---|
| **Occurrence** | **Duration:** | **Probability:** |
| | 5 – Permanent | 5 – Definite/don't know |
| | 4 - Long-term (ceases with the operational life) | 4 – Highly probable |
| | 3 - Medium-term (5-15 years) | 3 – Medium probability |
| | 2 - Short-term (0-5 years) | 2 – Low probability |
| | 1 – Immediate | 1 – Improbable |
| | | 0 – None |
| **Severity** | **Extent/scale:** | **Magnitude:** |
| | 5 – International | 10 - Very high/uncertain |
| | 4 – National | 8 – High |
| | 3 – Regional | 6 – Moderate |
| | 2 – Local | 4 – Low |
| | 1 – Site only | 2 – Minor |

Each potential impact identified must be ranked in terms of the above ranking scales and the environmental consequence and significance of each impact calculated using the following formula:

**Risk** = Consequence x Probability
**Consequence** = Duration + Extent + Magnitude
**Significance** = (Duration + Extent + Magnitude) x Probability

The environmental significance of each identified potential impact must then be rated as follows:

| Significance Rating | Score |
|---|---|
| High | > 60 – 100 |
| Moderate | 30 – 60 |
| Low | < 30 - 0 |

### 8.1.3 Reversibility

In order to assess the degree to which the potential impact can be managed and /or mitigated, each impact is to be assessed twice, as follows:

- Firstly, the potential impact is to be assessed and rated prior to implementing any mitigation and management measures.
- Secondly, the potential impact is to be assessed and rated after the proposed mitigation and management measures have been implemented. The purpose of this dual rating of the impact is to enable comparison of the pre- and post- mitigation significance ratings and to calculate the percentage change, which indicates the degree to which the impact may be avoided, managed, mitigated and /or reversed.

### 8.1.4 Irreplaceable Loss

In order to assess the degree to which the potential impact could cause irreplaceable Loss of Resources (LoR), one of the following classes (%) is to be selected based on the specialist's informed decision:

| | |
|---|---|
| 5 | 100% - permanent loss |
| 4 | 75% - 99% - significant loss |
| 3 | 50% - 74% - moderate loss |
| 2 | 25% - 49% - minor loss |
| 1 | 0% - 24% - limited loss |

The Loss of Resources aspect should not affect the overall significance rating of the impact.

## 8.2 Impact Assessment of NGEPP Gas to Power Facility

The impact of the chlorine installation is assessed as follows in Table 8-1:

**Table 8-1: Assessment of potential incidents**

| Scenario | Mitigation | Impact description | Nature | Extent | Duration | Magnitude | Probability | Significance | Irreplaceable Loss |
|---|---|---|---|---|---|---|---|---|---|
| | | a | b | c | d | e | f | =(e+c+d) *f | |
| Loss of containment of methane rich gas | 1. Pipeline design specifications<br>2. Limited mechanical damage due to routing away from vehicles | Loss of containment under pressure resulting in jet fires and explosions | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 2-Low | 34 Moderate | 4-Significant loss |
| | Instrumentation including detection and emergency Shut down | | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 1 – Improbable | 17 - Low | 4-Significant loss |
| LNG Iso Container failure | Designed to specific standards | Loss of containment under pressure resulting in fires and explosions | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 2-Low | 34 Moderate | 4-Significant loss |
| | 1. Pipeline design specifications<br>2. Limited mechanical damage due to routing away from vehicles | | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 1 – Improbable | 17 - Low | 4-Significant loss |
| LNG pipeline- failure | 1. Pipeline design specifications<br>2. Limited mechanical damage due to routing away from vehicles | Loss of containment resulting in fires and explosions<br>Loss of containment resulting in fires and explosions | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 2-Low | 34 Moderate | 4-Significant loss |
| | Instrumentation including detection and emergency Shut down | | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 1 – Improbable | 17 - Low | 4-Significant loss |

| Scenario | Mitigation | Impact description | Nature | Extent | Duration | Magnitude | Probability | Significance | Irreplaceable Loss |
|---|---|---|---|---|---|---|---|---|---|
| | | a | b | c | d | e | f | =(e+c+d) *f | |
| LNG Storage | 1. Bunded area<br>2. Pressure vessel with PSV | Loss of containment resulting in fires and explosions | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 2-Low | 34 Moderate | 4-Significant loss |
| | Emergency shut down systems | Loss of containment resulting in fires and explosions | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 1 – Improbable | 17 - Low | 4-Significant loss |
| LNG Vaporisers | Pressure vessel with PSV | Loss of containment resulting in fires and explosions | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 2-Low | 34 Moderate | 4-Significant loss |
| | Instrumentation including detection and emergency Shut down | Loss of containment resulting in fires and explosions | Negative | 2- Local | 5-Permanent - due to fatalities | 10 Very high - due to fatalities | 1 – Improbable | 17 - Low | 4-Significant loss |

# 9 CONCLUSIONS

Risk calculations are not precise. Accuracy of predictions is determined by the quality of base data and expert judgements.

This risk assessment included the consequences of fires and explosions as well as toxic releases at the NGEPP gas to power facility in Newcastle. A number of well-known sources of incident data were consulted and applied to determine the likelihood of an incident to occur.

This risk assessment was performed with the assumption that the site would be maintained to an acceptable level and that all statutory regulations would be applied. It was also assumed that the detailed engineering designs would be done by competent people and would be correctly specified for the intended duty. For example, it was assumed that tank wall thicknesses have been correctly calculated, that vents have been sized for emergency conditions, that instrumentation and electrical components comply with the specified electrical area classification, that material of construction is compatible with the products, etc.

It is the responsibility of the owners and their contractors to ensure that all engineering designs would have been completed by competent persons and that all pieces of equipment would have been installed correctly. All designs should be in full compliance with (but not limited to) the Occupational Health and Safety Act 85 of 1993 and its regulations, the National Buildings Regulations and the Buildings Standards Act 107 of 1977 as well as local by-laws.

A number of incident scenarios were simulated, taking into account the prevailing meteorological conditions, and described in the report.

The following installations were considered for analysis in the QRA:

- Sasol methane rich gas;
- LNG.

## 9.1 Limitations and Assumptions

The risk assessment was developed based on the information provided by NGEPP, and its engineering suppliers. These designs are conceptual and does not include detailed designs, which will be completed before construction. Thus, some information, as required by the risk assessment simulations, were assumed and based on similar installations. However, it is assumed that the relatively large storage tanks, will determine the endpoints from a release and will be the major contributor towards the risks generated. To this end the results obtained in this report may lack the accuracy of a detailed engineered plant. However, the risk generated are expected to represent the facility, provided the vessel size and inventory are not increased.

Part of the risk assessment is within the Karbochem Industrial Complex and thus this risk assessment was limited to the area LNG installation and did not other facilities within the Karbochem Industrial Complex. Should the project proceed, the risk assessment for the Karbochem Industrial Complex should be reviewed, as required by law.

## 9.2 Notifiable Substances

The General Machinery Regulation 8 and its Schedule A on notifiable substances, requires any employer who has a substance equal to or exceeding the quantity listed in the regulation to notify the divisional director. A site is classified as a Major Hazard Installation if it contains one or more notifiable substances or if the off-site risk is sufficiently high. The latter can only be determined from a quantitative risk assessment.

Methane (compressed) is listed as a notifiable substance at a threshold value of 15 t stored in a single vessel. As the LNG is not a compressed gas, LNG will not be classified as notifiable substance.

## 9.3 Sasol Gas

The Sasol gas would be the main source of energy to the NGEPP gas to power facility in Newcastle and would be supplied to gensets at approximately 8 bar(g). A loss of containment could result in las fires, jet fires and explosions. The maximum damage would result from large jet fires that could extend beyond the site boundary, but would not reach residential or vulnerable populations.

## 9.4 LNG Installation

The LNG installation consisting of ISO Container offloading storage, regasifier / vaporiser with associated pumping and pipelines transporting the LNG to the gensets.

The maximum extent from a large release of LNG at the storage area, could extend over 1 km downwind to the 1% fatality.

The risk of $1x10^{-6}$ fatalities per person per year isopleth, would extend beyond the Karbochem Industrial Complex site boundary, and **that alone qualifies the Karbochem Industrial Complex as a Major Hazard Installation.** The risks from the LNG facility would not impact any residential areas or vulnerable populations.

The risks to the public would be within the ALARP range and considered tolerable to the general public.

## 9.5 Impacts onto Neighbouring Properties and Residential Areas

While the large releases can extend just over 940 m downwind from the release. Large releases would mostly be within the Karbochem Industrial Complex, but could extend into the airfield to the north.

Residential vulnerable populations would not be impacted from this development.

The risks of the installation would be within a short distance of the NGEPP and would not impact the airfield to the north, nor vulnerable facilities. Thus, the risks to the public from the development of the NGEPP would be considered tolerable.

### 9.6 Major Hazard Installation

This investigation concluded that under typical design conditions, assuming conservative design options and inventories, the proposed power plant **could be considered as a Major Hazard Installation**, depending on the hazardous chemicals used on site as well as the layout of the power station. Furthermore, the risks of the LNG installation alone would classify the **Karbochem Industrial Complex as a Major Hazardous Installation**

**This study is not intended to replace the Major Hazard Installation risk assessment which should be completed prior to construction of the facility**.

# 10 RECOMMENDATIONS

RISCOM did not find any fatal flaws with the proposed NGEPP that would prevent the project proceeding to the detailed engineering phase of the project.

RISCOM would support the project with the following conditions:

- Compliance with all statutory requirements, i.e., pressure vessel designs;
- Compliance with applicable SANS codes, i.e., SANS 1461, SANS 10087, SANS 10089, SANS 10108, etc.;
- Incorporation of applicable guidelines or equivalent international recognised codes of good design and practice into the designs;
- Completion of a recognised process hazard analysis (such as a HAZOP study, FMEA, etc.) on the proposed facility prior to construction to ensure design and operational hazards have been identified and adequate mitigation put in place;
- Full compliance with IEC 61508 and IEC 61511 (Safety Instrument Systems) standards or equivalent to ensure that adequate protective instrumentation is included in the design and would remain valid for the full life cycle of the tank farm:
  - Including demonstration from the designer that sufficient and reliable instrumentation would be specified and installed at the facility;
- Preparation and issue of a safety document detailing safety and design features reducing the impacts from fires, explosions and flammable atmospheres to the MHI assessment body at the time of the MHI assessment:
  - Including compliance to statutory laws, applicable codes and standards and world's best practice;
  - Including the listing of statutory and non-statutory inspections, giving frequency of inspections;
  - Including the auditing of the built facility against the safety document;
  - Noting that codes such as IEC 61511 can be used to achieve these requirements;
- Demonstration by NGEPP or their contractor that the final designs would reduce the risks posed by the installation to internationally acceptable guidelines;
- Signature of all terminal designs by a professional engineer registered in South Africa in accordance with the Professional Engineers Act, who takes responsibility for suitable designs;
- Completion of an emergency preparedness and response document for on-site and off-site scenarios prior to initiating the MHI risk assessment (with input from local authorities);
- Permission not being granted for increases to the product list or product inventories without redoing part of or the full EIA;
- The Karbochem Industrial Complex must review the MHI requirements with regards to the new LNG installation, as required by the MHI regulation
- Final acceptance of the facility risks with an MHI risk assessment that must be completed in accordance to the MHI regulations:
  - Basing such a risk assessment on the final design and including engineering mitigation.

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## 12 ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **AAV** | **Air vaporizing units** use the relative "heat" of the **atmosphere** to derive the energy necessary for the **vaporization** of the liquid cryogen. **Ambient vaporizers** represent the most cost-effective equipment to vaporize or re-gasify liquid cryogens. ... Energy sources utilized are Steam, and externally sourced Hot Water. |
| **AIA** | See **Approved Inspection Authority** |
| **ALARP** | The UK Health and Safety Executive (HSE) developed the risk **ALARP** triangle, in an attempt to account for risks in a manner similar to those used in everyday life. This involved deciding:<br>Whether a risk is so high that something must be done about it;<br>Whether the risk is or has been made so small that no further precautions are necessary;<br>Whether a risk falls between these two states and has been reduced to levels '**as low as reasonably practicable'** (ALARP).<br>Reasonable practicability involves weighing a risk against the trouble, time and money needed to control it. |
| **Approved Inspection Authority** | An **approved inspection authority** (AIA) is defined in the Major Hazard Installation regulations (July 2001) |
| **ASME** | **ASME** code – also known as **ASME** Boiler & Pressure Vessel Code or BPVC – is the standard that regulates the design, development and construction of boilers and pressure vessels utilized in a variety of industries. |
| **Asphyxiant** | An **asphyxiant** is a gas that is nontoxic but may be fatal if it accumulates in a confined space and is breathed at high concentrations since it replaces oxygen containing air. |
| **Blast Overpressure** | **Blast overpressure** is a measure used in the multi-energy method to indicate the strength of the blast, indicated by a number ranging from 1 (for very low strengths) up to 10 (for detonative strength). |
| **BLEVE** | **Boiling liquid expanding vapour explosions** result from the sudden failure of a vessel containing liquid at a temperature above its boiling point. A **BLEVE** of flammables results in a large fireball. |
| **CNG** | **Compressed natural gas** (**CNG**) (methane stored at high pressure) is a fuel that can be used in place of gasoline, diesel fuel and liquefied petroleum gas (LPG). CNG combustion produces fewer undesirable gases than the aforementioned fuels. In comparison to other fuels, natural gas poses less of a threat in the event of a spill, because it is lighter than air and disperses quickly when released. Biomethane — refined biogas from anaerobic digestion or landfills — can be used. |
| **Detonation** | **Detonation** is a release of energy caused by extremely rapid chemical reaction of a substance, in which the reaction front of a substance is determined by compression beyond the auto-ignition temperature. |
| **EIA** | **Environmental assessment** is the assessment of the environmental consequences of a plan, policy, program, or actual projects prior to the decision to move forward with the proposed action. |
| **Emergency Plan** | An **emergency plan** is a plan in writing that describes how potential incidents identified at the installation together with their consequences should be dealt with, both on site and off site. |

| | |
|---|---|
| **Explosion** | An **explosion** is a release of energy that causes a pressure discontinuity or blast wave. |
| **Flammable Limits** | **Flammable limits** are a range of gas or vapour concentrations in the air that will burn or explode if a flame or other ignition source is present. The lower point of the range is called the lower flammable limit (LFL). Likewise, the upper point of the range is called the upper flammable limit (UFL). |
| **Flammable Liquid** | The Occupational Health and Safety Act 85 of 1993 defines a **flammable liquid** as any liquid which produces a vapour that forms an explosive mixture with air and includes any liquid with a closed cup flashpoint of less than 55°C.<br>Flammable products have been classified according to their flashpoints and boiling points, which ultimately determine the propensity to ignite. Separation distances described in the various codes are dependent on the flammability classification.<br>**Class Description**<br>0 Liquefied petroleum gas (LPG)<br>IA Liquids that have a closed cup flashpoint of below 23°C and a boiling point below 35°C<br>IB Liquids that have a closed cup flashpoint of below 23°C and a boiling point of 35°C or above<br>IC Liquids that have a closed cup flashpoint of 23°C and above but below 38°C<br>II Liquids that have a closed cup flashpoint of 38°C and above but below 60.5°C<br>IIA Liquids that have a closed cup flashpoint of 60.5°C and above but below 93°C |
| **Flash Fire** | A **flash fire** is defined as combustion of a flammable vapour and air mixture in which the flame passes through the mixture at a rate less than sonic velocity so that negligible damaging overpressure is generated. |
| **FMEA** | **Failure mode and effects analysis** is the process of reviewing as many components, assemblies, and subsystems as possible to identify potential failure modes in a system and their causes and effects |
| **Frequency** | **Frequency** is the number of times an outcome is expected to occur in a given period of time. |
| **HAZOP** | A hazard and operability study (HAZOP) is a structured and systematic examination of a complex planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment. |
| **HEL** | The highest concentration of a gas or vapor (percentage by volume in air) above which a flame will not spread in the presence of an ignition source (arc, flame, or heat). Concentrations higher than UEL are “too rich” to burn. Also called upper flammable limit (UFL). |
| **IBL** | Definition of in battery limits. A battery limit is a defined boundary between two areas of responsibility, which may be physical (e.g. a flange on a pipe); or represented by a map coordinate; or some other means (for example a point in time). Battery limits in a 'distributed' project are described in a blog article. |
| **Ignition Source** | An **ignition source** is a source of temperature and energy sufficient to initiate combustion. |

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|---|---|
| **Individual Risk** | **Individual risk** is the probability that in one year a person will become a victim of an accident if the person remains permanently and unprotected in a certain location. Often the probability of occurrence in one year is replaced by the frequency of occurrence per year. |
| **IPP** | **Independent Power Producers** (IPPs) or non-utility generator (NUG) are private entities (under unbundled market), which own and or operate facilities to generate **electricity** and then sell it to a utility, central government buyer and end users. |
| **ISO Container** | An **intermodal container**, often called a shipping container, is a large standardized shipping container, designed and built for intermodal freight transport, meaning these containers can be used across different modes of transport – from ship to rail to truck – without unloading and reloading their cargo. |
| **Isopleth** | See **Risk Isopleth** |
| **Jet** | A **jet** is the outflow of material emerging from an orifice with significant momentum. |
| **Jet Fire or Flame** | A **jet fire or flame** is combusting material emerging from an orifice with a significant momentum. |
| **LC** | **Lethal concentration** is the concentration by which a given percentage of the exposed population will be fatally injured. The $LC_{50}$ refers to the concentration of airborne material the inhalation of which results in death of 50% of the test group. The period of inhalation exposure could be from 30 min to a few hours (up to 4 hours). |
| **LEL** | **Lower Explosive Limit**, is defined as the **lowest** concentration (by percentage) of a gas or vapor in air that is capable of producing a flash of fire in presence of an ignition source (arc, flame, heat). ... In concentrations of 0-5% Methane in air, the mixture is too lean to ignite or burn. |
| **LFL** | **Lower Flammable Limit** see Flammable Limits |
| **LNG** | **Liquefied natural gas** (LNG) is natural gas (predominantly methane, CH4, with some mixture of ethane, C2H6) that has been cooled down to liquid form for ease and safety of non-pressurized storage or transport. |
| **LOC** | See **Loss of Containment** |
| **Local Government** | **Local government** is defined in Section 1 of the Local Government Transition Act, 1993 (Act No. 209 of 1993). |
| **LoR** | **Resource** depletion is the consumption of a resource faster than it can be replenished. Resource depletion is most commonly used in reference to farming, fishing, mining, water usage, and consumption of fossil fuels. |
| **Loss of Containment** | **Loss of containment** (LOC) is the event resulting in a release of material into the atmosphere. |
| **Major Hazard Installation** | **Major Hazard Installation** (MHI) means an installation:<br>Where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily;<br>Where any substance is produced, used, handled or stored in such a form and quantity that it has the potential to cause a major incident (the potential of which will be determined by the risk assessment). |
| **Major Incident** | A **major incident** is an occurrence of catastrophic proportions, resulting from the use of plant or machinery or from activities at a workplace.<br>When the outcome of a risk assessment indicates that there is a possibility that the public will be involved in an incident, then the incident is catastrophic. |

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| **Material Safety Data Sheet** | According to ISO-11014, a **material safety data sheet** (MSDS) is a document that contains information on the potential health effects of exposure to chemicals or other potentially dangerous substances and on safe working procedures when handling chemical products. It is an essential starting point for the development of a complete health and safety program. It contains hazard evaluations on the use, storage, handling and emergency procedures related to that material. An MSDS contains much more information about the material than the label and it is prepared by the supplier. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure and what to do if such incidents occur. |
| **MHI** | See **Major Hazard Installation** |
| **MIR** | **Maximum Individual Risk** (see Individual Risk) |
| **MRG** | The MRG® (**Methane Rich Gas**) process is low-temperature steam reforming technology that can convert hydrocarbons (such as LPG or naphtha), methanol or DME into methane. This process is applied to town gas production, or the pre-reforming step of synthesis gas production for GTL etc. |
| **MSDS** | See **Material Safety Data Sheet** |
| **MW** | A **megawatt** is a unit for measuring power that is equivalent to one million **watts**. One **megawatt** is equivalent to the energy produced by 10 automobile engines. A **megawatt** hour (Mwh) is equal to 1,000 Kilowatt hours (Kwh). It is equal to 1,000 kilowatts of electricity used continuously for one hour. |
| **MWe** | **Megawatts electric** or **MWe** is one of the two values assigned to a power plant, the other being megawatts thermal or MWt. Megawatts electric refers to the electricity output capability of the plant, and megawatts thermal refers to the input energy required |
| **NEMA** | 107 of 1998, abbreviated NEMA) is the statutory framework to enforce Section 24 of the Constitution of the Republic of South Africa. The NEMA is intended to promote co-operative governance and ensure that the rights of people are upheld, but also recognising the necessity of economic development. |
| **NGEPP** | **Newcastle Gas Engine Power Plant** |
| **OBL** | **Outside Battery Limits** (OSBL) is defined as utilities, common facilities, and other equipment and components not included in the ISBL definition. OSBL refers to systems (equipment pieces and associated components) that support several units |
| **OHS Act** | **Occupational Health and Safety Act**, 1993 (Act No. 85 of 1993) |
| **PAC** | See **Protective Action Criteria** |
| **PADHI** | **PADHI** (**planning advice for developments near hazardous installations**) is the name given to a methodology and software decision support tool developed and used in the HSE. It is used to give land-use planning (LUP) advice on proposed developments near hazardous installations.<br>PADHI uses two inputs into a decision matrix to generate either an ‘advise against’ or ‘don’t advise against’ response:<br>The zone in which the development is located of the three zones that HSE sets around the major hazard: |

| | |
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| | The inner zone (> $1x10^{-5}$ fatalities per person per year);<br>The middle zone ($1x10^{-5}$ fatalities per person per year to $1x10^{-6}$ fatalities per person per year);<br>The outer zone ($1x10^{-6}$ fatalities per person per year to $3x10^{-7}$ fatalities per person per year);<br>The ‘sensitivity level’ of the proposed development which is derived from an HSE categorisation system of ‘development types’ (see the ‘development type tables’ in Appendix E). |
| **POST** | **The Parliamentary Office of Science and Technology** is the Parliament of the United Kingdom's in-house source of independent, balanced and accessible analysis of public policy issues related to science and technology. |
| **PPE** | **Personal protective equipment**, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses. |
| **Protective Action Criteria** | **Protective action criteria** (PAC) for emergency planning of chemical release events are based on the following chemical exposure limit values:<br>Acute exposure guideline level (AEGL) values published by the US Environmental Protection Agency (EPA);<br>Emergency response planning guideline (ERPG) values produced by the American Industrial Hygiene Association (AIHA);<br>Temporary emergency exposure limit (TEEL) values developed by the Subcommittee on Consequence Assessment and Protective Actions (SCAPA). |
| **PSV** | **Pressure Safety Valve** or **pressure relief valve** is a type of safety valve used to control or limit the pressure in a system; pressure might otherwise build up and create a process upset, instrument or equipment failure, or fire. |
| **QRA** | See **Quantitative Risk Assessment** |
| **Quantitative Risk Assessment** | A **quantitative risk assessment** is the process of hazard identification, followed by a numerical evaluation of effects of incidents, both consequences and probabilities and their combination into the overall measure of risk. |
| **Risk** | **Risk** is the measure of the consequence of a hazard and the frequency at which it is likely to occur. Risk is expressed mathematically as:<br>**Risk = Consequence x Frequency of Occurrence** |
| **Risk Assessment** | **Risk assessment** is the process of collecting, organising, analysing, interpreting, communicating and implementing information in order to identify the probable frequency, magnitude and nature of any major incident which could occur at a major hazard installation and the measures required to remove, reduce or control potential causes of such an incident. |
| **RM** | **Risk mitigation** involves taking action to reduce an organization's exposure to potential **risks** and reduce the likelihood that those **risks** will happen again. |
| **SANAS** | **South African National Accreditation System** |
| **Temporary Installation** | A **temporary installation** is an installation that can travel independently between planned points of departure and arrival for the purpose of |

| | |
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| | transporting any substance and which is only deemed to be an installation at the points of departure and arrival, respectively. |
| **UFL** | **Upper Flammable Limit** (see Flammable Limits) |
| **Vapour Cloud Explosion** | A **vapour cloud explosion** (VCE) results from ignition of a premixed cloud of a flammable vapour, gas or spray with air, in which flames accelerate to sufficiently high velocities to produce significant overpressure. |

# 13 APPENDIX A: DECLARATION OF THIRD-PARTY INDEPENDENCE

4.2 The specialist appointed in terms of the Regulations.

I, Michael Paul Oberholzer declare that -- General declaration:
I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Riscom (Pty) Ltd

Name of company (if applicable):

30 October 2020

Date:

# 14 APPENDIX B: DEPARTMENT OF LABOUR CERTIFICATE

labour

Department:
Labour
REPUBLIC OF SOUTH AFRICA

National Department of Labour
Republic of South Africa

## *APPROVED INSPECTION AUTHORITY*

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

This is to certify that:

**RISCOM (PTY) LTD**

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

CONDITIONS OF REGISTRATION:

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

**CHIEF INSPECTOR**

Valid from: **27 May 2017**
Expires: **26 May 2021**
Certificate Number: **CI MHI 0005**

# 15 APPENDIX C: SANAS CERTIFICATES

sanas
South African National
Accreditation System

## CERTIFICATE OF ACCREDITATION

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

**RISCOM (PTY) LTD**
**Co. Reg. No.: 2002/019697/07**
**JOHANNESBURG**

Facility Accreditation Number: **MHI0013**

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 17020:2012**

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: 27 May 2017**
**Certificate Expires: 26 May 2021**

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

# 16 APPENDIX D: NOTIFICATION OF MAJOR HAZARD INSTALLATION

Prior to assessment of potential impacts of various accidental spills, reference needs to be made to the legislation, regulations and guidelines governing the operation of the development.

Section 1 of the Occupational Health and Safety Act (OHS Act; Act No. 85 of 1993) defines a "major hazard installation" to mean an installation:

" (a) *Where more than the prescribed quantity of any substance is or may be kept, whether permanently or temporarily;*

(b) *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 (our emphasis).* "

It should be noted that if either (a) or (b) is satisfied, the Major Hazard Installation (MHI) regulations will apply. The prescribed quantity of a chemical can be found in Section 8(1) of the General Machinery Regulation 8 (our emphasis).

A major incident is defined as: "an occurrence of catastrophic proportions, resulting from the use of plant and machinery or from activities at a workplace". Catastrophic in this context means loss of life and limbs or severe injury to employees or members of the public, particularly those who are in the immediate vicinity (our emphasis).

It is important to note that the definition refers to an occurrence, whereas Section 1b) refers to potential to cause a major incident. If potential to cause a major incident exists, then the OHS Act and the Major Hazard Installation regulations will apply (our emphasis).

On the 16th of January 1998, the MHI regulations were promulgated under the OHS Act (Act No. 85 of 1993), with a further amendment on the 30th of July 2001. The provisions of the regulations apply to installations that have on their premises a certain quantity of a substance that can pose a significant risk to the health and safety of employees and the public.

The scope of application given in Section 2 of the MHI regulations is as follows:

" (1) *Subject to the provisions of Sub regulation (3) these regulations shall apply to employers, self-employed persons and users, who have on their premises, either permanently or temporarily, a major hazard installation or a quantity of a substance which may pose a risk that could affect the health and safety of employees and the public (our emphasis);*

(2) *These regulations shall apply to local governments, with specific reference to Regulation 9.* "

It is important to note that the regulations refer to a substance, and furthermore the regulations are applicable to risks posed by the substance and **NOT** merely the potential consequences (our emphasis).

The regulations essentially consist of six parts, namely:

1. Duties for notification of a Major Hazard Installation (existing or proposed), including:
   a. Fixed (see List 1);
   b. Temporary installations;
2. Minimum requirements for a quantitative risk assessment (see List 2);
3. Requirements of an on-site emergency plan (see List 3);
4. Reporting steps of risk and emergency occurrences (see List 4);
5. General duties required of suppliers;
6. General duties required of local government.

Notification of installation (List 1) indicates that:

- Applications need to be made in writing to the relevant local authority and the provincial director for permission:
  - To erect any Major Hazard Installation;
  - Prior to the modification of any existing installation that may significantly increase risk related to it (e.g., an increase in storage or production capacity or alteration of a process);
  - Applications need to include the following information:
  - The physical address of installation;
  - Complete material safety data sheets of all hazardous substances;
  - The maximum quantity of each substance envisaged to be on premises at any one time;
  - The risk assessment of the installation (see List 2);
  - Any further information that may be deemed necessary by an inspector in interests of health and safety to the public;
- Applications need to be advertised in at least one newspaper serving the surrounding communities and by way of notices posted within these communities.

The risk assessment (List 2):

- Is the process of collecting, organising, analysing, interpreting, communicating and implementing information in order to identify the probable frequency, magnitude and nature of any major incident which could occur at a Major Hazard Installation and measures required to remove, reduce or control the potential causes of such an incident;
- Needs to be undertaken at intervals not exceeding 5 years and needs to be submitted to the relevant local emergency services;
- Must be made available in copies to the relevant health and safety committee, with 60 days given to comment thereon and the results of the assessment made available to any relevant representative or committee to comment thereon;
- Should be undertaken by competent person(s) and include the following:
    - A general process description;
    - A description of major incidents associated with this type of installation and consequences of such incidents (including potential incidents);
    - An estimation of the probability of a major incident;
    - The on-site emergency plan;
    - An estimation of the total result in the case of an explosion;
    - An estimation of the effects of thermal radiation in the case of fire;
    - An estimation of concentration effects in the case of a toxic release;
    - Potential effects of a major incident on an adjacent major hazard installation or part thereof;
    - Potential effects of a major incident on any other installation, members of the public (including all persons outside the premises) and on residential areas;
    - Meteorological tendencies;
    - Suitability of existing emergency procedures for risks identified;
    - Any requirements laid down in terms of the Environmental Conservation Act of 1989 (Act No. 73 of 1989);
    - Any organisational measures that may be required;
- The employer shall ensure that the risk assessment is of an acceptable standard and shall be reviewed should:
    - It be suspected that the preceding assessment is no longer valid;
    - Changes in the process that affect hazardous substances;
    - Changes in the process that involve a substance that resulted in the installation being classified a Major Hazard Installation or in the methods, equipment or procedures for the use, handling or processing of that substance;
    - Incidents that have brought the emergency plan into operation and may affect the existing risk assessment;
    - Must be made available at a time and place and in a manner agreed upon between parties for scrutiny by any interested person that may be affected by the activities.

The duties of the supplier refer specifically to:

- Supplying of material safety data sheets for hazardous substances employed or contemplated at the installation;
- Assessment of the circumstances and substance involved in an incident or potential incident and the informing all persons being supplied with that substance of the potential dangers surrounding it;
- Provision of a service that shall be readily available on a 24-hour basis to all employers, self-employed persons, users, relevant local government and any other body concerned to provide information and advice in the case of a major incident with regard to the substance supplied.

The duties of local government are summarised as follows:

*" 9. (1) Without derogating from the provisions of the National Building Regulations and Building Standards Act of 1977 (Act No. 103 of 1977), no local government shall permit the erection of a new major hazard installation at a separation distance less than that which poses a risk to:*

*(a) Airports;*

*(b) Neighbouring independent major hazard installations;*

*(c) Housing and other centres of population; or,*

*(d) Any other similar facility…*

*Provided that the local government shall permit new property development only where there is a separation distance which will not pose a <u>risk</u> (our emphasis) in terms of the risk assessment: Provided further that the local government shall prevent any development adjacent to an installation that will result in that installation being declared a major hazard installation.*

*(2) Where a local government does not have facilities available to control a major incident or to comply with the requirements of this regulation that local government shall make prior arrangements with a neighbouring local government, relevant provincial government or the employer, self-employed person and user for assistance…*

*(3) All off-site emergency plans to be followed outside the premises of the installation or part of the installation classified as a major hazard installation shall be the responsibility of the local government… "*

# 17 APPENDIX E: PADHI LAND-PLANNING TABLES

## 17.1 Development Type Table 1: People at Work, Parking

| Development Type | Examples | Development Detail and Size | Justification |
|---|---|---|---|
| **DT1.1 Workplaces** | Offices, factories, warehouses, haulage depots, farm buildings, nonretail markets, builder's yards | Workplaces (predominantly nonretail), providing for less than 100 occupants in each building and less than 3 occupied storeys (Level 1) | Places where the occupants will be fit and healthy and could be organised easily for emergency action Members of the public will not be present or will be present in very small numbers and for a short time |
| | **Exclusions** | | |
| | | DT1.1 x1 Workplaces (predominantly nonretail) providing for 100 or more occupants in any building or 3 or more occupied storeys in height (Level 2 except where the development is at the major hazard site itself, where it remains Level 1) | Substantial increase in numbers at risk with no direct benefit from exposure to the risk |
| | Sheltered workshops, Remploy | DT1.1 x2 Workplaces (predominantly nonretail) specifically for people with disabilities (Level 3) | Those at risk may be especially vulnerable to injury from hazardous events or they may not be able to be organised easily for emergency action |
| **DT1.2 Parking Areas** | Car parks, truck parks, lockup garages | Parking areas with no other associated facilities (other than toilets; Level 1) | |
| | **Exclusions** | | |
| | Car parks with picnic areas or at a retail or leisure development or serving a park and ride interchange | DT1.2 x1 Where parking areas are associated with other facilities and developments the sensitivity level and the decision will be based on the facility or development | |

## 17.2 Development Type Table 2: Developments for Use by the General Public

| Development Type | Examples | Development Detail and Size | Justification |
|---|---|---|---|
| **DT2.1 Housing** | Houses, flats, retirement flats or bungalows, residential caravans, mobile homes | Developments up to and including 30 dwelling units and at a density of no more than 40 per hectare (Level 2) | Development where people live or are temporarily resident<br>It may be difficult to organise people in the event of an emergency |
| | **Exclusions** | | |
| | Infill, back-land development | DT2.1 x1<br>Developments of 1 or 2 dwelling units (Level 1) | Minimal increase in numbers at risk |
| | Larger housing developments | DT2.1 x2<br>Larger developments for more than 30 dwelling units (Level 3) | Substantial increase in numbers at risk |
| | | DT2.1 x3<br>Any developments (for more than 2 dwelling units) at a density of more than 40 dwelling units per hectare (Level 3) | High-density developments |
| **DT2.2 Hotel or Hostel or Holiday Accommodation** | Hotels, motels, guest houses, hostels, youth hostels, holiday camps, holiday homes, halls of residence, dormitories, accommodation centres, holiday caravan sites, camping sites | Accommodation up to 100 beds or 33 caravan or tent pitches (Level 2) | Development where people are temporarily resident<br>It may be difficult to organise people in the event of an emergency |
| | **Exclusions** | | |
| | Smaller: guest houses, hostels, youth hostels, holiday homes, halls of residence, dormitories, holiday caravan sites, camping sites | DT2.2 x1<br>Accommodation of less than 10 beds or 3 caravan or tent pitches (Level 1) | Minimal increase in numbers at risk |
| | Larger: hotels, motels, hostels, youth hostels, holiday camps, holiday homes, halls of residence, dormitories, holiday | DT2.2 x2<br>Accommodation of more than 100 beds or 33 caravan or tent pitches (Level 3) | Substantial increase in numbers at risk |

| Development Type | Examples | Development Detail and Size | Justification |
|---|---|---|---|
| | caravan sites, camping sites | | |
| **DT2.3 Transport Links** | Motorway, dual carriageway | Major transport links in their own right i.e., not as an integral part of other developments (Level 2) | Prime purpose is as a transport link<br>Potentially large numbers exposed to risk but exposure of an individual is only for a short period |
| | **Exclusions** | | |
| | Estate roads, access roads | DT2.3 x1<br>Single carriageway roads (Level 1) | Minimal numbers present and mostly a small period of time exposed to risk<br>Associated with other development |
| | Any railway or tram track | DT2.3 x2<br>Railways (Level 1) | Transient population, small period of time exposed to risk<br>Periods of time with no population present |

| Development Type | Examples | Development Detail and Size | Justification |
|---|---|---|---|
| **DT2.4 Indoor Use by Public** | Food and drink: restaurants, cafes, drive-through fast food, pubs Retail: shops, petrol filling station (total floor space based on shop area not forecourt), vehicle dealers (total floor space based on showroom or sales building not outside display areas), retail warehouses, super-stores, small shopping centres, markets, financial and professional services to the public Community and adult education: libraries, art galleries, museums, exhibition halls, day surgeries, health centres, religious buildings, community centres. adult education, 6th form college, college of FE Assembly and leisure: Coach or bus or railway stations, ferry terminals, airports, cinemas, concert or bingo or dance halls, conference centres, sports or leisure centres, sports halls, facilities associated with golf courses, flying clubs (e.g., changing rooms, club house), indoor go kart tracks | Developments for use by the general public where total floor space is from 250 m$^2$ up to 5000 m$^2$ (Level 2) | Developments where members of the public will be present (but not resident) Emergency action may be difficult to coordinate |
| | **Exclusions** | | |
| | | DT2.4 x1 Development with less than 250 m$^2$ total floor space (Level 1) | Minimal increase in numbers at risk |
| | | DT2.4 x2 Development with more than 5000 m$^2$ total floor space (Level 3) | Substantial increase in numbers at risk |
| **DT2.5 Outdoor Use by Public** | Food and drink: food festivals, picnic areas | Principally an outdoor development for use by the general public | Developments where members of the public will |

| Development Type | Examples | Development Detail and Size | Justification |
|---|---|---|---|
| | Retail: outdoor markets, car boot sales, funfairs Community and adult education: open-air theatres and exhibitions Assembly and leisure: coach or bus or railway stations, park and ride interchange, ferry terminals, sports stadia, sports fields or pitches, funfairs, theme parks, viewing stands, marinas, playing fields, children's play areas, BMX or go kart tracks, country parks, nature reserves, picnic sites, marquees | i.e., developments where people will predominantly be outdoors and not more than 100 people will gather at the facility at any one time (Level 2) | be present (but not resident) either indoors or outdoors Emergency action may be difficult to coordinate |
| | **Exclusions** | | |
| | Outdoor markets, car boot sales, funfairs picnic area, park and ride interchange, viewing stands, marquees | DT2.5 x1 Predominantly open-air developments likely to attract the general public in numbers greater than 100 people but up to 1000 at any one time (Level 3) | Substantial increase in numbers at risk and more vulnerable due to being outside |
| | Theme parks, funfairs, large sports stadia and events, open air markets, outdoor concerts, pop festivals | DT2.5 x2 Predominantly open-air developments likely to attract the general public in numbers greater than 1000 people at any one time (Level 4) | Very substantial increase in numbers at risk, more vulnerable due to being outside Emergency action may be difficult to coordinate |

## 17.3 Development Type Table 3: Developments for Use by Vulnerable People

<table>
<tr><th>Development Type</th><th>Examples</th><th>Development Detail and Size</th><th>Justification</th></tr>
<tr><td rowspan="4">DT3.1<br>Institutional Accommodation and Education</td><td>Hospitals, convalescent homes, nursing homes, old people’s homes with warden on site or ‘on call’, sheltered housing, nurseries, crèches, schools and academies for children up to school leaving age</td><td>Institutional, educational and special accommodation for vulnerable people or that provides a protective environment (Level 3)</td><td>Places providing an element of care or protection<br>Because of age, infirmity or state of health the occupants may be especially vulnerable to injury from hazardous events<br>Emergency action and evacuation may be very difficult</td></tr>
<tr><td colspan="3">Exclusions</td></tr>
<tr><td>Hospitals, convalescent homes, nursing homes, old people’s homes, sheltered housing</td><td>DT3.1 x1<br>24-hour care where the site on the planning application being developed is larger than 0.25 hectare (Level 4)</td><td>Substantial increase in numbers of vulnerable people at risk</td></tr>
<tr><td>Schools, nurseries, crèches</td><td>DT3.1 x2<br>Day care where the site on the planning application being developed is larger than 1.4 hectare (Level 4)</td><td>Substantial increase in numbers of vulnerable people at risk</td></tr>
<tr><td>DT3.2<br>Prisons</td><td>Prisons, remand centres</td><td>Secure accommodation for those sentenced by court, or awaiting trial, etc. (Level 3)</td><td>Places providing detention<br>Emergency action and evacuation may be very difficult</td></tr>
</table>

### 17.4 Development Type Table 4: Very Large and Sensitive Developments

| Development Type | Examples | Development Detail and Size | Justification |
|---|---|---|---|
| Note: all Level 4 developments are by exception from Level 2 or 3 and are reproduced in this table for convenient reference | | | |
| **DT4.1 Institutional Accommodation** | Hospitals, convalescent homes, nursing homes, old people's homes, sheltered housing | Large developments of institutional and special accommodation for vulnerable people (or that provide a protective environment) where 24-hour care is provided and where the site on the planning application being developed is larger than 0.25 hectare (Level 4) | Places providing an element of care or protection<br>Because of age or state of health the occupants may be especially vulnerable to injury from hazardous events<br>Emergency action and evacuation may be very difficult<br>The risk to an individual may be small but there is a larger societal concern |
| | Nurseries, crèches, schools for children up to school leaving age | Large developments of institutional and special accommodation for vulnerable people (or that provide a protective environment) where day care (not 24-hour care) is provided and where the site on the planning application being developed is larger than 1.4 hectare (Level 4) | Places providing an element of care or protection<br>Because of the occupants may be especially vulnerable to injury from hazardous events<br>Emergency action and evacuation may be very difficult<br>The risk to an individual may be small but there is a larger societal concern |
| **DT4.2 Very Large Outdoor Use by Public** | Theme parks, large sports stadia and events, open air markets, outdoor concerts, pop festivals | Predominantly open-air developments where there could be more than 1000 people present (Level 4) | People in the open air may be more exposed to toxic fumes and thermal radiation than if they were in buildings<br>Large numbers make emergency action and evacuation difficult<br>The risk to an individual may be small but there is a larger societal concern |

# 18 APPENDIX F: MATERIAL SAFETY DATA SHEETS (MSDS)

## 18.1 LNG / Natural Gas Modelled as Methane

| | |
|---|---|
| **ETHANE** | **ICSC: 0291** |
| Methyl hydride | **February 2000** |
| **CAS #: 74-82-8** | |
| **UN #: 1971** | |
| **EC Number: 200-812-7** | |

| | ACUTE HAZARDS | PREVENTION | FIRE FIGHTING |
|---|---|---|---|
| **FIRE & EXPLOSION** | Extremely flammable. Gas/air mixtures are explosive. | NO open flames, NO sparks and NO smoking. Closed system, ventilation, explosion-proof electrical equipment and lighting. Use non-sparking hand tools. | Shut off supply; if not possible and no risk to surroundings, let the fire burn itself out. In other cases, extinguish with water spray, powder, carbon dioxide. In case of fire: keep cylinder cool by spraying with water. Combat fire from a sheltered position. |

| | SYMPTOMS | PREVENTION | FIRST AID |
|---|---|---|---|
| **Inhalation** | Suffocation. See Notes. | Use ventilation. Use breathing protection. | Fresh air, rest. Artificial respiration may be needed. Refer for medical attention. |
| **Skin** | ON CONTACT WITH LIQUID: FROSTBITE. | Cold-insulating gloves. | ON FROSTBITE: rinse with plenty of water, do NOT remove clothes. Refer for medical attention. |
| **Eyes** | ON CONTACT WITH LIQUID: FROSTBITE. | Wear safety goggles. | First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then refer for medical attention. |
| **Ingestion** | | | |

| SPILLAGE DISPOSAL | CLASSIFICATION & LABELLING |
|---|---|
| Evacuate danger area! Personal protection: self-contained breathing apparatus. Consult an expert! Ventilation. Remove all ignition sources. NEVER direct water jet on liquid. | **According to UN GHS Criteria** |
| **STORAGE** | **Transportation**<br>**UN Classification**<br>UN Hazard Class: 2.1 |
| Fireproof. Cool. Ventilation along the floor and ceiling. | |
| **PACKAGING** | |
| | |

International Labour Organization | World Health Organization



European Commission

| | |
|---|---|
| **METHANE** | **ICSC: 0291** |

**PHYSICAL & CHEMICAL INFORMATION**

| | |
|---|---|
| **Physical State; Appearance**<br>COLOURLESS ODOURLESS COMPRESSED OR LIQUEFIED GAS.<br><br>**Physical dangers**<br>The gas is lighter than air.<br><br>**Chemical dangers** | Formula: $CH_4$<br>Molecular mass: 16.0<br>Boiling point: -161°C<br>Melting point: -183°C<br>Solubility in water, ml/100ml at 20°C: 3.3<br>Relative vapour density (air = 1): 0.6<br>Flash point: Flammable gas<br>Auto-ignition temperature: 537°C<br>Explosive limits, vol% in air: 5-15<br>Octanol/water partition coefficient as log Pow: 1.09 |

## EXPOSURE & HEALTH EFFECTS

| | |
|---|---|
| **Routes of exposure**<br>The substance can be absorbed into the body by inhalation.<br><br>**Effects of short-term exposure**<br>Rapid evaporation of the liquid may cause frostbite. | **Inhalation risk**<br>On loss of containment this substance can cause suffocation by lowering the oxygen content of the air in confined areas.<br><br>**Effects of long-term or repeated exposure** |

## OCCUPATIONAL EXPOSURE LIMITS

## ENVIRONMENT

## NOTES

Density of the liquid at boiling point: 0.42 kg/l.
High concentrations in the air cause a deficiency of oxygen with the risk of unconsciousness or death.
Check oxygen content before entering area.
Turn leaking cylinder with the leak up to prevent escape of gas in liquid state.
After use for welding, turn valve off; regularly check tubing, etc., and test for leaks with soap and water.
The measures mentioned in section PREVENTION are applicable to production, filling of cylinders, and storage of the gas.
Other UN number: 1972 (refrigerated liquid), Hazard class: 2.1.

## ADDITIONAL INFORMATION

**EC Classification**
Symbol: F+; R: 12; S: (2)-9-16-33