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Confidential

MHI RISK ASSESSMENT ON THE NATURAL GAS FACILITY AT TETRA4 NEAR VIRGINIA IN THE FREE STATE

June 2022

Prepared by:

Dr H F B Minnaar
Managing Director
(Approved Inspection Authority CI MHI 010)

MHI0033

AIA CI MHI 010

COMPANY DETAILS

Company Name:	Tetra4 (Pty) Ltd
Physical Address:	Next to the R30 near Viginia in the Free State.
Postal Address:	1 Bompas Road, Dunkeld West, Johannesburg, 2196
Facility Name:	CNG and LNG Processing Plant
MHI Status:	Modification
Facility Location:	Near Virginia, Free State
GPS Co-ordinates:	28˚07'41.55"S; 26˚43'17.33"E
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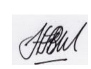
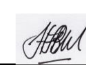
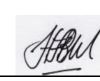
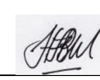
Name of Assessor:	Dr HFB Minnaar
Contact Details:	082 577 7181 or 011 768 7832
BIRA File Number:	R954-3 Tetra4 CNG LNG
Assessment Date:	27st May 2022
Report Date:	20th June 2022
Expiry Date:	On completion of Phase 11 Construction prior to commissioning

Report Summary Sheet

Client: **Tetra4**	**Client Contract No.** **1630**
Title of Report: MHI Risk Assessment on the Natural Gas facility at Tetra4 near Virginia in the Free State	
Summary: (Brief description of report) This report deals with the risks associated with the natural gas facility at Tetra4 near Virginia in the Free State	
Indexing Terms: (keywords) MHI Risk Assessment Methane BLEVE Vapour Cloud Explosion (VCE) Jet Flame CNG LNG	
Work Carried Out By: (Team initials or names) HM	
Job No:	**1064**

Document Revision Record

Rev No	Issue Date	Reason for Issue	Prepared By	Reviewed By
0	May 2019	Draft	HM	
1	21st June 2019	Report	HM	
2	3rd June 2021	Report	HM	
3	31st May 2022	Draft Preliminary Report	HM	
4	20th June 2022	Preliminary Report	HM	

ABBREVIATIONS AND DEFINITIONS

CH_4 – Methane

CNG – Compressed Natural Gas

LNG – Liquefied Natural Gas

VCE – Vapour Cloud Explosion

VC – Vapour Cloud

Isopleths – Lines of constant concentration

f/p/y - fatality/person/year

PRV - Pressure Relief Valve

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APPENDICES:

EXECUTIVE SUMMARY

On 27th May 2022, BIRA, a SANAS accredited MHI risk assessment facility (MHI 033) and a Department of Labour Approved Inspection Authority (CI MHI 010), conducted a preliminary MHI risk assessment of Tetra4 Phase 11 near Virginia in the Free State.

The OHSAct (85) of 1993 and its Major Hazard Installation (MHI) Regulations (July 2001) requires 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, to conduct a risk assessment in accordance with the legislation.

Natural gas is obtained from wells at a pressure of approximately 19kPa and compressed to 250bar for CNG transport. From the wells natural gas is also delivered to a compressor station where it is compressed to approximately 23barg, fed to the LNG process equipment and stored in three 100m^3 and eleven 300m^3 containers for delivery to LNG trucks for transport to clients.

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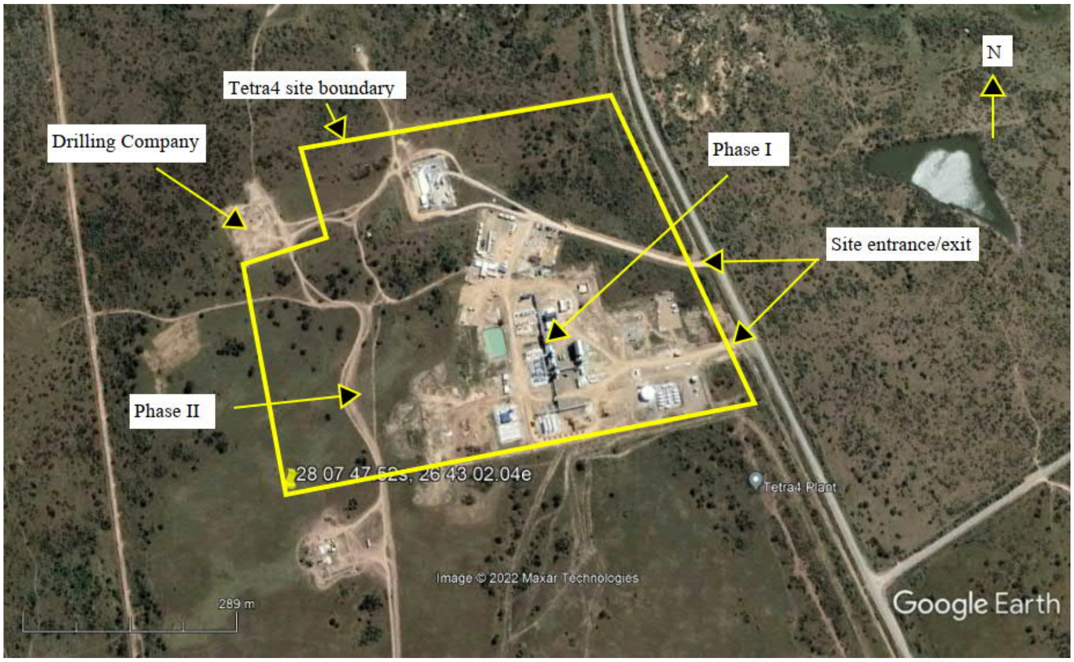
Tetra4is located in an industrial area with relative flat topography. The figure below shows the nearby developments to Tetra4.

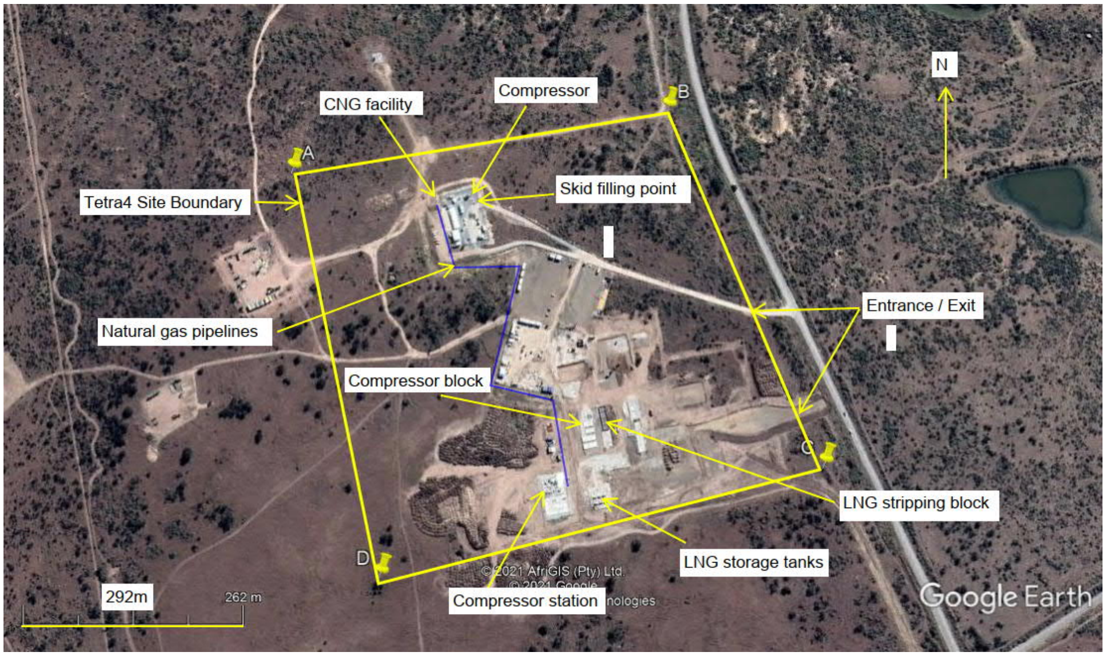


Tetra4 and nearby developments

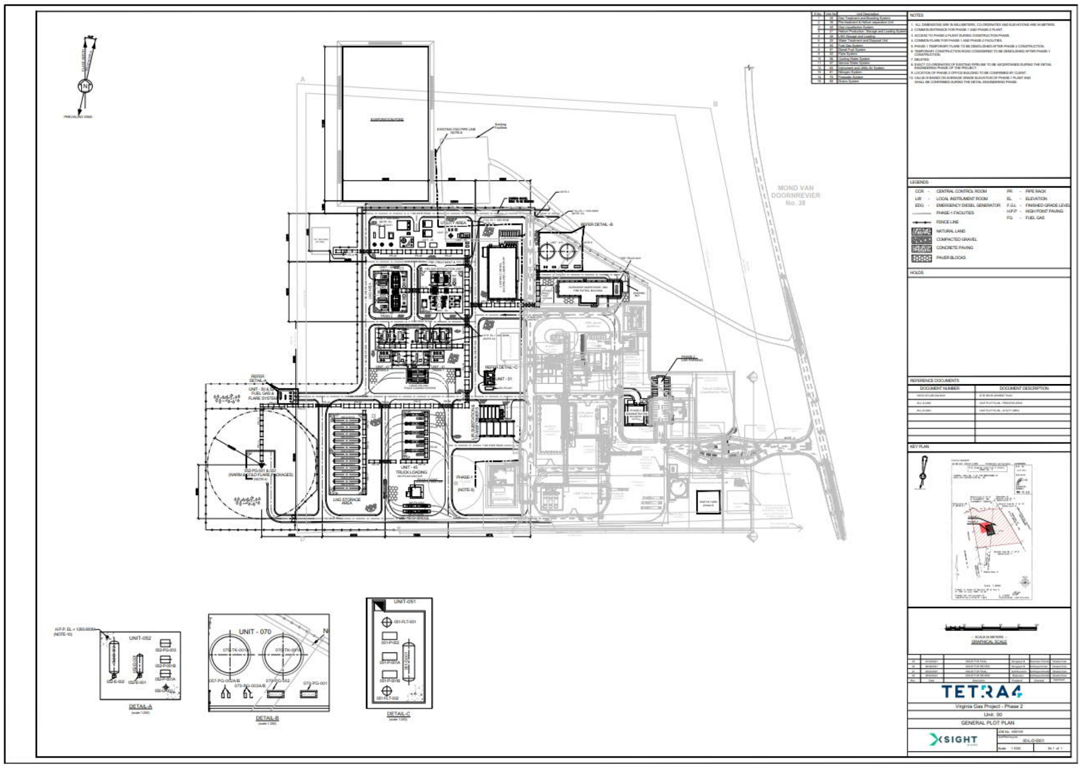
There are no sensitive receptors such as schools or hospitals in the near vicinity of Tetra4.

Tetra4 is a 24/7 operation with two shifts. In the buildings in the immediate surrounding of the CNG facility, there will be approximately 40 people during the day and 15 people during the night.

The site layout is shown in the figure below.



Site layout Phase I



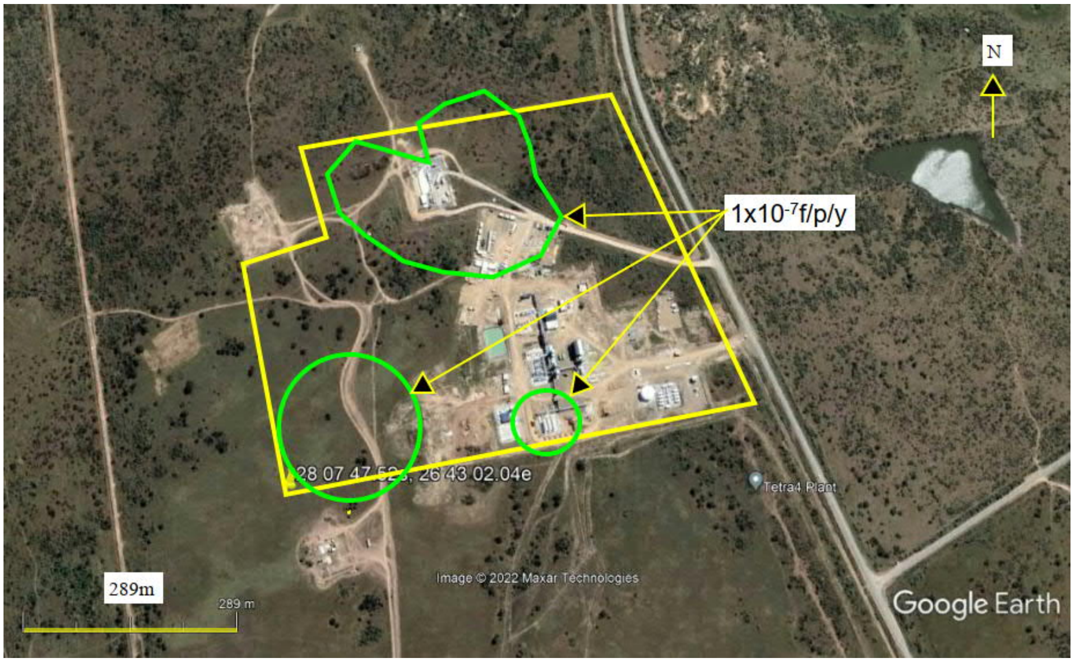
Site Layout Phase II

For the risk assessment the following scenarios were considered.

1) Rupture of a 12 mm pigtail pipeline on the trailer system (all cylinders filled to full capacity) and the slam shut valves fails to close on the initial high flow rate, resulting in one cylinder releasing its contents through a 12mm hole and the eight other cylinders releasing their contents via the header through a 12mm hole, or failure of the 12mm pipeline, from the dispenser to the nine cylinder skid, with a resultant average release rate of approximately 2000g/s.
2) Release through a 25mm hole in one of the CNG cylinders at a rate of 3200g/s.

3) Instantaneous release of the contents of a CNG cylinder at an average release rate of 7300g/s.
4) Jet flame from a 12mm hole.
5) Full bore rupture of the pipeline between the natural gas compressor (50barg) and the LNG stripping block.
6) BLEVE from a 100m^3 LNG cryogenic storage tank
7) BLEVE from an LNG cryogenic road tanker
8) Pool fire due to a catastrophic failure of a 100m^3 cryogenic container into a bunded area.
9) BLEVE from a 300m^3 LNG cryogenic storage tank
10) Pool fire due to a catastrophic failure of a 300m^3 cryogenic container into a bunded area.

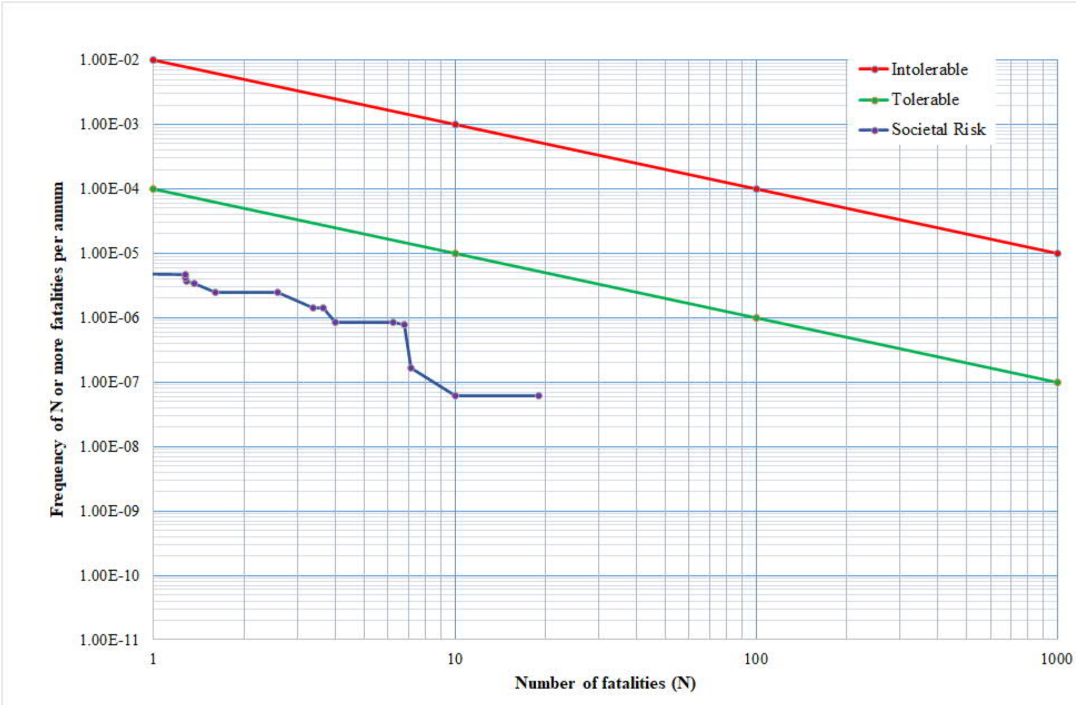
The individual risk calculations were done for the 16 main wind directions. The risk zones are shown in the figure below.



Risk zones

The societal risk is normally presented by the so-called FN-curves. Where F is the cumulative frequency of events that may cause fatalities to the public and N represents the number of fatalities.

The societal risk, as shown in the figure below, was calculated for the eight main wind directions.



Societal Risk

It follows from the previous paragraphs that an accidental release of methane will not impact on any residential area or sensitive receptor.

In order to keep the risk as low as reasonably practicable (ALARP) the following is recommended.

- The maintenance plan for the CNG facility to be maintained
- The site emergency plan to be reviewed in accordance with SANS 1514:2018.

It is not foreseen that the accidental release of CH_4 will have any long term environmental impact.

There should not be any restriction on land-use planning outside the perimeter of Tetra4 except in the case of development within the 10^{-7}f/p/y risk zone (outer zone), where such development will involve vulnerable members of the public (children, those with mobility difficulties or those unable to recognise physical danger), in which case advise against development should be obtained from the local authorities.

It is concluded as follows:

It is concluded as follows:

a) The hazardous installations addressed in this report are the only hazardous installations on the premises of Tetra4.

b) The maximum extend of the 1% consequence lethality zone is 594m, which will not impact on any residential area or sensitive receptor.
c) The risk posed to the public is lower than $1x10^{-7}$ f/p/y.
d) The societal risk is well below the tolerable level and thus broadly acceptable.
e) The maintenance plan for the CNG and LNG facilities to be maintained.
f) The site emergency plan to be reviewed in accordance with SANS 1514:2018.
g) Documentation for the storage of flammable material on site to be submitted to BIRA
h) There should not be any restriction on land-use planning outside the perimeter of Tetra4 except in the case of development within the 10^{-7}f/p/y risk zone, where such development will involve vulnerable members of the public (children, those with mobility difficulties or those unable to recognise physical danger), in which case advise against development should be obtained from the local authorities.
i) Tetra4 should be classified as an MHI.

1.0 INTRODUCTION

On 27th May 2022, BIRA, a SANAS accredited MHI risk assessment facility (MHI 033) and a Department of Labour Approved Inspection Authority (CI MHI 010), conducted a preliminary MHI risk assessment of Tetra4 Phase 11 near Virginia in the Free State.

1.1. Scope of the Risk Assessment

The OHSAct (85) of 1993 and its Major Hazard Installation (MHI) Regulations (July 2001) requires 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, to conduct a risk assessment in accordance with the legislation.

This risk assessment will also be in accordance with SANS1461:2018 (Major Hazard Installation – Risk Assessments).

The purpose of this study is not to identify all the risks associated with the operations, but to identify those hazards that may result in a major event causing harm to personnel, the public and or the environment. For that purpose the hazardous substances and the associated scenarios have been identified that may result in incidents causing major harm to employees and or the public.

1.2 Legal Aspects

Tetra4 to obtain the necessary legal approval from the local authorities for the facility based on the outcome of this MHI risk assessment.

1.3 Methodologies

For the risk assessment the following methodologies are used:

- Fault Tree Analysis (FTA)
- BLEVE and VCE Calculations (CPR 14E)
- ALOHA Heavy Gas Model

2.0 DESCRIPTION

The Tetra4 LNG facility is located in a rural area near Virginia in the Free State on a relatively flat terrain.

Natural gas is obtained from wells at a pressure of approximately 19kPa and compressed to 250bar for CNG transport. From the wells natural gas is also delivered to a compressor station where it is compressed to approximately 5barg to the LNG process equipment and stored in three 100m^3 containers for delivery to LNG trucks for transport to clients.

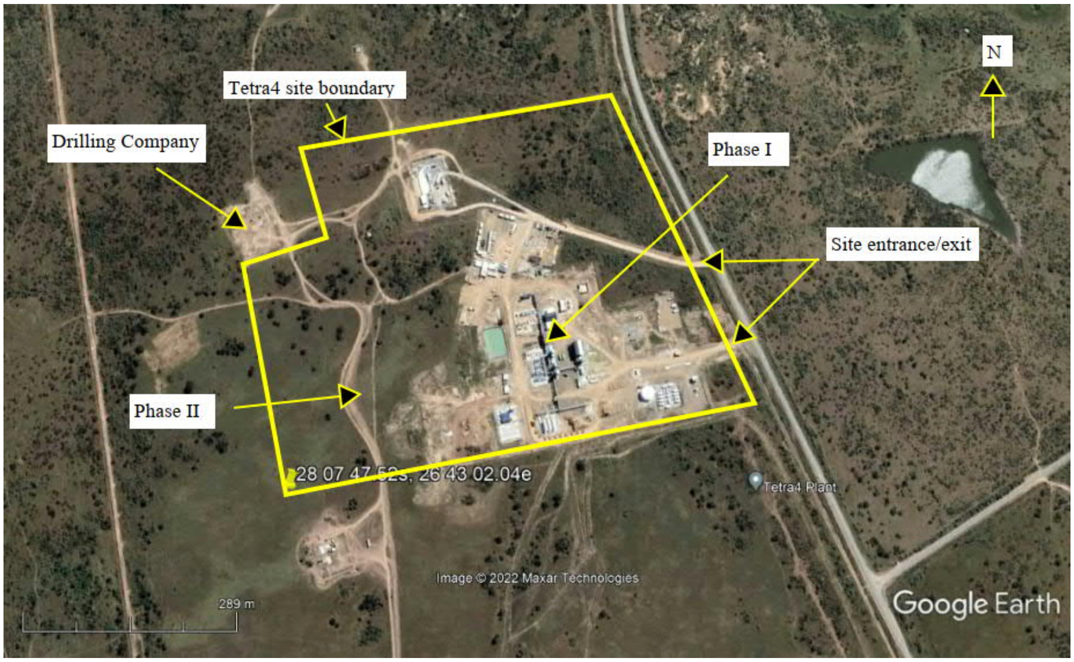


Figure 2.1 Tetra4 and nearby developments

Tetra4 is a 24/7 operation with two shifts. During the day shift there will be approximately 40 people on site and 15 people during night shift.

2.1 Meteorology

Meteorological data was obtained for the site from EScience. The wind rose for a complete year is shown in Figure 2.2 and is superimposed on the Tetra4 site as shown in Figure 2.3. ***(Please note that the wind rose indicates the direction from which the wind is blowing).***

From analysis of the day and night wind characteristics it was found that the following atmospheric conditions could be present during a period of one year.

- 3B – unstable with a wind speed of 3m/s, which will occur mostly in the afternoon on a hot sunny day prevailing at 10.35% of the time
- 5D – neutral with a wind speed of 5m/s, which will occur mostly during day time, with some cloud cover and a strong wind blowing prevailing at 43.21% of the time
- 5E- stable with a wind speed of 5m/s which will occur mostly during night time prevailing at 21.11% of the time
- 1.5F – very stable with a wind speed of 1.5m/s, which will occur mostly during night time with cloud cover and a moderate wind speed, prevailing at 25.31% of the time

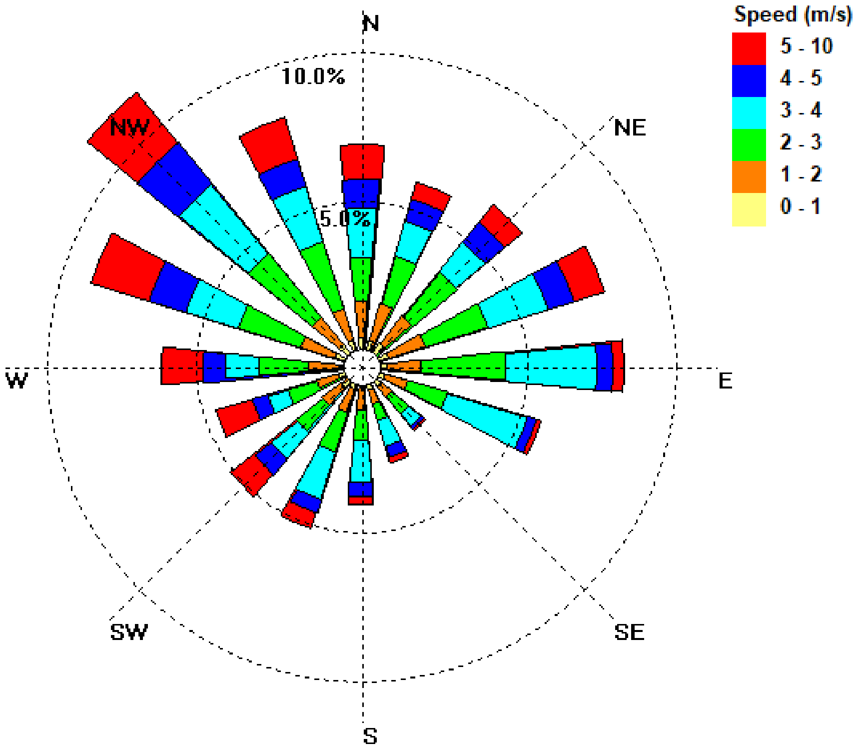
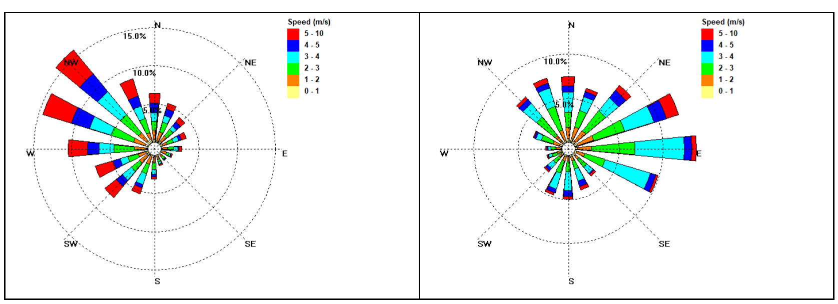


Figure 2.2a Wind rose generated from the meteorological data for Tetra4 for a complete year



Day **Night**

Figure 2.2b Wind roses generated from the meteorological data for Tetra4, for day and night respectively

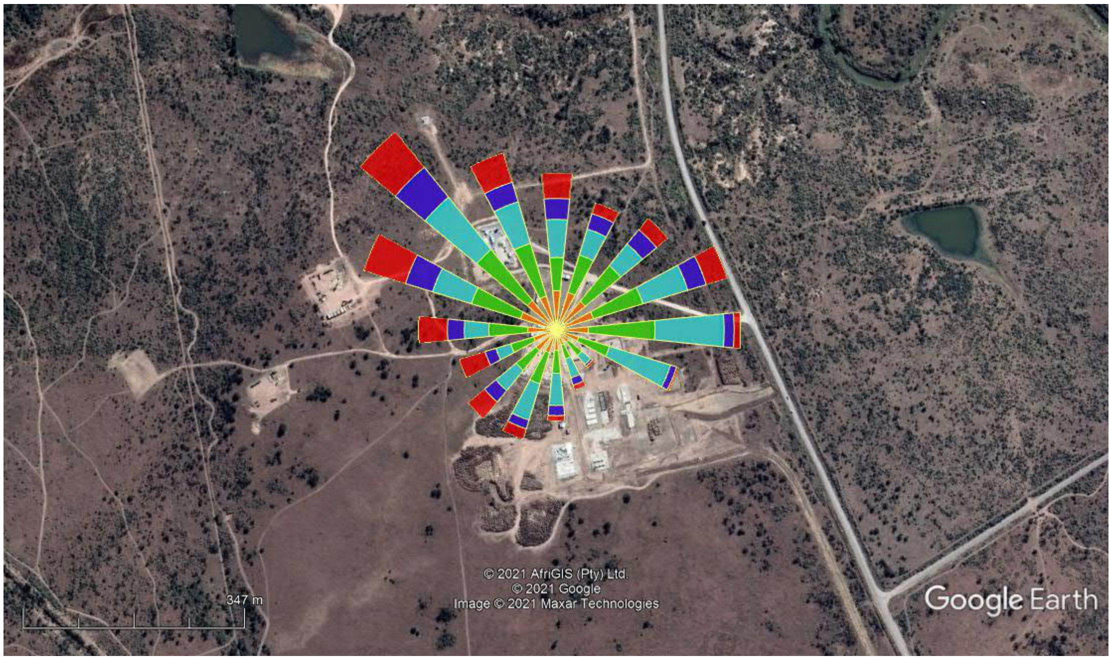


Figure 2.3 Wind rose superimposed on the Tetra4 site

3.0 RISK ASSESSMENT

3.1 Hazard Identification

The following hazardous substances will be stored on site.

Four skid trailers each containing 9 tubes of CNG with a total mass of 438kg/cylinder. The maximum mass of CNG on site at any time will thus be

4 skids x 9cylinders/skid x 438kg/cylinder = 15,768.00 ton

Three LNG tanks with a capacity of 100m^3 each and four road tankers with a capacity of 61.5m^3 each, plus eleven LNG tanks with a capacity of 300m^3 each thus in total 3846m^3 of LNG

There will also be 10000litre of diesel stored onsite.

3.1.1 Methane (CAS No. 74-82-8), (UN No. 1971)

Natural gas consists mainly of methane (87.6% by weight). Methane is a flammable gas with a lower flammable limit of 5% (v/v) and an upper flammable limit of 15% (v/v). It is flammable in the presence of open flames, sparks, static discharge and heat.

Since 2001, natural gas pipeline explosions and other accidents have resulted in the loss of at least 45 lives and many more serious injuries, usually from burns. The list below may not be comprehensive, and there may be additional accidents, deaths and injuries that are not known to us.

March 22, 2001 - A 12-inch natural gas pipeline exploded in Weatherford, Texas on . No one was injured, but the blast created a hole in the ground about 15 feet in diameter and the explosion was felt several miles away.

May 1, 2001-A 10 inch diameter propane pipeline exploded and burned in Platte County, Missouri.

June 13, 2001 - In Pensacola, Florida, at least ten persons were injured when two natural gas lines ruptured and exploded after a parking lot gave way beneath a cement truck at a car dealership. The blast sent chunks of concrete flying across a four-lane road, and several employees and customers at neighbouring businesses were evacuated. About 25 cars at the dealership and 10 boats at a neighbouring business were damaged or destroyed.

August 11, 2001 - At approximately 5:05 a.m. MST a 24 inch gas pipeline failed near Williams, Arizona, resulting in the release of natural gas. The natural gas continued to discharge for about an hour before igniting.

August 19, 2000 - A 30 inch diameter natural gas pipeline rupture and fire near Carlsbad, New Mexico killed 12 members of an extended Family camping over 600 feet from the rupture point. The force of the rupture and the violent ignition of the escaping gas created a 51-foot-wide crater about 113 feet along the pipe. A 49-foot section of the pipe was ejected from the crater in three pieces measuring approximately 3 feet, 20 feet, and 26 feet in length. The largest piece of pipe was found about 287 feet northwest of the crater. The cause of the failure was determined to be severe internal corrosion of that pipeline.

September 7, 2000 - A Bulldozer ruptured a 12 inch diameter NGL pipeline on Route 36, south of Abilene, Texas. A police detective, with 21 years of service, was killed. Nearby, a woman saved herself by going underwater in her swimming pool. Her house was destroyed by the explosion & fire.

September 8, 2000 - For the second time in 24 hours, a state contractor building a noise wall along IH 475 in Toledo, Ohio struck an underground pipeline, and for a second time the contractor blamed faulty pipeline mapping for the accident. In this incident, the pipe was a six-inch gas pipeline. The crew was digging a hole with an auger for a noise-wall support when it hit the underground pipe less than 500 meters from the previous day's incident.

August 5, 2002 - A natural gas pipeline exploded and caught fire west of Rt. 622, on Poca River Road near Lanham, West Virginia. Emergency workers evacuated three or four families. Kanawha and Putnam Counties in the area were requested Shelter-In-Place. Parts of the Pipeline were thrown hundreds of yards away, around, and across Poca River. The

Fire was not contained for several hours because valves to shut down the pipeline did not exist. The orange glow from the fire at 11 PM could be seen for several miles.

February 2, 2003 - A natural gas pipeline ruptured near Viola, Illinois resulting in the release of natural gas which ignited. A l6-foot long section of the pipe fractured into three sections, which were ejected to distances of about 300 yards from the failure site.
March 23, 2003 - A 24-inch diameter gas pipeline near Eaton, Colorado exploded. The explosion sent flames 160 meters in the air and sent thousands of Weld County residents into a panic, but no one was injured. The heat from the flames melted the siding of two nearby homes and started many smaller grass fires.

July 2, 2003 - Excavation damage to a natural gas distribution line resulted in an explosion and fire in Wilmington, Delaware. A contractor hired by the city of Wilmington to replace sidewalk and curbing, dug into an unmarked natural gas service line with a backhoe. Although the service line did not leak where it was struck, the contact resulted in a break in the line inside the basement of a nearby building, where gas began to accumulate. A manager for the contractor said that he did not smell gas and therefore did not believe there was imminent danger and that he called an employee of the gas company and left a voice mail message. At approximately 1:44 p.m., an explosion destroyed two residences and damaged two others to the extent that they had to be demolished. Other nearby residences sustained some damage, and the residents on the block were displaced from their homes for about a week. Three contractor employees sustained serious injuries. Eleven additional people sustained minor injuries.

November 2, 2003 - A Texas Eastern Transmission natural gas pipeline exploded in Bath County, Kentucky, about 1.5 km south of a Duke Energy pumping station. A fire burned for about an hour before firefighters extinguished it. No one was injured and no property damage was reported.

August 21, 2004 - A natural gas explosion destroyed a residence located at in DuBois, Pennsylvania. Two residents were killed in this accident. The NTSB determined that the probable cause of the leak, explosion, and fire was the fracture of a defective butt-fusion joint.

November 8, 2004 - A NGL pipeline failed in a housing division in Ivel, Kentucky. The vapour cloud from the leak ignited, seriously burning a Kentucky State Trooper evacuating those living in the area. 8 others were injured and 5 homes were destroyed. The pipeline had 11 previous corrosion failures, and is only 65 miles long.

May 13, 2005 - An underground natural gas pipeline exploded near Marshall, Texas, sending a giant fireball into the sky and hurling a 160-foot section of pipe onto the grounds of a nearby electric power generating plant. 2 people were hurt. The OPS concluded that stress corrosion cracking was the culprit.

September 19, 2005 - A pipeline pumping station employee was killed in Monroe, Ohio, when leaking propane was ignited and exploded by an arcing pump. Flames reached 300 feet high in the following fire.

December 13, 2005 - Workers removing an underground oil tank in Bergenfield, New Jersey undermined a 1 1/4 inch steel gas pipeline. The gas line later failed, causing an explosion. Three residents of a nearby apartment building were killed. Four other residents and a tank removal worker were injured. Failure to evacuate the apartment building after the gas line ruptured was listed as a contributing factor.
July 22, 2006 - A gas pipeline ruptured, resulting in an estimated release of 42,946 MSCF of natural gas near Clay City in Clark County, Kentucky. The gas ignited, but there were no injuries, and just minor property damage. External corrosion was suspected.

October 12, 2006 - A pipeline explosion occurred when a tugboat pushing two barges hit the pipeline Thursday in West Cote Blanche Bay, about two miles from shore and 100 miles southwest of New Orleans, Louisiana. 4 crew members were killed, and 2 were missing and later presumed dead.

November 11, 2006 - A jet-black, 300-acre burn site surrounded the skeletal hulk of a bulldozer that struck a natural-gas pipeline and produced a powerful explosion 2 miles north of the Wyoming-Colorado line. The bulldozer operator was killed.

November 1, 2007 - A 12-inch propane pipeline exploded, killing two and injuring five others near Carmichael, Mississippi. The NTSB determined the probable cause was likely an ERW seam failure. Inadequate education of residents near the pipeline about the existence of a nearby pipeline and how to respond to a pipeline accident were also cited as a factors in the deaths.

February 5, 2008 - A natural gas pipeline explodes and catches fire near Hartsville, Tennessee, believed to have been caused by a tornado hitting the facility.

August 28, 2008 - A 36-inch gas pipeline fails near Stairtown, Texas causing a fire with flames 400 feet tall. The failure was caused by external corrosion.

August 29, 2008 - A 24-inch gas transmission pipeline ruptured in Cooper County, Missouri. Corrosion had caused the pipeline to lose 75% of its wall thickness in the failure area.

September 9, 2008 - Workers constructing a new pipeline hit an existing natural gas pipeline in Wheeler County, Texas.

September 14, 2008 - A 30-inch gas pipeline ruptured & gas ignited near Appomattox, Virginia. 2 homes were destroyed by the fire. External corrosion seems to be the cause of the failure.

February 1, 2009 - A gas pipeline explosion rocked the area 2 miles east of Carthage, Texas.

May 4, 2009 - A gas pipeline bursts near Hobe City, Florida on injuring 2 people on the Florida Turnpike from flying debris. The escaping gas did not ignite.

May 5, 2009 - Natural gas pipeline explodes and catches fire on near Rockville in Parke County, about 24 miles north of Terre Haute, Indiana. PHMSA indicated the possibility of external corrosion in its Corrective Action Order (CAO) to the pipeline company. Pictures have been released around the area showing the damage caused. 49 homes were evacuated in a one-mile area of the explosion. No injuries reported.

November 5, 2009 - Two people were hurt when a natural gas pipeline exploded in Bushland in the Texas Panhandle. The explosion left a hole about 30 yards by 20 yards and close to 15 feet deep. The blast shook homes, melted window blinds and shot flames hundreds of feet into the air. The home nearest the blast - about 100 yards away - was destroyed. Bushland is about 15 miles west of Amarillo.

November 14, 2009 - A newly built 42-inch gas transmission pipeline near Philo, Ohio failed on the second day of operation. There was no fire, but evacuations resulted. Several indications of pipe deformation were found.

January, 2010 - A gas pipeline exploded near Barksdale Air Force Base, Louisiana killing a pipeline employee.

February 1, 2010 - A plumber trying to unclog a sewer line in St. Paul, Minnesota ruptured a gas service line that has been "cross bored" through the house's sewer line. The plumper & resident escaped the home moments before as an explosion and following fire destroyed the home. The Minnesota Office of Pipeline Safety ordered that gas utility, Xcel, to check for more cross bored gas lines. In the following year, 25,000 sewer lines inspected showed 57 other cross bored gas lines. In Louisville, Kentucky, 430 gas line cross bores were found in 200 miles of a sewer project, including some near schools and a hospital. The NTSB had cited such cross bore incidents as a known hazard since 1976.

March 15, 2010 - A 24-inch gas pipeline bursts, but did not ignite near Pampa, Texas.

June 7, 2010 - A 36-inch gas pipeline explosion and fire in Johnson County, Texas, was from workers installing poles for electrical lines. One worker was killed, and six were injured. Confusion over the location and status of the construction work lead to the pipeline not being marked beforehand.

June 8, 2010 - Construction workers hit an unmarked 14-inch gas gathering pipeline near Darrouzett, Texas. Two workers were killed.

August 25, 2010 - A construction crew installing a gas pipeline in Roberts County, Texas hits an unmarked pipeline on seriously burning one man.

August 27, 2010 - A LPG pipeline sprang a leak in Gilboa, New York, forcing the evacuation of 23 people.

September 9, 2010 - A high pressure gas pipeline exploded in San Bruno, CA, a suburb of San Francisco. The blast destroyed 38 homes and damaged 120 homes. Eight people died and 58 were injured. Ten acres of brush also burned. Later, PG&E was unable to supply the California Public Utilities Commission with documents on how PG&E established pressure limits on some of its gas transmission pipelines.

September 28, 2010 - A repair crew was working on a corroded gas pipe in Cairo, Georgia when the line exploded. One crew member was killed, and 3 others burned.

October 15, 2010 - A gas pipeline under construction in Grand Prairie, Texas was running a cleaning pig without a pig "trap" at the end of the pipe. The 150 pound pig was expelled from the pipeline with enough force to fly 500 feet, and crash through the side of a house. No one was injured.

November 12, 2010 - Three men working on natural gas lines were injured when a pipeline ruptured in Monroe, Louisiana.

November 30, 2010 - A 30-inch diameter gas pipeline failed at Natchitoches, Louisiana. There was no fire, but the pipeline had a Magnetic Flux smart pig test earlier in the year that indicated no flaws in the pipeline. The deadly 1965 gas pipeline accident occurred on a different pipeline owned by the same company nearby.

December 17, 2010 - A gas line fire and explosion just outside of Corpus Christi, Texas city limits left one person critically injured. A man was working on removing an abandoned pipeline when it exploded, and the man's face was severely burned.

December 28, 2010 - A pipeline at an underground gas storage facility in Covington County, Mississippi exploded forcing the evacuation of about 2 dozen families for over a week.

January 18, 2011 - A gas main being repaired in Philadelphia, Pennsylvania explodes, killing a repair crew member and injuring 6 others.

January 24, 2011 - Gas pressure regulators failed and caused a gas pressure surge in Fairport Harbor, Ohio causing gas fires in numerous homes, and one apartment. 7 homes were destroyed, and damaged 45 furnaces, 10 boilers, 19 water heaters, and 10 other gas appliances. Gas company Dominion East Ohio says it found fluids and debris in a failed regulator and is investigating how that happened.

February 10, 2011 - 5 people are killed and 8 homes are destroyed in an apparent gas explosion and fire in Allentown, Pennsylvania. The NTSB had warned UGI about cast iron gas mains needing replacement after the 1990 gas explosion in that city. Between 1976 and the date of the letter, July 10, 1992, two more gas explosions occurred. Three people were killed, 23 injured and 11 homes were destroyed or damaged in those explosions.

February 10, 2011 - A 36-inch diameter gas transmission pipeline exploded near Lisbon, Ohio. No injuries resulted.

March 17, 2011 - A 20-inch steel natural gas line running through a Minneapolis, Minnesota neighbourhood ruptured and gas from it ignited, caused evacuations to buildings nearby, and Interstate 35W was closed from downtown Minneapolis to Highway 62. There were no injuries.

CNG compression stations have been used in Southern Africa for the last 20 years. The first CNG compression station was built by SASOL Gas in 1995 in their refinery plant in Secunda. This CNG compression plant was used to fill vehicles and storage with CNG. A total of 10 million kilometres was done on vehicles for period of 3 years. In 1996 a CNG station was built in Sasolburg by SASOL Gas as secondary station for vehicles traveling between Secunda and Sasolburg. In this time no risk incidents were recorded or any injuries related to CNG compression station operation. During the same period two CNG stations were built in Brakpan and Krugersdorp for compression of upgraded biogas from landfill gas and waste water works. This two sites supplied CNG to dump trucks and LDV used by council for period of 3 years.

In Mozambique the next CNG compression station was built and operated by 2005. This CNG station in Matola near Maputo was built by Matola Gas Company (MGC) to supply compressed natural gas via mobile storage to industrial customers in and around Maputo. This station since 2007 also supply CNG for vehicle filling and also supplies CNG via road to Autogaz Maputo for filling of vehicles inside Maputo currently filling nearly 1500 vehicles and 150 busses. Since 2013 three more CNG refuelling stations were built in and around Maputo. Currently to date no major incidents occurred during operation of facilities in Mozambique.

In South Africa methane explosions in the mines, especially coal mines, resulted in major incidents.

Based on reports from international CNG associations and industries there are apart from the pipeline explosions mentioned above, no record of major incidents in the CNG industry and the only recorded incidents with no fatalities is related to vehicle system failures meaning only CNG systems on vehicles.

From the above it is clear the vapour cloud explosions (VCE) are the most hazardous incidents associated with natural gas especially where it is ignited in enclosed environments. As methane is lighter than air, any release will result in the released gas moving upwards and disperse more than for instance a gas heavier than air that will tend to gather at lower levels.

3.1.2 Plant Layout and Description

The plant layout is shown in Figure 3.1.

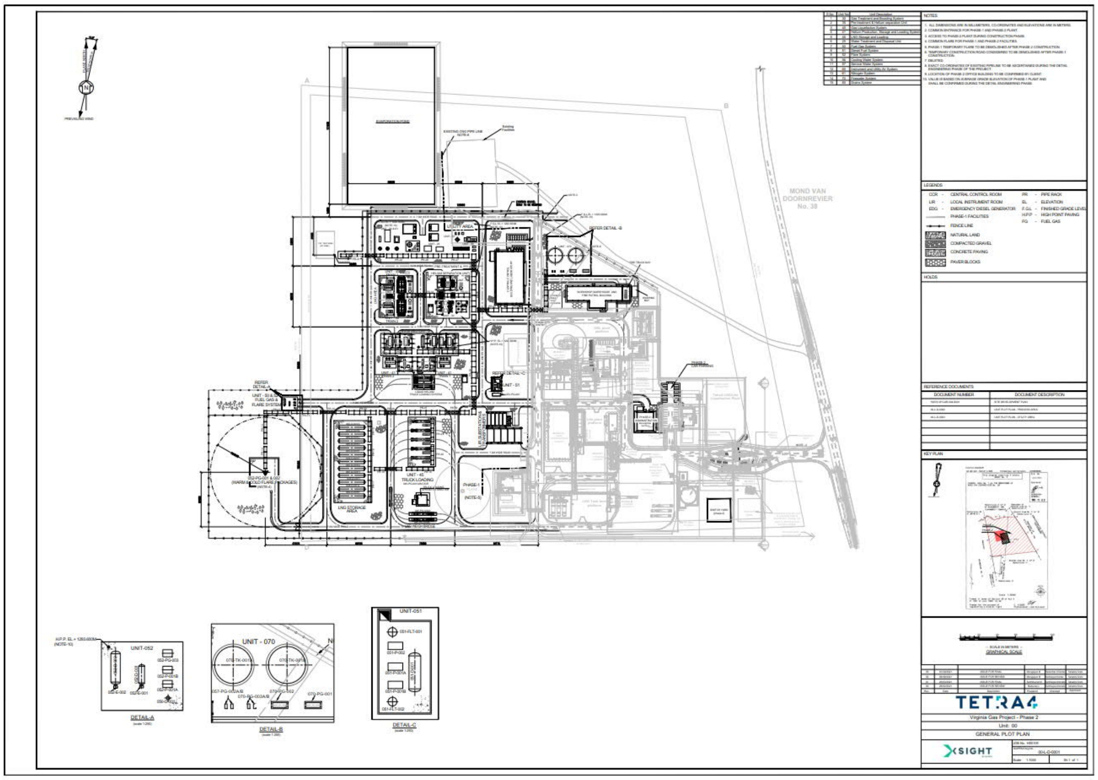


Figure 3.1a Site layout

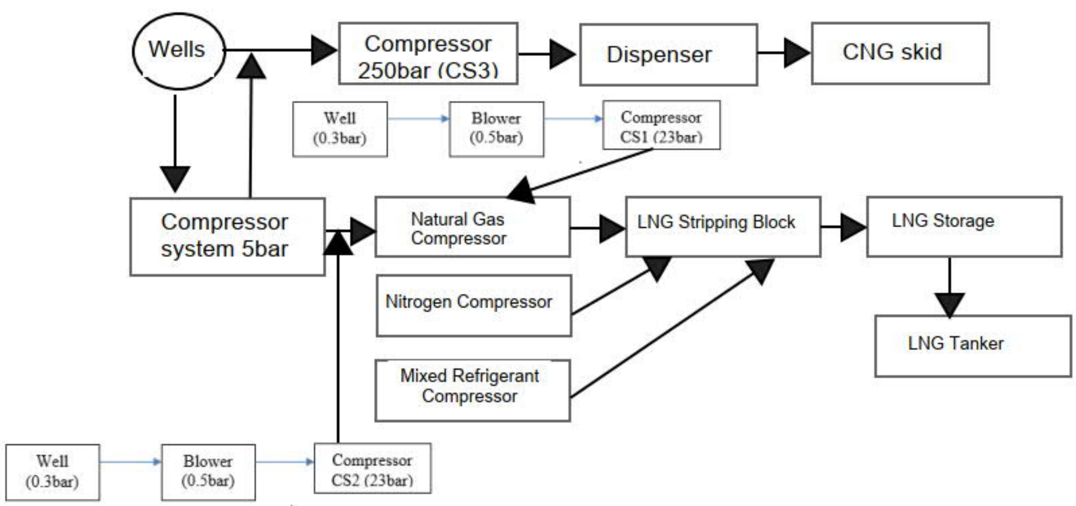


Figure 3.1b CNG LNG facility block diagram

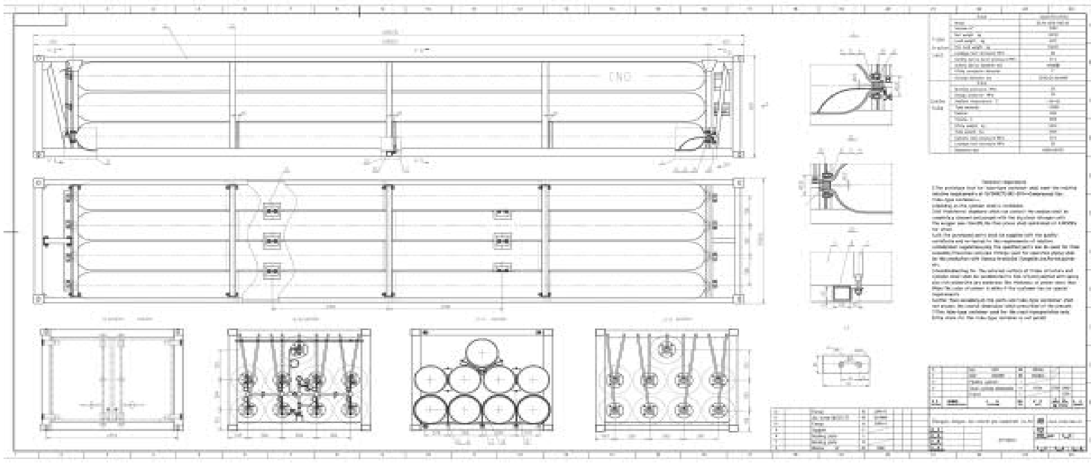


Figure 3.1c Nine tube skid general drawing

Natural gas is withdrawn from a well at a pressure of approximately 19kPa. The gas is then compressed to 250barg and supplied via a dispenser to a 9 tube CNG skid.

The natural gas from the well is also supplied to a compressor system where it will be compressed to approximately 5barg, which is then supplied to a natural gas compressor and compressed to approximately 50bar to the LNG stripping block. Liquid nitrogen and mixed refrigerants is then used to cool the natural gas to -162°C . The liquefied natural gas is the fed to three LNG cryogenic storage tanks, from where it is loaded into LNG road tankers.

From the compressor system natural gas at a pressure of approximately 5barg is also supplied to the CNG compressor in the event where a capacity increase is needed at the CNG facility.

3.2 Hazard Analysis

3.2.1 Accidental release of CH_4

For the risk assessment the following scenarios were considered.

1) Rupture of a 12 mm pigtail pipeline on the trailer system (all cylinders filled to full capacity) and the slam shut valves fails to close on the initial high flow rate, resulting in one cylinder releasing its contents through a 12mm hole and the eight other cylinders releasing their contents via the header through a 12mm hole, or failure of the 12mm pipeline, from the dispenser to the nine cylinder skid, with a resultant average release rate of approximately 2000g/s.
2) Release through a 25mm hole in one of the CNG cylinders at a rate of 3200g/s.

3) Instantaneous release of the contents of a CNG cylinder at an average release rate of 7300g/s.

4) Jet flame from a 12mm hole.
5) Full bore rupture of the pipeline between the natural gas compressor (50barg) and the LNG stripping block.
6) BLEVE from a 100m^3 LNG cryogenic storage tank
7) BLEVE from an LNG cryogenic road tanker
8) Pool fire due to a catastrophic failure of a 100m^3 cryogenic container into a bunded area.
9) BLEVE from a 300m^3 LNG cryogenic storage tank
10) Pool fire due to a catastrophic failure of a 300m^3 cryogenic container into a bunded area.

3.3 Consequence Analysis

For this consequence analyses a Gaussian dispersion model based on the methodology as described in CPR 14E is used, as well as Fault Tree Analysis (Reliability Workbench) to determine the consequences and associated probabilities of occurrence.

For the analysis is done for the four atmospheric conditions 3B, 5D, 5E and 1.5F

3.3.1 Scenario 1

Rupture of a 12 mm pigtail pipeline on the trailer system (all cylinders filled to full capacity) and the slam shut valves fails to close on the initial high flow rate, resulting in one cylinder releasing its contents through a 12mm hole and the eight other cylinders releasing their contents via the header through a 12mm hole, with a resultant average release rate of approximately 2000g/s, or the failure of the 12mm pipeline, from the dispenser to the connecting valve on the trailer, , resulting in in an average release of approximately 2000g/s

The vapour clouds resulting from such a release are shown in figures 3.2, 3.3, 3.4 and 3.5 for the four different atmospheric conditions.

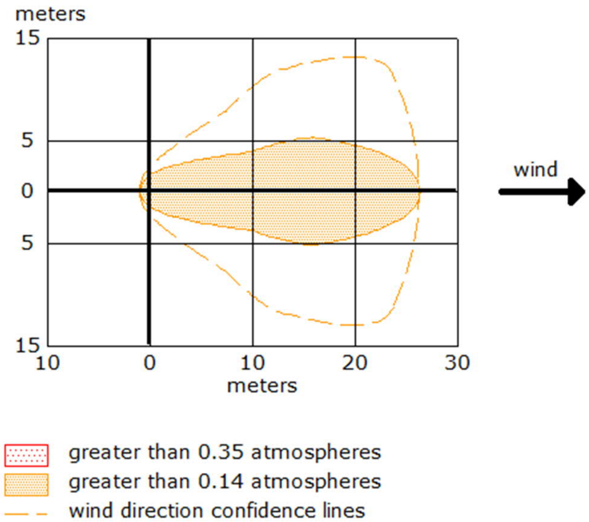


Figure 3.2 VCE under atmospheric stability 3B

It follows from Figure 3.2 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 26.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

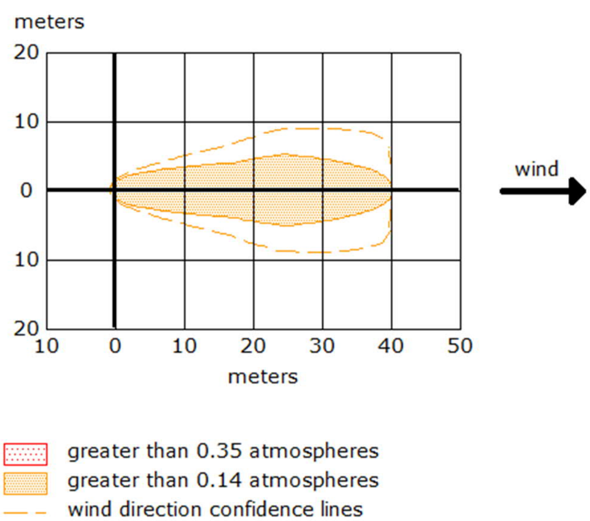


Figure 3.3 VCE under atmospheric stability 5D

It follows from Figure 3.3 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 40.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

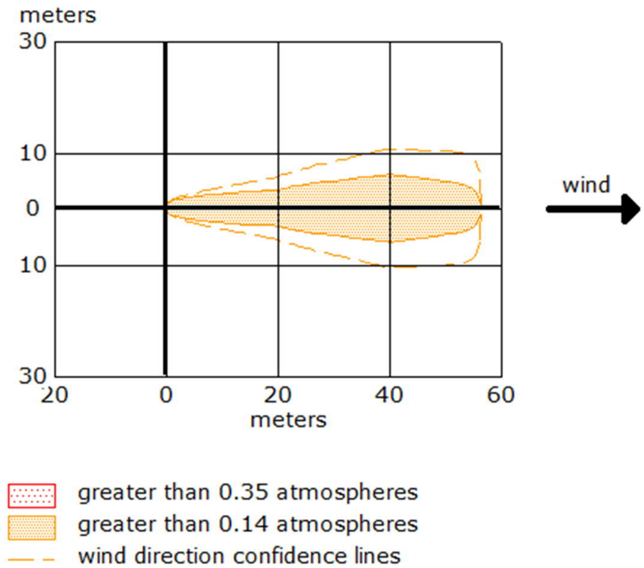


Figure 3.4 VCE under atmospheric stability 5E

It follows from Figure 3.4 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 57.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

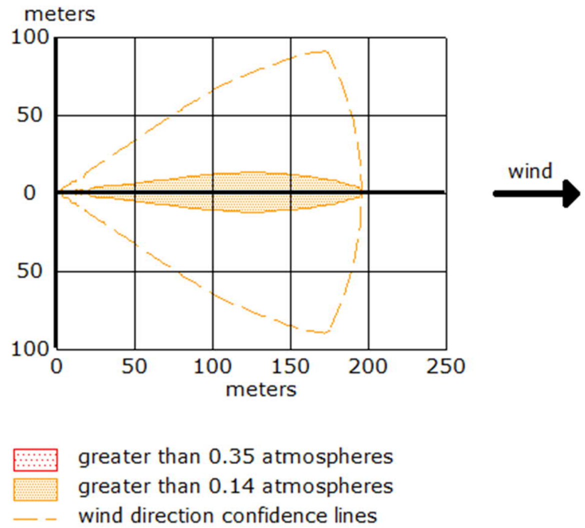


Figure 3.5 VCE under atmospheric stability 1.5F

It follows from Figure 3.5 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 196.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

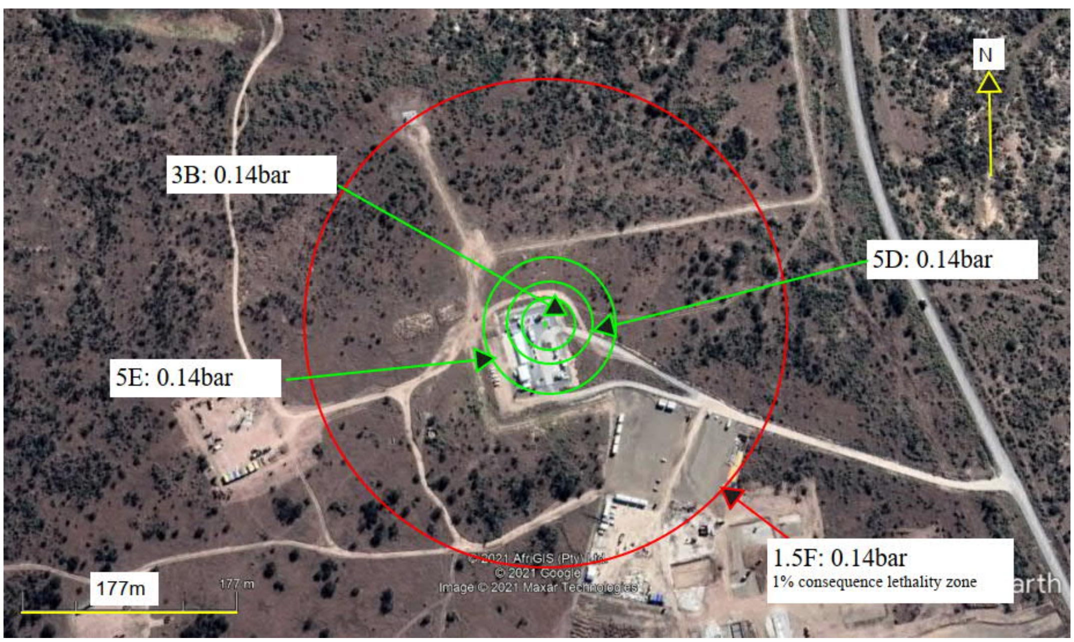


Figure 3.6 Overpressure levels for the different weather stabilities superimposed on the CNG facility

3.3.2 Scenario 2

Release of CH_4 at a rate of 3200g/s, due to a 25mm hole in one of the CNG cylinders

The vapour clouds resulting from such a release are shown in figures 3.7, 3.8, 3.9 and 3.10 for the four different atmospheric conditions.

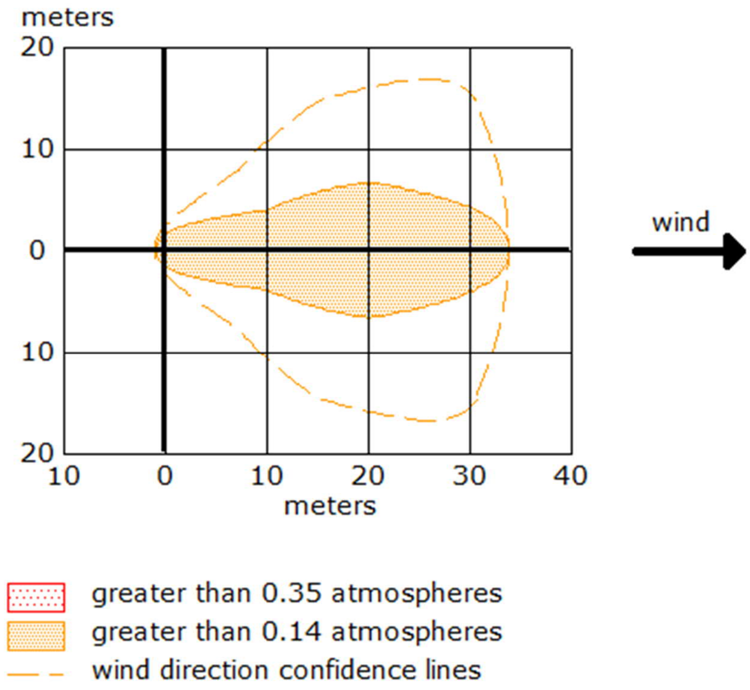


Figure 3.7 VCE under atmospheric stability 3B

It follows from Figure 3.7 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 34.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

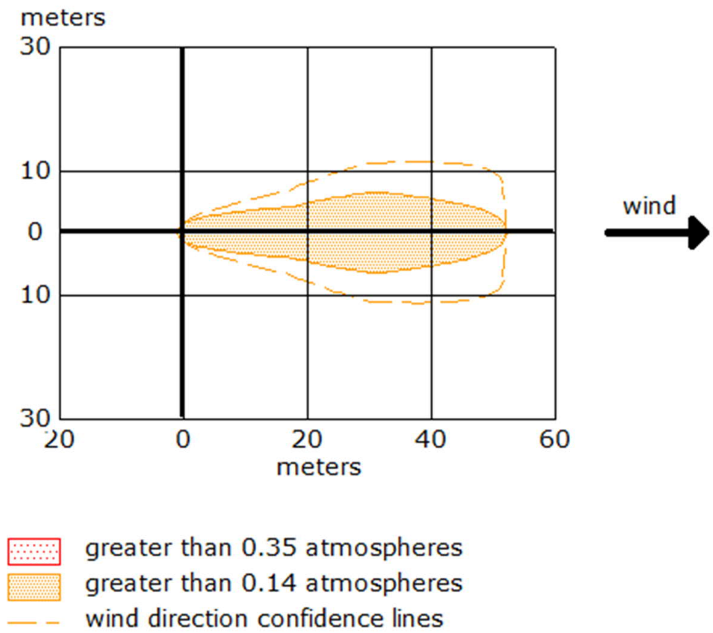


Figure 3.8 VCE under atmospheric stability 5D

It follows from Figure 3.8 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 52.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

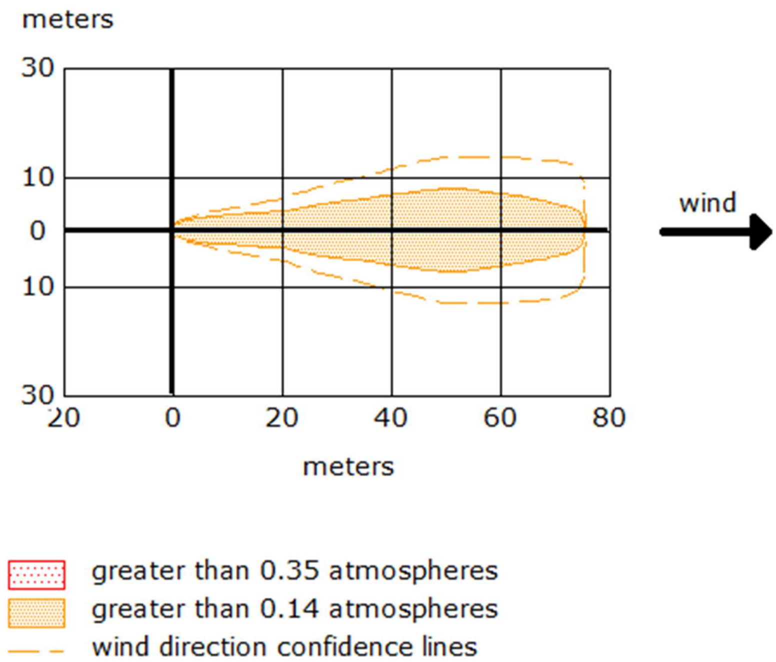


Figure 3.9 VCE under atmospheric stability 5E

It follows from Figure 3.9 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 76.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

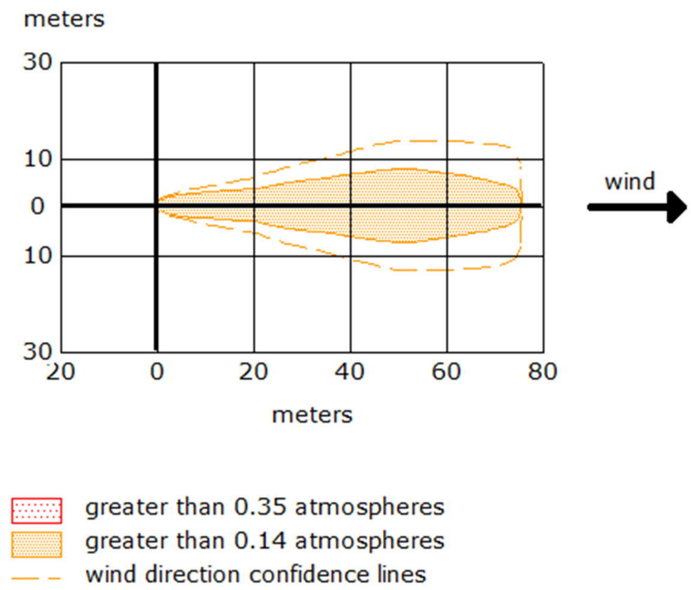


Figure 3.10 VCE under atmospheric stability 1.5F

It follows from Figure 3.10 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 252.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

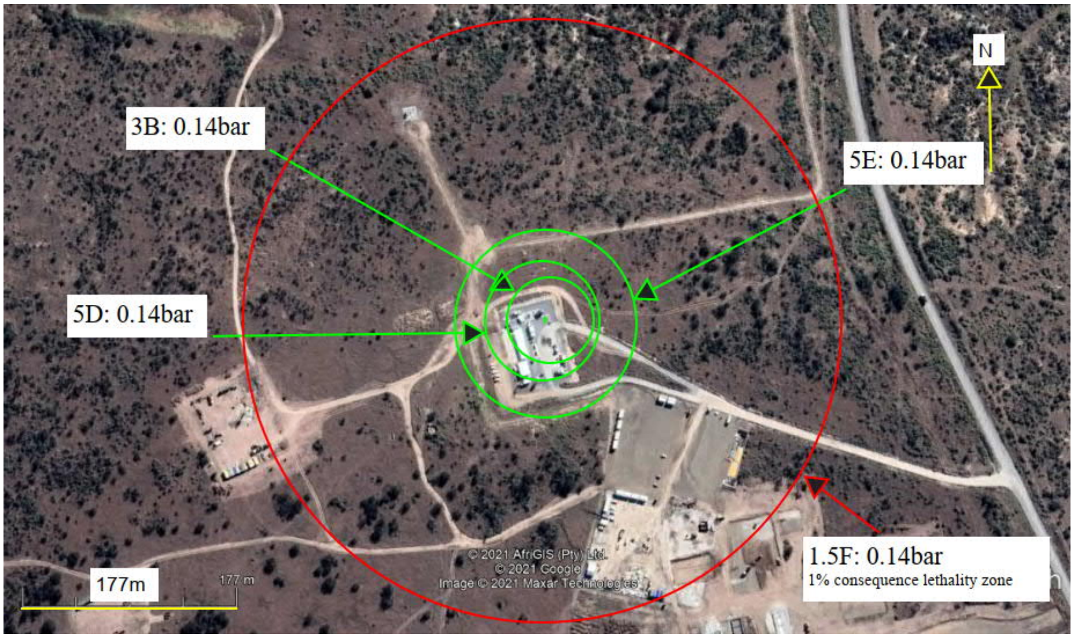


Figure 3.11 Overpressure levels for the different atmospheric stabilities superimposed on the CNG facility

3.3.3 Scenario 3

Release of CH_4 at a rate of 7300g/s, due to an instantaneous release of the total contents of a CNG cylinder.

The vapour clouds resulting from such a release are shown in figures 3.12, 3.13, 3.14 and 3.15 for the four different atmospheric conditions.

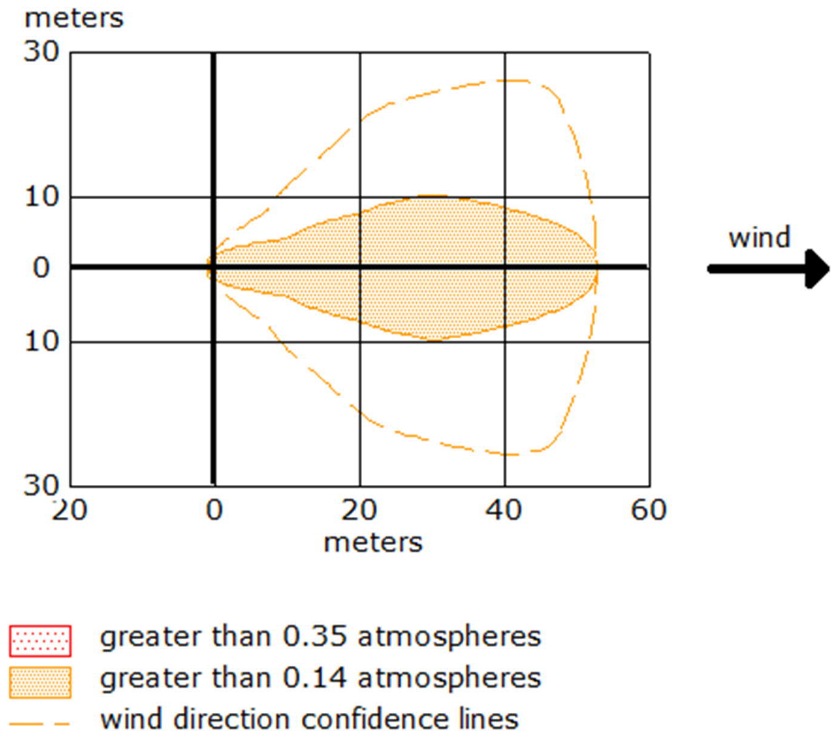


Figure 3.12 VCE under atmospheric stability 3B

It follows from Figure 3.12 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 53.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

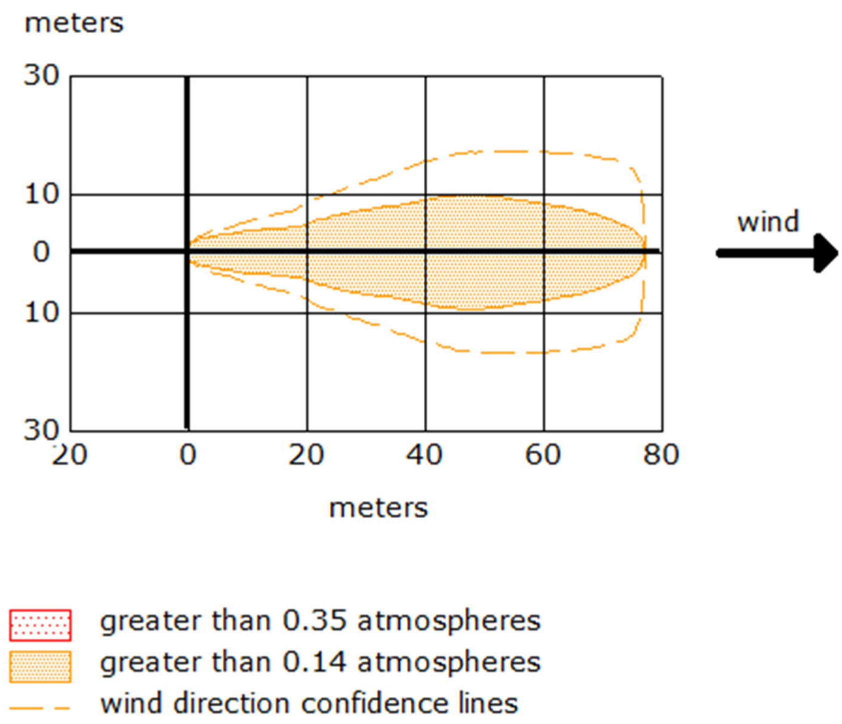


Figure 3.13 VCE under atmospheric stability 5D

It follows from Figure 3.13 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 78.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

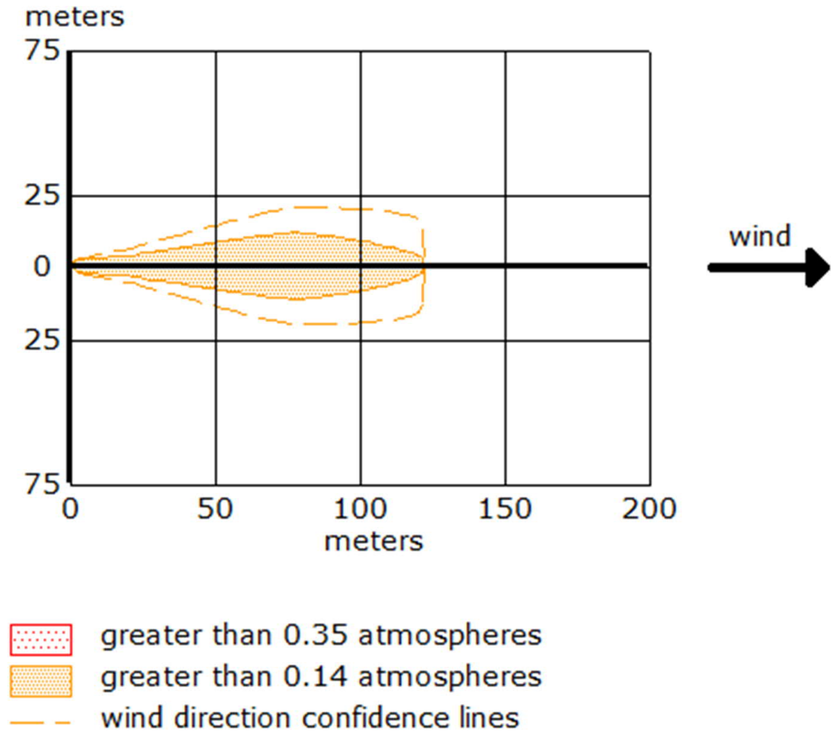


Figure 3.14 Isopleths for the explosive part of the CH_4-plume for atmospheric stability 5E

It follows from Figure 3.14 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 123.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

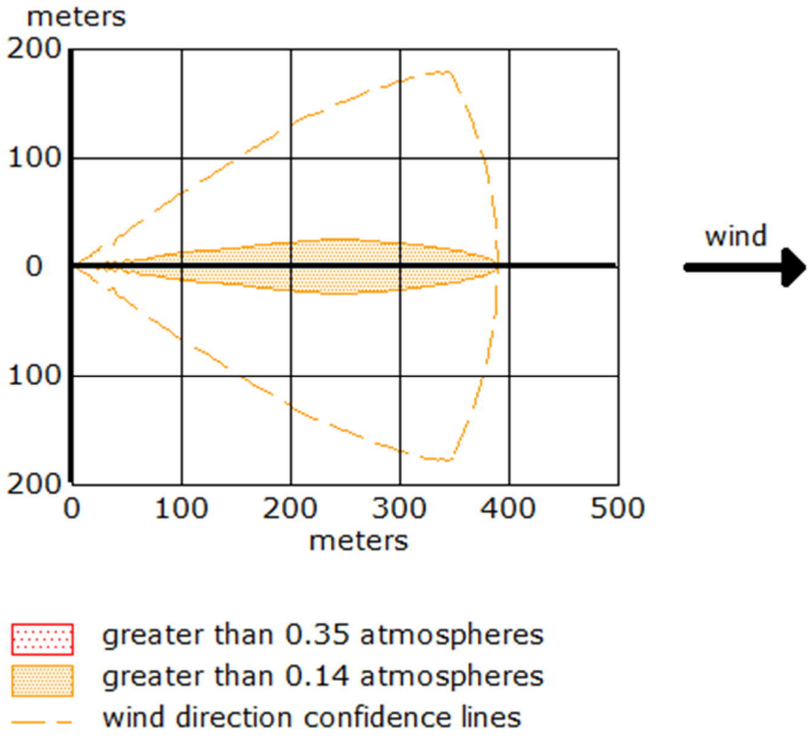


Figure 3.15 VCE under atmospheric stability 1.5F

It follows from Figure 3.15 that the following explosion overpressures will be present due to VCE:

- An over pressure of 0.14 bar occurs at a distance of 392.0m from the point of release. At this overpressure, minor damage to process equipment and less than 1% fatalities may occur.

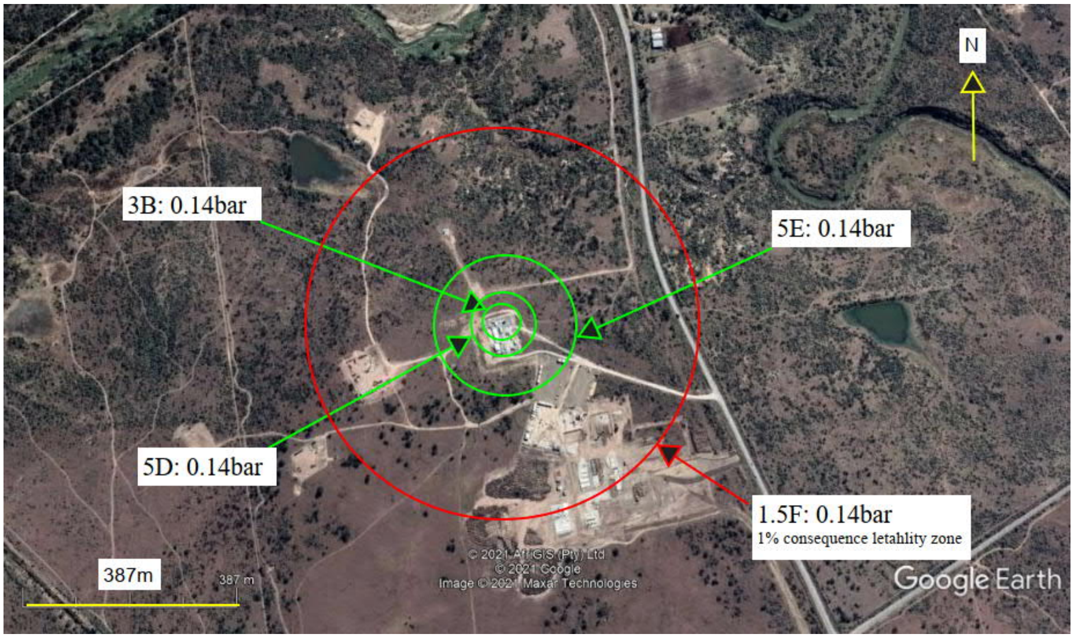


Figure 3.16 Overpressure levels for the different atmospheric stabilities superimposed on the CNG facility

3.3.4 Scenario 4: *Accidental release of methane through a 12mm hole resulting in a jet flame.*

The jet flame from a 12mm line failure at a pressure of 250bar, and a relative humidity of 50%, will have an approximate flame length of 5m.

The heat radiation from such a jet flame is shown in Figure 3.17.

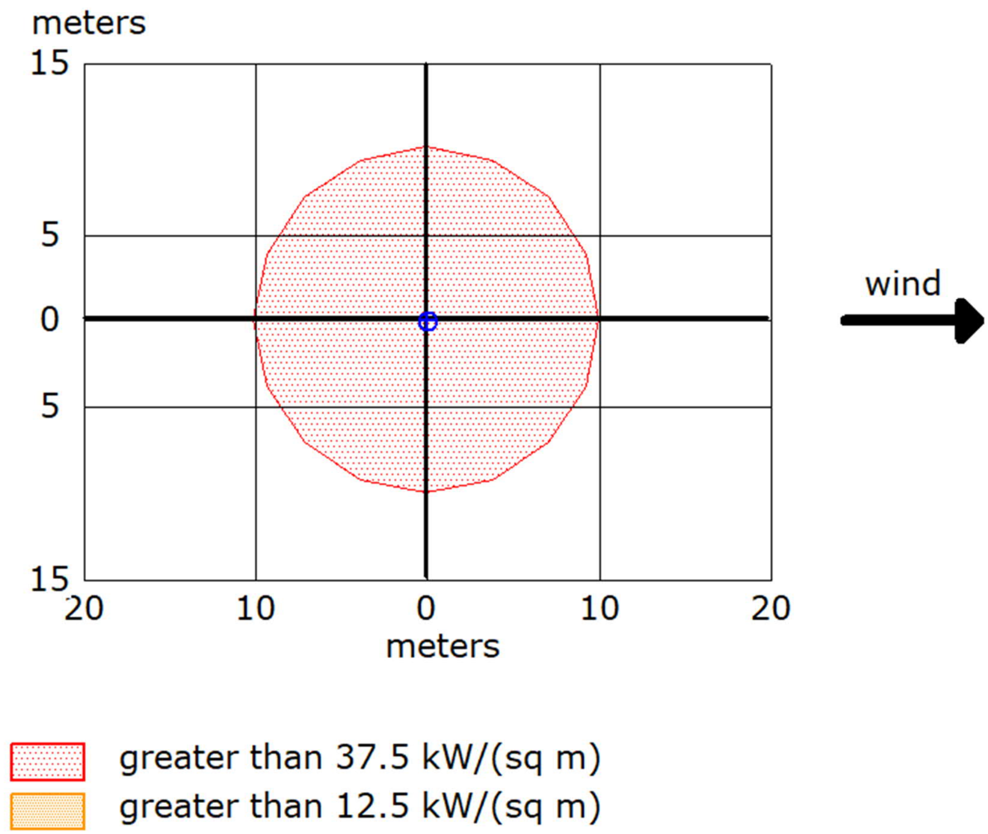


Figure 3.17 Heat radiation from jet flame

It follows from Figure 3.17that the following heat radiation levels will be present due to a jet flame.

- Heat radiation of 37.5kW/m^2 at a distance 10.0m from the centre of the fireball. This heat intensity (37.5kW/m^2) is sufficient to damage process equipment and result in 100% fatalities within one minute. A fuel tank of a vehicle exposed to such a radiation level can explode.
- Heat radiation of 12.5kW/m^2 up to a distance 10.0m from the centre of the fireball. This heat intensity is sufficient to ignite wood or melt plastic and may result in 1% fatalities within one minute.

For a 25mm hole the jet flame will have approximately the same radiation level distances, but the flame length will be approximately 6m.

3.3.5 Scenario 5: Full bore rupture of the 75mm pipe at 50 barg between the natural gas compressor and the LNG stripper block, resulting in a jet flame.

The jet flame from a 75mm pipeline at a pressure of 50bar, and a relative humidity of 50%, will have an approximate flame length of 8m.

The heat radiation from such a jet flame is shown in Figure 3.18.

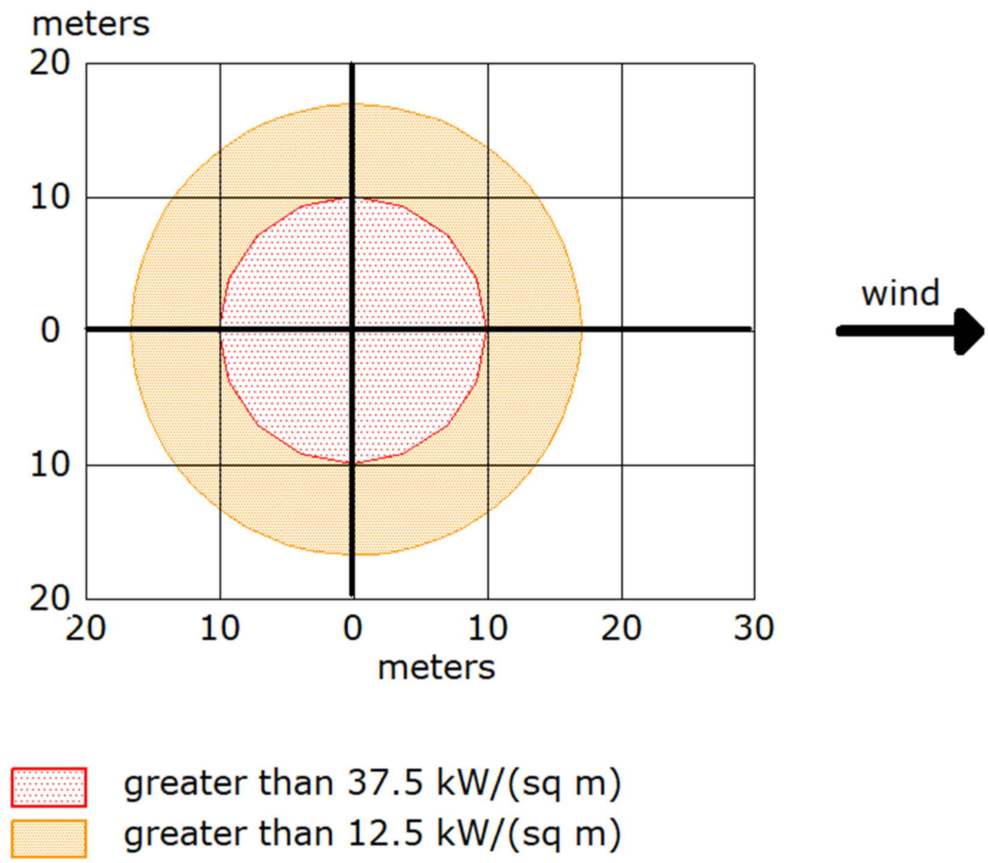


Figure 3.18 Heat radiation from jet flame

It follows from Figure 3.18 that the following heat radiation levels will be present due to a jet flame.

- Heat radiation of 37.5kW/m^2 at a distance 10.0m from the centre of the fireball. This heat intensity (37.5kW/m^2) is sufficient to damage process equipment and result in 100% fatalities within one minute. A fuel tank of a vehicle exposed to such a radiation level can explode.
- Heat radiation of 12.5kW/m^2 up to a distance 17.0m from the centre of the fireball. This heat intensity is sufficient to ignite wood or melt plastic and may result in 1% fatalities within one minute.

3.3.6 Scenario 6: BLEVE from a 100m^3 LNG Container

Failure of the cryogenic process on a filled 100m^3 cryogenic container will result in the contents of the container to heat up with subsequent increase in pressure. The container operates under low-t-medium pressure, but is protected from over pressurization by a dual relief valve and rupture disc system. In the event where the pressure will rise above a certain level the PRV's on the container should open for a while to reduce the pressure. As methane is lighter than air, this release will not result in any accident and if ignited during release will result in a jet flame, if immediate ignition takes place, directed away from the IOS container.

In the event where the cryogenic system fails and the PRV's are failed and the container cannot be decanted timeously a BLEVE may result.

The radius of the fireball was calculated to be 101.5m and the duration of such a fire ball will be 13.0s. Figure 3.19 presents the heat load as a function of the distance from the centre of the explosion due to a BLEVE.

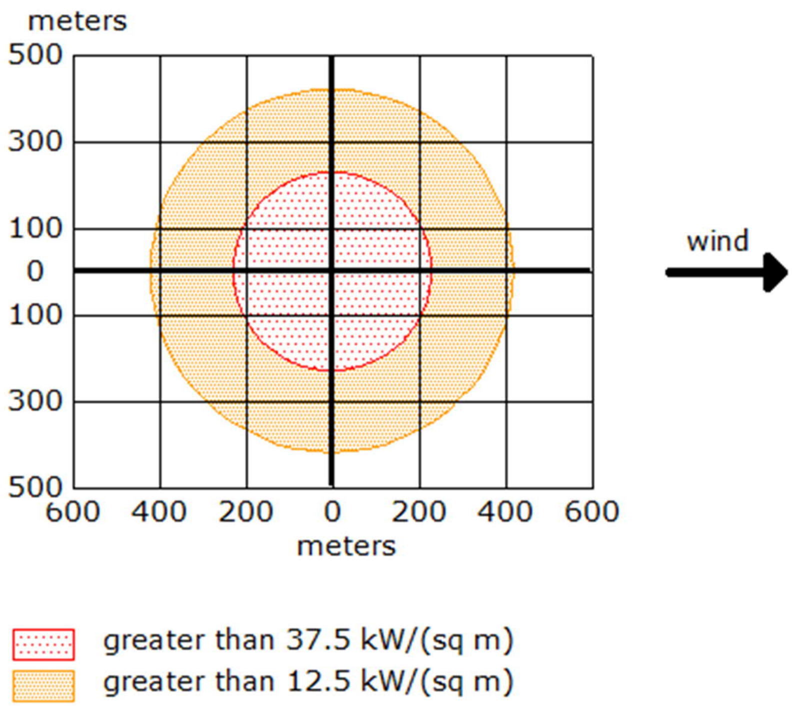


Figure 3.19. Heat load as a function of the distance from the centre of the fireball

It follows from Figure 3.19 that the following heat radiation levels will be present:

- Heat radiation of 37.5kW/m^2 at a distance of 229m from the centre of the fireball. This heat intensity is sufficient to damage process equipment and result in 100 % fatalities within one minute. A fuel tank of a vehicle exposed to such a radiation level can explode.

- Heat radiation of 12.5kW/m^2 up to a distance 420m from the centre of the fireball. This heat intensity is sufficient to ignite wood or melt plastic and may result in 1 % fatalities within one minute.

Figure 3.20 shows the radii of the thermal radiation and overpressure due to a BLEVE from a 100m^3 cryogenic container.

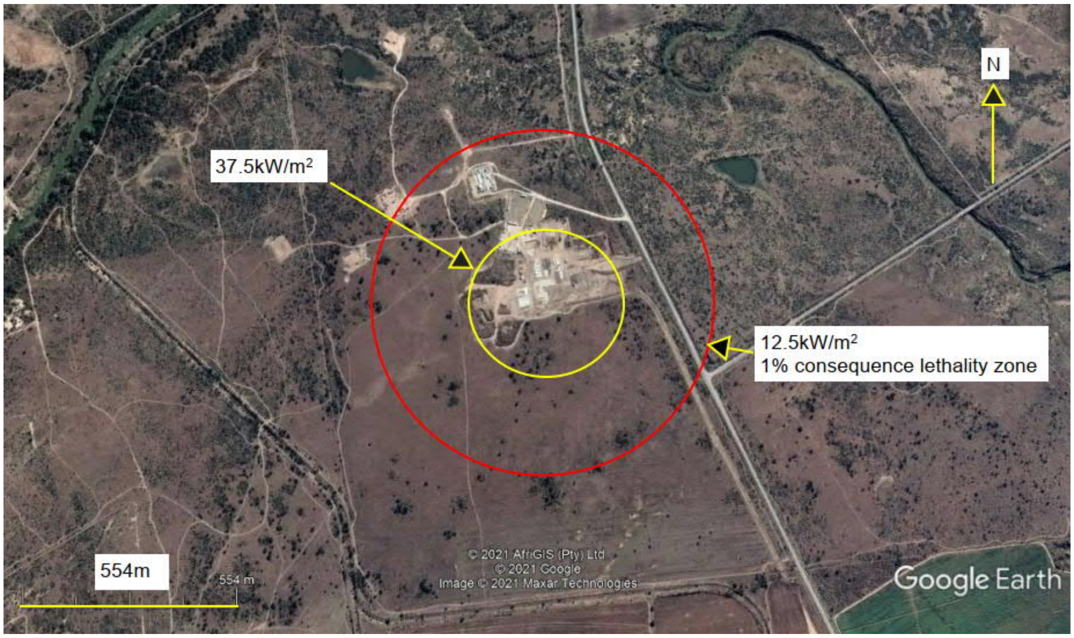


Figure 3.20: Heat radiation levels due to a BLEVE from a 100m^3 container

3.3.7 BLEVE from a 61.5m^3 LNG Cryogenic Road Tanker

Accidental failure of a 61.5m^3 LNG Cryogenic Tanker during normal operation resulting in a BLEVE.

The radius of the fireball was calculated to be 86.0m and the duration of such a fire ball will be 11.0s. Figure 3.21 presents the heat load as a function of the distance from the centre of the fireball.

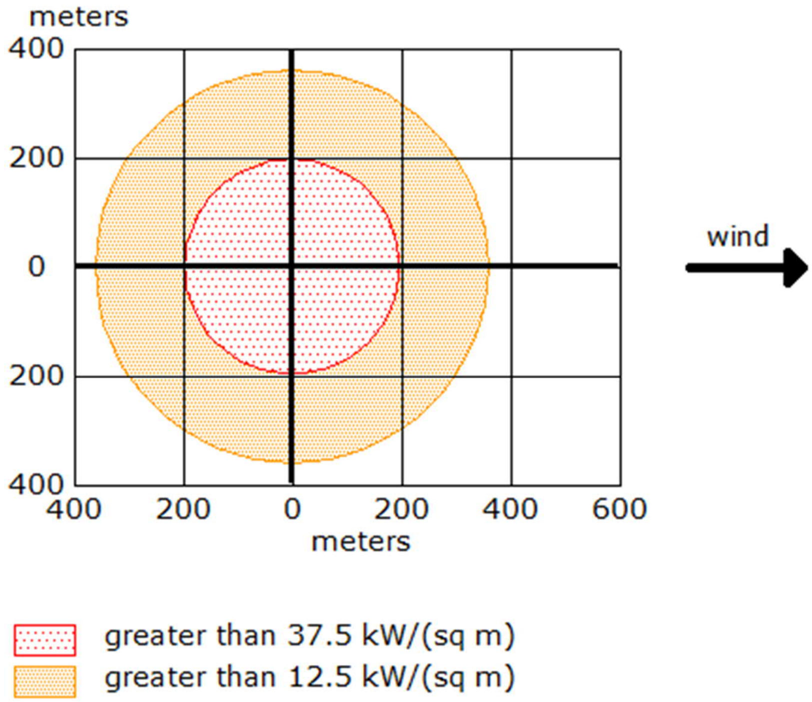


Figure 3.21 Heat load as a function of the distance from the centre of the fireball

It follows from Figure 3.21 that the following heat radiation levels will be present:

- Heat radiation of 37.5kW/m^2 at a distance of 140m from the centre of the fireball. This heat intensity is sufficient to damage process equipment and result in 100 % fatalities within one minute. A fuel tank of a vehicle exposed to such a radiation level can explode.
- Heat radiation of 12.5kW/m^2 up to a distance 360m from the centre of the fireball. This heat intensity is sufficient to ignite wood or melt plastic and may result in 1 % fatalities within one minute.

Figure 3.22 shows the radii of the thermal radiation and the overpressure due to a BLEVE from a 61.5m^3 cryogenic tanker

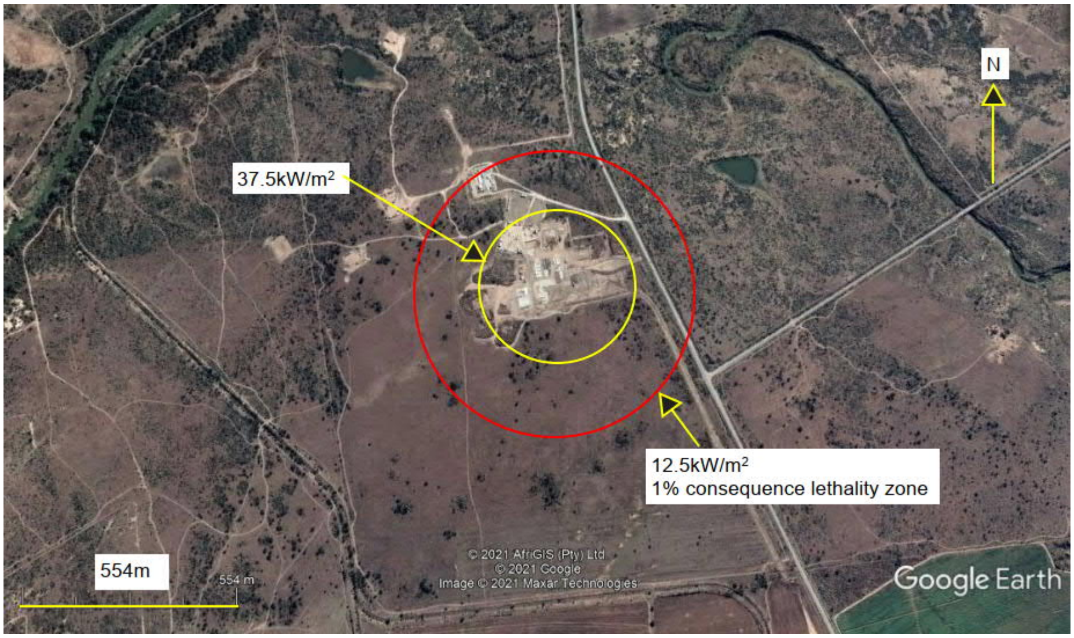


Figure 3.22: Heat radiation due to a BLEVE from a 61.5m^3 cryogenic tanker

3.3.8 Scenario 8: Catastrophic failure of a 100m^3 cryogenic container into the bunded area (23.4mx 23.5m) resulting in a pool fire.

In the event of a catastrophic failure of a 100m^3 cryogenic container into the bunded area a fire may result in the presence of an ignition source. Figure 3.23 shows the radiation levels of such a fire.

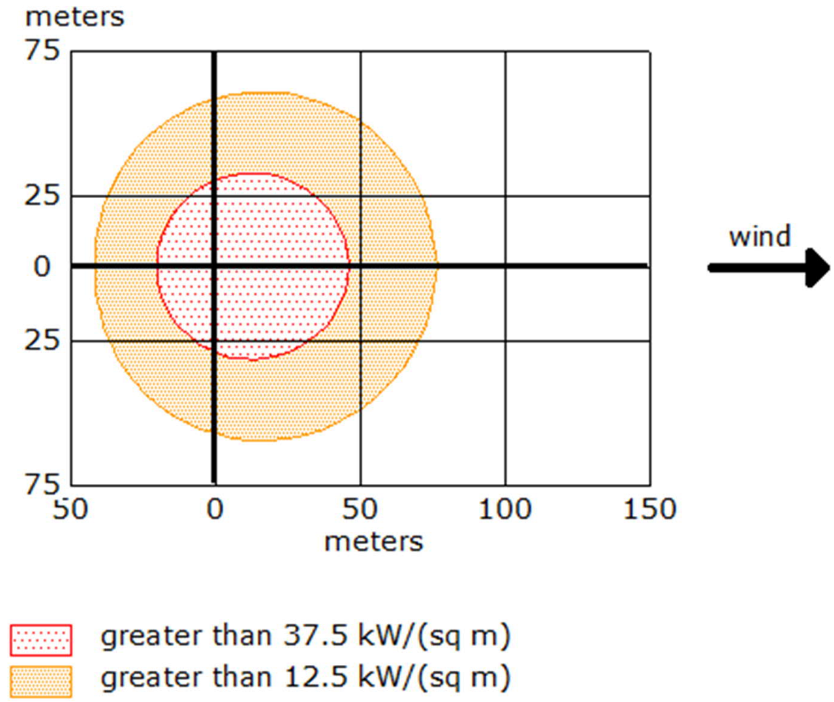


Figure 3.23 Thermal radiation levels from the pool fire under atmospheric stability 5D

It follows from Figure 3.23 that the following heat radiation levels will be present:

- Heat radiation of 37.5kW/m^2 at a distance of 47m from the centre of the fireball. This heat intensity is sufficient to damage process equipment and result in 100 % fatalities within one minute. A fuel tank of a vehicle exposed to such a radiation level can explode.
- Heat radiation of 12.5kW/m^2 up to a distance 77m from the centre of the fireball. This heat intensity is sufficient to ignite wood or melt plastic and may result in 1 % fatalities within one minute.

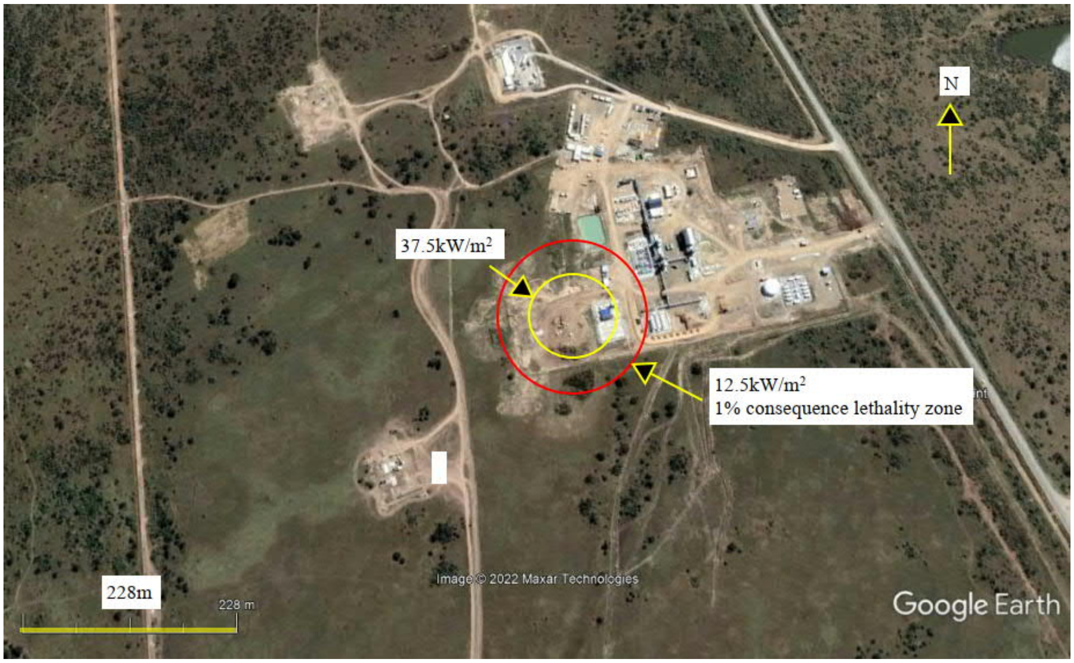


Figure 3.22: Heat radiation due to a pool fire at the 100m^3 LNG storage tanks

3.3.9 Scenario 9: BLEVE from a 300m^3 LNG Container

Failure of the cryogenic process on a filled 300m^3 cryogenic container will result in the contents of the container to heat up with subsequent increase in pressure. The container operates under low-t-medium pressure, but is protected from over pressurization by a dual relief valve and rupture disc system. In the event where the pressure will rise above a certain level the PRV's on the container should open for a while to reduce the pressure. As methane is lighter than air, this release will not result in any accident and if ignited during release will result in a jet flame, if immediate ignition takes place, directed away from the IOS container.

In the event where the cryogenic system fails and the PRV's are failed and the container cannot be decanted timeously a BLEVE may result.

The radius of the fireball was calculated to be 101.5m and the duration of such a fire ball will be 13.0s. Figure 3.23 presents the heat load as a function of the distance from the centre of the explosion due to a BLEVE.

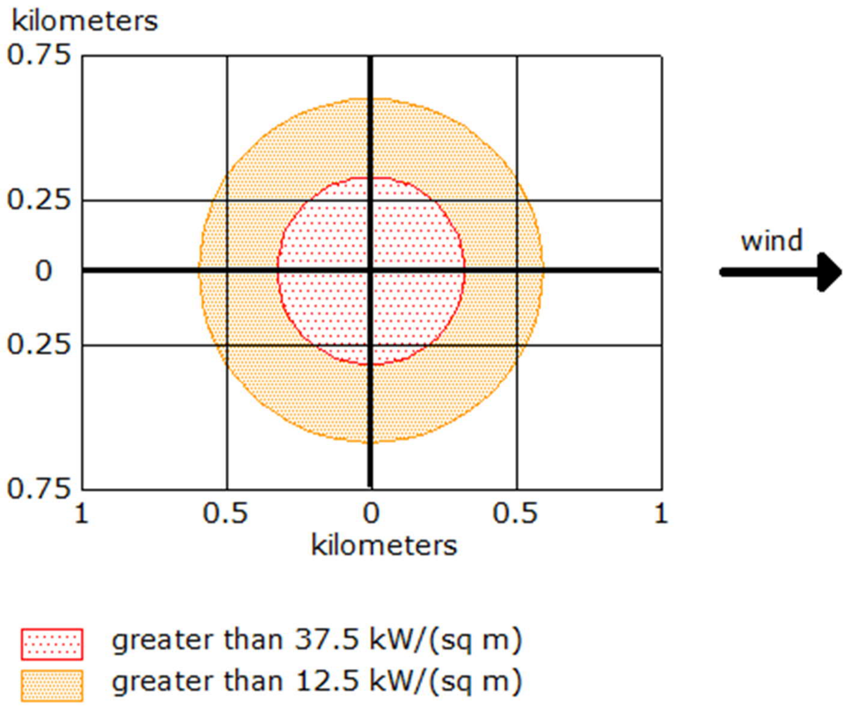


Figure 3.19. Heat load as a function of the distance from the centre of the fireball

It follows from Figure 3.23 that the following heat radiation levels will be present:

- Heat radiation of 37.5kW/m^2 at a distance of 324m from the centre of the fireball. This heat intensity is sufficient to damage process equipment and result in 100 % fatalities within one minute. A fuel tank of a vehicle exposed to such a radiation level can explode.
- Heat radiation of 12.5kW/m^2 up to a distance 594m from the centre of the fireball. This heat intensity is sufficient to ignite wood or melt plastic and may result in 1 % fatalities within one minute.

Figure 3.24 shows the radii of the thermal radiation levels due to a BLEVE from a 300m^3 cryogenic container.

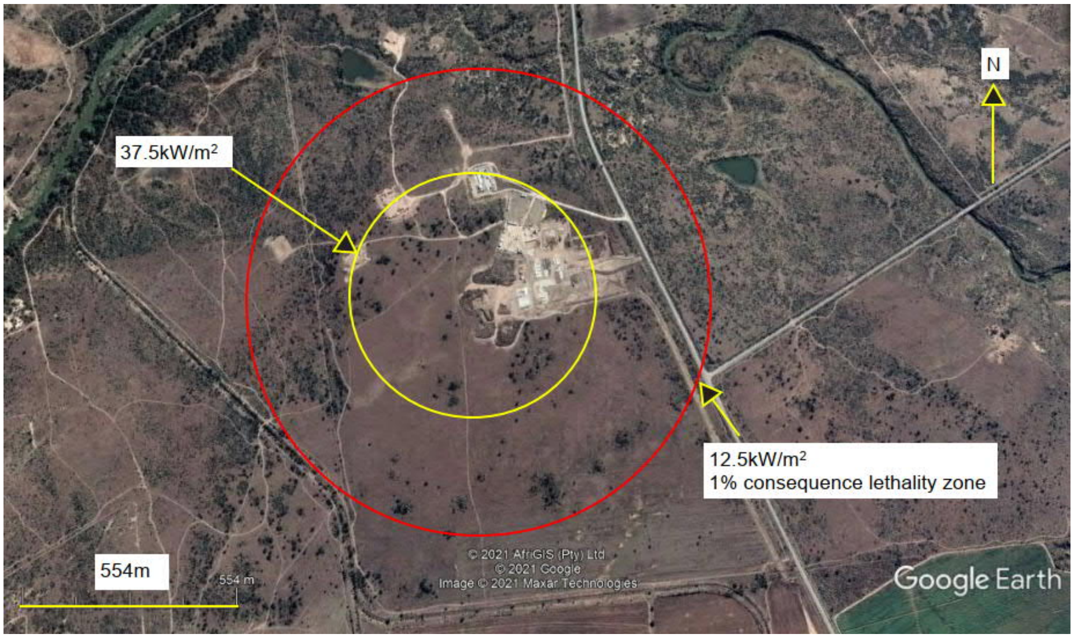


Figure 3.24: Heat radiation levels due to a BLEVE from a 300m^3 container

3.3.10 Scenario 10: Catastrophic failure of a 300m^3 cryogenic container into the bunded area (40mx 86m) resulting in a pool fire.

In the event of a catastrophic failure of a 100m^3 cryogenic container into the bunded area a fire may result in the presence of an ignition source. Figure 3.25 shows the radiation levels of such a fire.

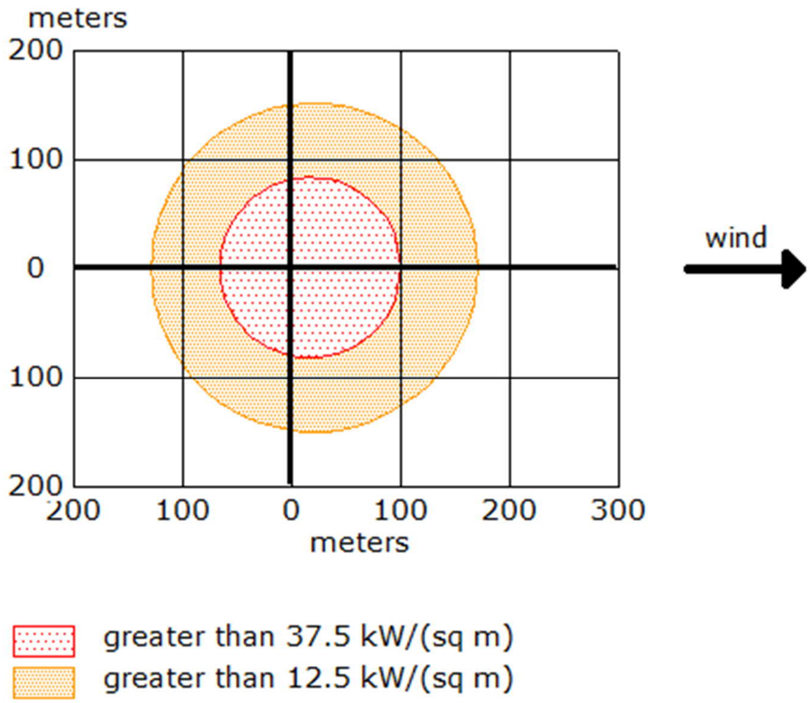


Figure 3.25 Thermal radiation levels from the pool fire under atmospheric stability 5D

It follows from Figure 3.25 that the following heat radiation levels will be present:

- Heat radiation of 37.5kW/m^2 at a distance of 101m from the centre of the fireball. This heat intensity is sufficient to damage process equipment and result in 100 % fatalities within one minute. A fuel tank of a vehicle exposed to such a radiation level can explode.
- Heat radiation of 12.5kW/m^2 up to a distance 171m from the centre of the fireball. This heat intensity is sufficient to ignite wood or melt plastic and may result in 1 % fatalities within one minute.

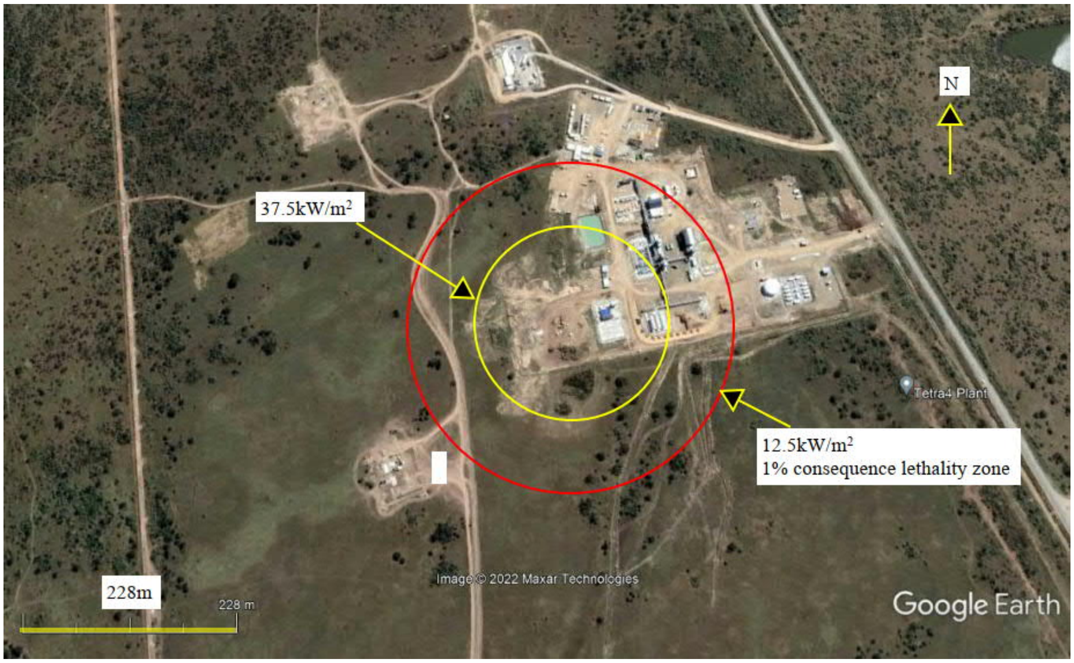


Figure 3.22: Heat radiation due to a pool fire at the 300m³ LNG storage tanks

3.4 Frequency Analysis

The following failure probabilities were used:

$P_{Scenario\ 1} = 3.5 \times 10^{-10}$ (Appendix A)

$P_{Scenario\ 2} = 5 \times 10^{-6}$ (Bevi)

$P_{Scenario\ 3} = 5 \times 10^{-7}$ (Bevi)

$P_{Scenario\ 4} = 1.0 \times 10^{-7}$ (Bevi)

$P_{Scenario\ 5} = 1.0 \times 10^{-7}$ (Bevi)

$P_{Scenario\ 6} = 3.0 \times 10^{-13}$ (Appendix A)

$P_{Scenario\ 7} = 8.0 \times 10^{-14}$ (Appendix A)

$P_{Scenario\ 8} = 1.0 \times 10^{-7}$ (Bevi)

$P_{Scenario\ 9} = 3.0 \times 10^{-13}$ (Appendix A)

$P_{Scenario\ 10} = 1.0 \times 10^{-7}$ (Bevi)

3.5 Risk Calculation

3.5.1 Individual Risk

These calculations were done with the following equation.

$$Risk_{WD}(x) = [\sum_{S=1}^{S=n} Pe\{aP_{3B}(x)+bP_{5D}(x)+cP_{5E}(x)+dP_{1.5F}(x)\}]P_{WD}$$

Where

$Risk_{WD}(x)$ = Risk of fatality in a specific wind direction

x = Distance from the point of release (m)

S = Scenario

n = number of scenarios

Pe = Probability of the accident scenario

a = Probability of atmospheric condition B, 3m/s prevailing

b = Probability of atmospheric condition D, 5m/s prevailing

c = Probability of atmospheric condition E, 5m/s prevailing

d = Probability of atmospheric condition F, 1.5m/s prevailing

P_{3B} = Probability of fatality under atmospheric condition B, 3m/s

P_{5D} = Probability of fatality under atmospheric condition D, 5m/s

P_{5E} = Probability of fatality under atmospheric condition E, 5m/s

$P_{1.5F}$ = Probability of fatality under atmospheric condition F, 1.5m/s

P_{WD} = Probability of the wind blowing in a specific direction

These calculations were done for the 16 main wind directions. The risk zones are shown in Figure 3.39.

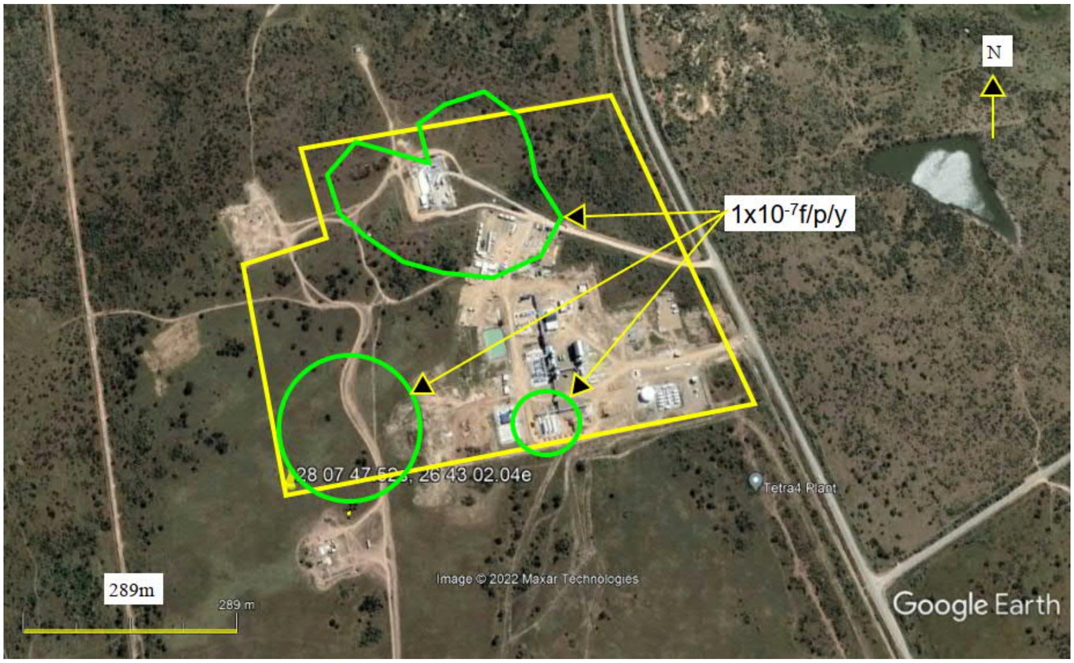


Figure 3.39: Risk Zones

The ALARP (as low as reasonably practicable) risk decision making frameworks as per SANS 1461:2018, are shown in Figure 3.40.

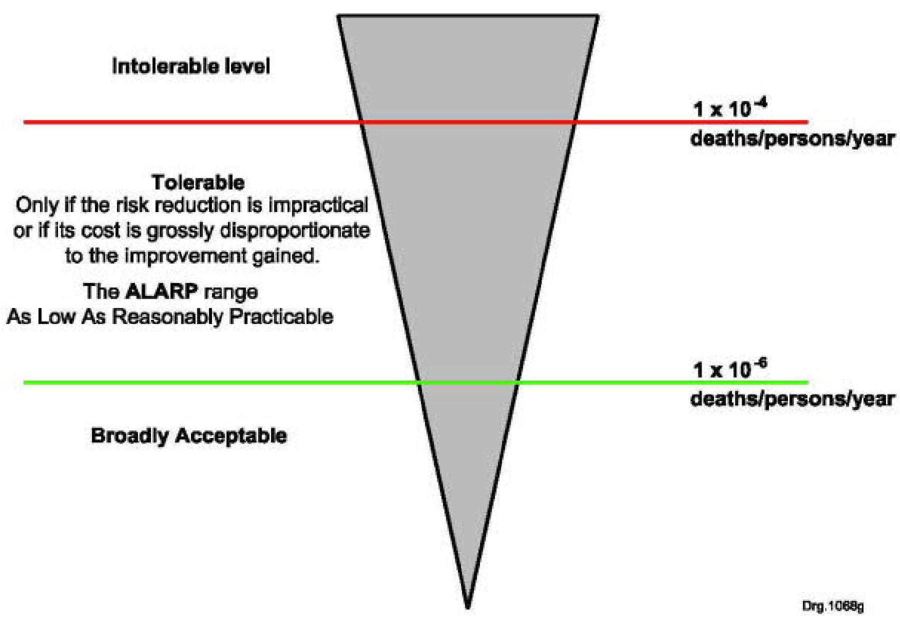


Figure 3.40a The Public ALARP Risk Decision Making Framework

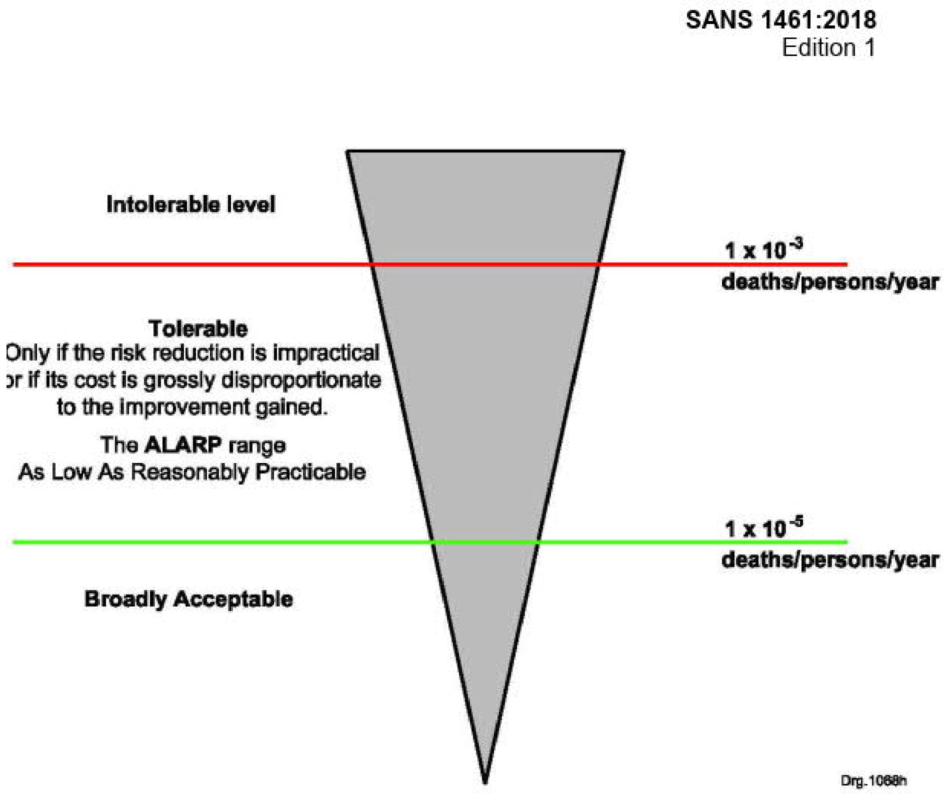


Figure 3.40b The Employee ALARP Risk Decision Making Framework

3.5.2 Societal Risk

The societal risk is normally presented by the so-called FN-curves. Where F is the cumulative frequency of events that may cause fatalities to the public and N represents the number of fatalities.

The societal risk, as shown in Figure 3.41, was calculated for the eight main wind directions.

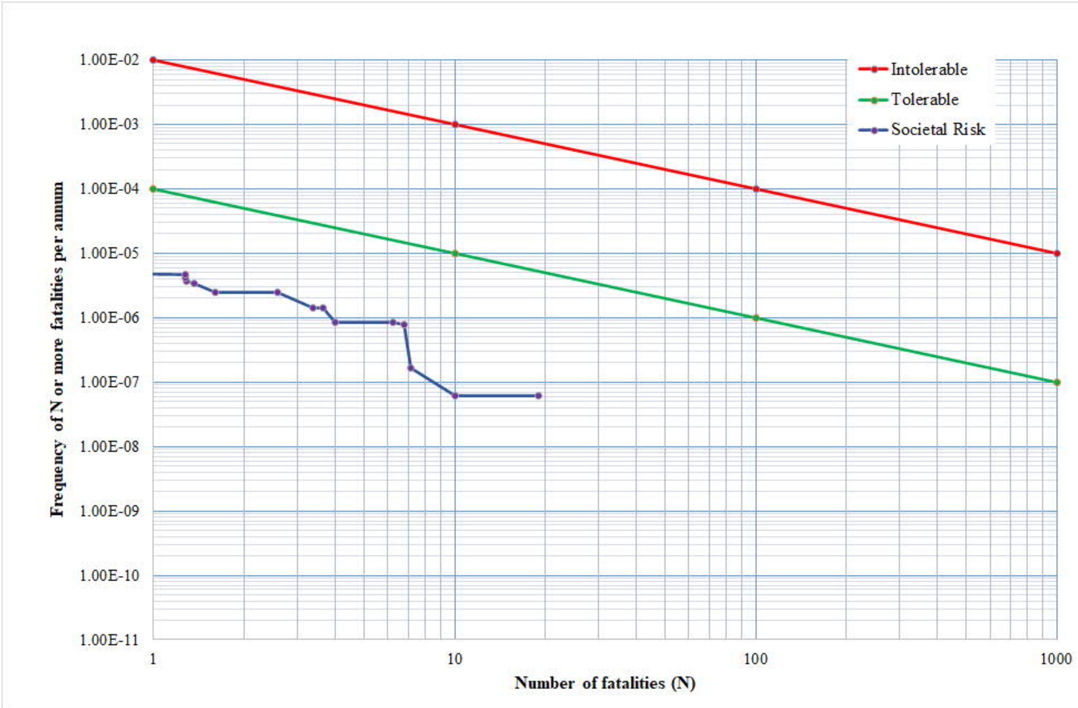


Figure 3.41 Societal risk as posed by the CNG and LNG facilities

3.6 Risk Judgement

It follows from the previous paragraphs that an accidental release of methane will not impact on any residential area or sensitive receptor.

3.7 Risk Treatment

In order to keep the risk as low as reasonably practicable (ALARP) the following is recommended.

- The maintenance plan for the CNG and LNG facilities to be maintained.
- The site emergency plan to be reviewed in accordance with SANS 1514:2018.

4.0 SITE EMERGENCY PLAN

The Site Emergency Procedure submitted to BIRA for evaluation and inclusion in this report is acceptable, but should be reviewed to comply to SANS 1514:2018 (Major Haard Installations: Emergency response Plan).

5.0 INFLUENCE ON OTHER MHI FACILITIES

Ther are no other MHI's in the close proximity of Tetra4.

6.0 ENVIRONMENTAL IMPACT

It is not foreseen that the accidental release of CH_4 will have any long term environmental impact.

7.0 LAND-USE PLANNING

There should not be any restriction on land-use planning outside the perimeter of Tetra4 except in the case of development within the 10^{-7}f/p/y risk zone (outer zone), where such development will involve vulnerable members of the public (children, those with mobility difficulties or those unable to recognise physical danger), in which case advise against development should be obtained from the local authorities.

8.0 CONCLUSION AND RECOMMENDATIONS

It is concluded as follows:

a) The hazardous installations addressed in this report are the only hazardous installations on the premises of Tetra4.
b) The maximum extend of the 1% consequence lethality zone is 594m, which will not impact on any residential area or sensitive receptor.
c) The risk posed to the public is lower than $1x10^{-7}$ f/p/y.
d) The societal risk is well below the tolerable level and thus broadly acceptable.
e) The maintenance plan for the CNG and LNG facilities to be maintained.
f) The site emergency plan to be reviewed in accordance with SANS 1514:2018.
g) Documentation for the storage of flammable material on site to be submitted to BIRA
h) There should not be any restriction on land-use planning outside the perimeter of Tetra4 except in the case of development within the 10^{-7}f/p/y risk zone, where such development will involve vulnerable members of the public (children, those with mobility difficulties or those unable to recognise physical danger), in which case advise against development should be obtained from the local authorities.
i) Tetra4 should be classified as an MHI.

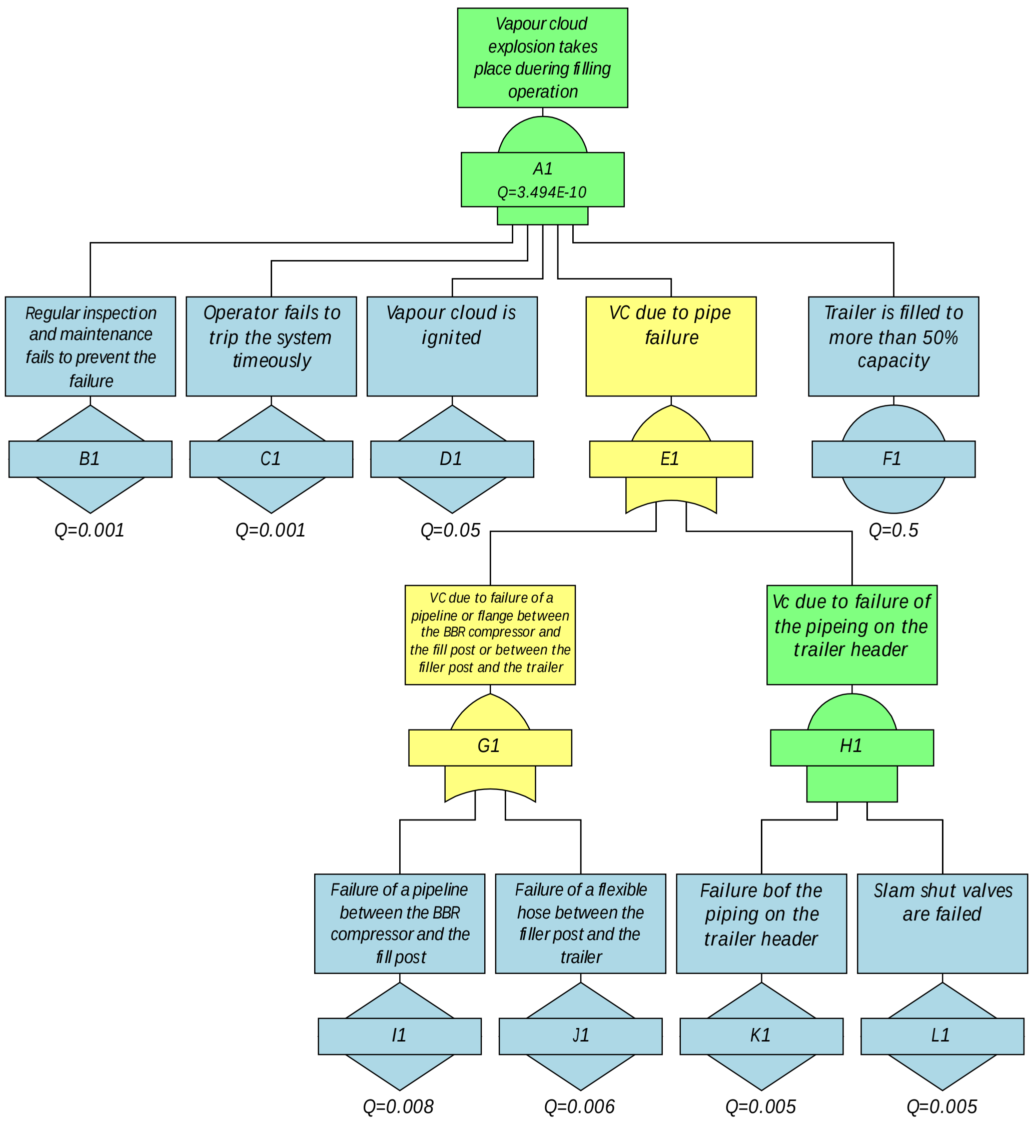
9.0 REFERENCES

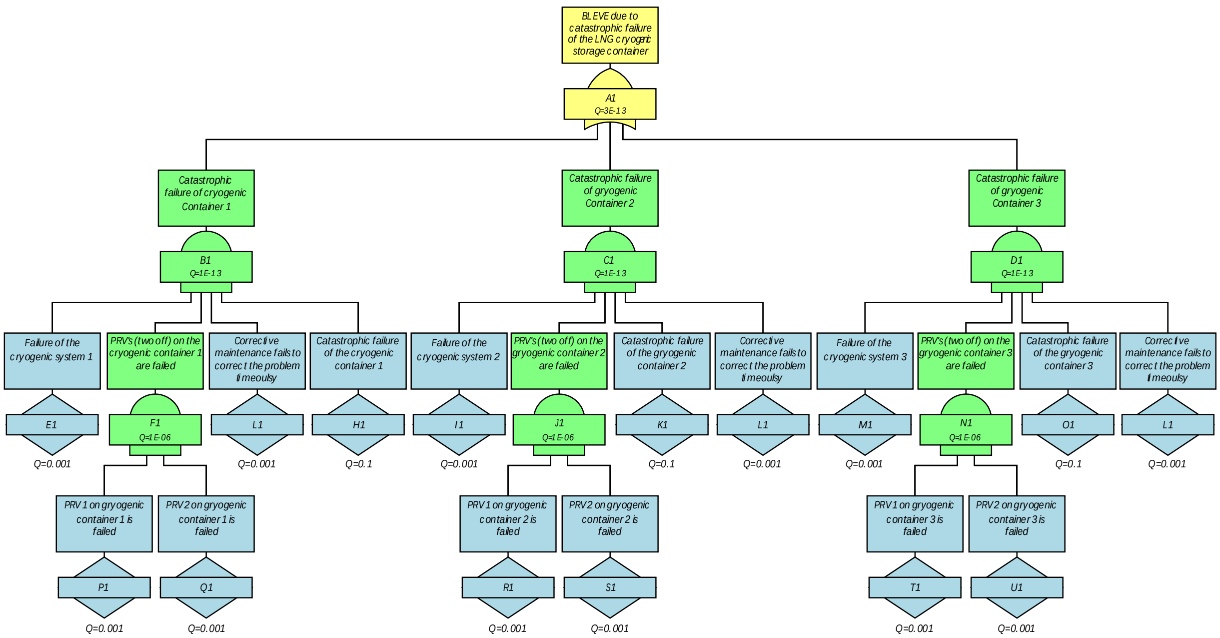
1. CPR 14E. 2005. Methods for the calculation of physical effects
2. NPRD Parts Library 2011 as published by Isograph limited.
3. 4 CPR 18E. 2005. Guidelines for Quantitative Risk Assessments

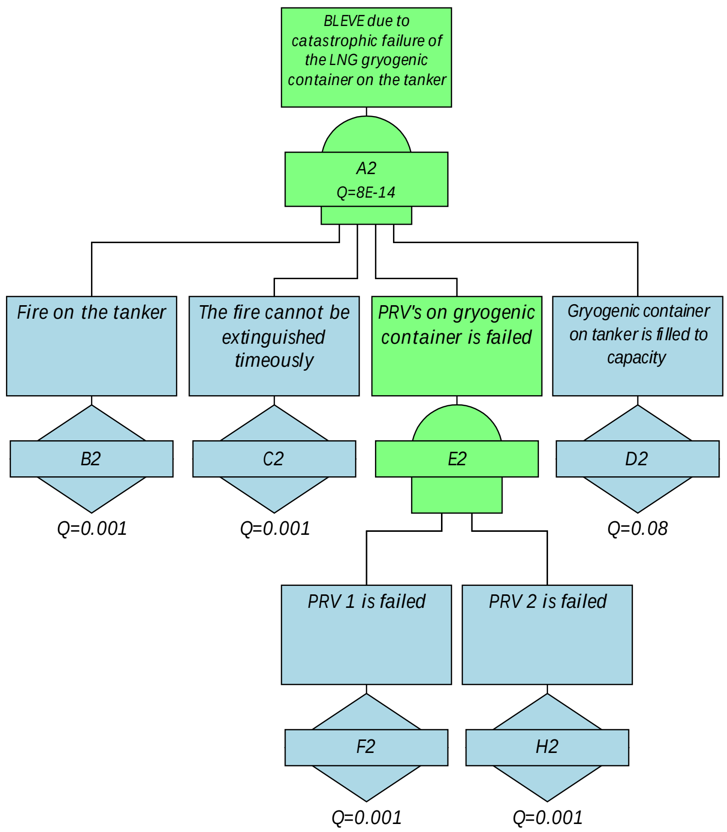
4. SANS 1461:2018. Major Hazard Installation Risk Assessments.

Appendix A

Fault Tree Analysis


Vapour cloud explosion takes place duering filling operation
A1
Q=3.494E-10
Regular inspection and maintenance fails to prevent the failure
Operator fails to trip the system timeously
Vapour cloud is ignited
VC due to pipe failure
Trailer is filled to more than 50% capacity
B1
C1
D1
E1
F1
Q=0.001
Q=0.001
Q=0.05
Q=0.5
VC due to failure of a pipeline or flange between the BBR compressor and the fill post or between the filler post and the trailer
Vc due to failure of the pipeing on the trailer header
G1
H1
Failure of a pipeline between the BBR compressor and the fill post
Failure of a flexible hose between the filler post and the trailer
Failure bof the piping on the trailer header
Slam shut valves are failed
I1
J1
K1
L1
Q=0.008
Q=0.006
Q=0.005
Q=0.005


BLEVE due to catastrophic failure of the LNG cryogenic storage container
A1
Q=3E-13
Catastrophic failure of cryogenic Container 1
B1
Q=1E-13
Catastrophic failure of gryogenic Container 2
C1
Q=1E-13
Catastrophic failure of gryogenic Container 3
D1
Q=1E-13
Failure of the cryogenic system 1
E1
Q=0.001
PRV's (two off) on the cryogenic container 1 are failed
F1
Q=1E-06
Corrective maintenance fails to correct the problem timeoulsy
L1
Q=0.001
Catastrophic failure of the cryogenic container 1
H1
Q=0.1
Failure of the cryogenic system 2
I1
Q=0.001
PRV's (two off) on the gryogenic container 2 are failed
J1
Q=1E-06
Catastrophic failure of the gryogenic container 2
K1
Q=0.1
Corrective maintenance fails to correct the problem timeoulsy
L1
Q=0.001
Failure of the cryogenic system 3
M1
Q=0.001
PRV's (two off) on the gryogenic container 3 are failed
N1
Q=1E-06
Catastrophic failure of the gryogenic container 3
O1
Q=0.1
Corrective maintenance fails to correct the problem timeoulsy
L1
Q=0.001
PRV 1 on gryogenic container 1 is failed
P1
Q=0.001
PRV 2 on gryogenic container 1 is failed
Q1
Q=0.001
PRV 1 on gryogenic container 2 is failed
R1
Q=0.001
PRV 2 on gryogenic container 2 is failed
S1
Q=0.001
PRV 1 on gryogenic container 3 is failed
T1
Q=0.001
PRV 2 on gryogenic container 3 is failed
U1
Q=0.001


BLEVE due to catastrophic failure of the LNG gryogenic container on the tanker
A2
Q=8E-14
Fire on the tanker
The fire cannot be extinguished timeously
PRV's on gryogenic container is failed
Gryogenic container on tanker is filled to capacity
B2
Q=0.001
C2
Q=0.001
E2
D2
Q=0.08
PRV 1 is failed
PRV 2 is failed
F2
Q=0.001
H2
Q=0.001

Appendix B

MSDS Methane

MATERIAL SAFETY DATA SHEET

SECTION 1. PRODUCT IDENTIFICATION

PRODUCT NAME: **Methane** **FORMULA:** CH_4
CHEMICAL NAME: Methane, Saturated Alphatic Hydrocarbon, Alkane
SYNONYMS: Methyl Hydride, Marsh Gas, Fire Damp

MANUFACTURER: **Air Products and Chemicals, Inc.**
7201 Hamilton Boulevard
Allentown, PA 18195 - 1501

PRODUCT INFORMATION : (800) 752-1597

MSDS NUMBER: 1070 **REVISION:** 6
REVIEW DATE: July 1999 **REVISION DATE:** July 1999

SECTION 2. COMPOSITION / INFORMATION ON INGREDIENTS

Methane is packaged as pure product (>99%).

CAS NUMBER: 74-82-8

EXPOSURE LIMITS:
OSHA: None established **ACGIH:** Simple Asphyxiant **NIOSH:** None established

SECTION 3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW

Methane is a flammable, colorless, odorless, compressed gas packaged in cylinders under high pressure. It poses an immediate fire and explosion hazard when mixed with air at concentrations exceeding 5.0%. High concentrations that can cause rapid suffocation are within the flammable range and should not be entered.

EMERGENCY TELEPHONE NUMBERS
800 - 523 - 9374 in Continental U.S. , Canada and Puerto Rico
610 - 481 - 7711 outside U.S.

ACUTE POTENTIAL HEALTH EFFECTS:
ROUTES OF EXPOSURE:
EYE CONTACT: No harmful affect.
INGESTION: Not applicable
INHALATION: Methane is nontoxic. It can, however, reduce the amount of oxygen in the air necessary to support life. Exposure to oxygen-deficient atmospheres (less than 19.5 %) may produce dizziness, nausea, vomiting, loss of consciousness, and death. At very low oxygen concentrations (less than 12 %) unconsciousness and death may occur without warning. It should be noted that before suffocation could occur, the lower flammable limit for Methane in air will be exceeded; causing both an oxygen deficient and an explosive atmosphere.
SKIN CONTACT: No harmful affect.
POTENTIAL HEALTH EFFECTS OF REPEATED EXPOSURE:
ROUTE OF ENTRY: None
SYMPTOMS: None

TARGET ORGANS: None
MEDICAL CONDITIONS AGGRAVATED BY OVEREXPOSURE: None
CARCINOGENICITY: Methane is not listed as a carcinogen or potential carcinogen by NTP, IARC, or OSHA Subpart Z.

SECTION 4. FIRST AID MEASURES

EYE CONTACT: No treatment necessary.
INGESTION: Not applicable
INHALATION: Remove person to fresh air. If not breathing, administer artificial respiration. If breathing is difficult, administer oxygen. Obtain prompt medical attention.
SKIN CONTACT: No treatment necessary.
NOTES TO PHYSICIAN: Treatment of overexposure should be directed at the control of symptoms and the clinical condition.

SECTION 5. FIRE FIGHTING MEASURES

FLASH POINT:	AUTOIGNITION:	FLAMMABLE RANGE:
-306 °F (-187.8 °C)	999 °F (537 °C)	5.0% - 15%

EXTINGUISHING MEDIA: Dry chemical, carbon dioxide, or water.
SPECIAL FIRE FIGHTING INSTRUCTIONS: Evacuate all personnel from area. If possible, without risk, shut off source of methane, then fight fire according to types of materials burning. Extinguish fire only if gas flow can be stopped. This will avoid possible accumulation and re-ignition of a flammable gas mixture. Keep adjacent cylinders cool by spraying with large amounts of water until the fire burns itself out. Self-contained breathing apparatus (SCBA) may be required.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Most cylinders are designed to vent contents when exposed to elevated temperatures. Pressure in a cylinder can build up due to heat and it may rupture if pressure relief devices should fail to function.
HAZARDOUS COMBUSTION PRODUCTS: Carbon monoxide

SECTION 6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED: Evacuate immediate area. Eliminate any possible sources of ignition, and provide maximum explosion-proof ventilation. Use a flammable gas meter (explosimeter) calibrated for Methane to monitor concentration. Never enter an area where Methane concentration is greater than 1.0% (which is 20% of the lower flammable limit). An immediate fire and explosion hazard exists when atmospheric Methane concentration exceeds 5.0%. Use appropriate protective equipment (SCBA and fire resistant suit). Shut off source of leak if possible. Isolate any leaking cylinder. If leak is from container, pressure relief device or its valve, contact your supplier. If the leak is in the user's system, close the cylinder valve, safely vent the pressure, and purge with an inert gas before attempting repairs.

SECTION 7. STORAGE AND HANDLING

STORAGE: Store cylinders in a well-ventilated, secure area, protected from the weather. Cylinders should be stored upright with valve outlet seals and valve protection caps in place. There should be no sources of ignition. All electrical equipment should be explosion-proof in the storage areas. Storage areas must meet National Electrical Codes for class 1 hazardous areas. Flammable storage areas must be separated from oxygen and other oxidizers by a minimum distance of 20 ft. or by a barrier of non-combustible material at least 5 ft. high having a fire resistance rating of at least _ hour. Post "No Smoking or Open Flames" signs in the storage or use areas. Do not allow storage temperature to exceed 125 °F (52 °C). Storage should be away from heavily traveled areas and emergency exits. Full and empty cylinders should be segregated. Use a first-in first-out inventory system to prevent full containers from being stored for long periods of time.

HANDLING: Do not drag, roll, slide or drop cylinder. Use a suitable hand truck designed for cylinder movement. Never attempt to lift a cylinder by its cap. Secure cylinders at all times while in use. Use a pressure reducing regulator to safely discharge gas from cylinder. Use a check valve to prevent reverse flow into cylinder. Never apply flame or localized heat directly to any part of the cylinder. Do not allow any part of the cylinder to exceed 125 °F (52 °C). Use piping and equipment adequately designed to withstand pressures to be encountered. Once cylinder has been connected to properly purged and inerted process, open cylinder valve slowly and carefully. If user experiences any difficulty operating cylinder valve, discontinue use and contact supplier. Never insert an object (e.g., wrench, screwdriver, etc.) into valve cap openings. Doing so may damage valve causing a leak to occur. Use an adjustable strap-wrench to remove over-tight or rusted caps. All piped systems and associated equipment must be grounded. Electrical equipment should be non-sparking or explosion-proof.

SPECIAL PRECAUTIONS: Always store and handle compressed gas cylinders in accordance with Compressed Gas Association, Inc. (telephone 703-412-0900) pamphlet CGA P-1, ***Safe Handling of Compressed Gases in Containers***. Local regulations may require specific equipment for storage or use.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS:

VENTILATION: Provide adequate natural or explosion-proof ventilation to prevent accumulation of gas concentrations above 1.0% Methane (20% of LEL).

RESPIRATORY PROTECTION:

Emergency Use: Do not enter areas where Methane concentration is greater than 1.0% (20% of the LEL). Exposure to concentrations below 1.0% do not require respiratory protection.

EYE PROTECTION: Safety glasses and/or face shield.
SKIN PROTECTION: Leather gloves for handling cylinders. Fire resistant suit and gloves in emergency situations.
OTHER PROTECTIVE EQUIPMENT: Safety shoes are recommended when handling cylinders.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE, ODOR AND STATE: Colorless, odorless, flammable gas.
MOLECULAR WEIGHT: 16.04
BOILING POINT (1 atm): -258.7 °F (-161.5 °C)
SPECIFIC GRAVITY (Air = 1): 0.554
FREEZING POINT / MELTING POINT: -296. 5 °F (-182.5 °C)
VAPOR PRESSURE (At 70 _F (21.1 _C)): Permanent, noncondensable gas.
GAS DENSITY (At 70 _F (21.1 _C) and 1 atm): 0.042 lb/ft^3
SOLUBILITY IN WATER (vol/vol): 3.3 ml gas / 100 ml

SECTION 10. STABILITY AND REACTIVITY

CHEMICAL STABILITY: Stable
CONDITIONS TO AVOID: Cylinders should not be exposed to temperatures in excess of 125 °F (52 °C).
INCOMPATIBILITY (Materials to Avoid): Oxygen, Halogens and Oxidizers
REACTIVITY:

A) HAZARDOUS DECOMPOSITION PRODUCTS: None
B) HAZARDOUS POLYMERIZATION: Will not occur

SECTION 11. TOXICOLOGICAL INFORMATION

LC_{50} (Inhalation): Not applicable. Simple asphyxiant.
LD_{50} (Oral): Not applicable
LD_{50} (Dermal): Not applicable

SKIN CORROSIVITY: Methane is not corrosive to the skin.
ADDITIONAL NOTES: None

SECTION 12. ECOLOGICAL INFORMATION

AQUATIC TOXICITY: Not determined
MOBILITY: Not determined
PERSISTENCE AND BIODEGRADABILITY: Not determined
POTENTIAL TO BIOACCUMULATE: Not determined
REMARKS: This product does not contain any Class I or Class II ozone depleting chemicals.

SECTION 13. DISPOSAL CONSIDERATIONS

UNUSED PRODUCT / EMPTY CONTAINER: Return container and unused product to supplier. Do not attempt to dispose of residual or unused quantities.

DISPOSAL INFORMATION: Residual product in the system may be burned if a suitable burning unit (flair incinerator) is available on site. This shall be done in accordance with federal, state, and local regulations. Wastes containing this material may be classified by EPA as hazardous waste by characteristic (i.e., Ignitability, Corrosivity, Toxicity, Reactivity). Waste streams must be characterized by the user to meet federal, state, and local requirements.

SECTION 14. TRANSPORT INFORMATION

DOT SHIPPING NAME: Methane, compressed
HAZARD CLASS: 2.1
IDENTIFICATION NUMBER: UN1971
SHIPPING LABEL(s): Flammable gas
PLACARD (When required): Flammable gas

SPECIAL SHIPPING INFORMATION: Cylinders should be transported in a secure upright position in a well-ventilated truck. Never transport in passenger compartment of a vehicle. Ensure cylinder valve is properly closed, valve outlet cap has been reinstalled, and valve protection cap is secured before shipping cylinder.

CAUTION: Compressed gas cylinders shall not be refilled except by qualified producers of compressed gases. Shipment of a compressed gas cylinder which has not been filled by the owner or with the owner's written consent is a violation of Federal law (49 CFR 173.301).

NORTH AMERICAN EMERGENCY RESPONSE GUIDEBOOK NUMBER (NAERG #): 115

SECTION 15. REGULATORY INFORMATION

U.S. FEDERAL REGULATIONS:

EPA - ENVIRONMENTAL PROTECTION AGENCY
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (40 CFR Parts 117 and 302)
Reportable Quantity (RQ): None

SARA TITLE III: Superfund Amendment and Reauthorization Act
SECTIONS 302/304: Emergency Planning and Notification (40 CFR Part 355)
Extremely Hazardous Substances: Methane is not listed.
Threshold Planning Quantity (TPQ): None
Reportable Quantity (RQ): None

SECTIONS 311/312: Hazardous Chemical Reporting (40 CFR Part 370)

IMMEDIATE HEALTH:	Yes	PRESSURE:	Yes
DELAYED HEALTH:	No	REACTIVITY:	No
		FIRE:	Yes

SECTION 313: Toxic Chemical Release Reporting (40 CFR Part 372)
Methane does not require reporting under Section 313.

CLEAN AIR ACT:

SECTION 112 (r): Risk Management Programs for Chemical Accidental Release (40 CFR PART 68)

Methane is listed as a regulated substance.
Threshold Planning Quantity (TPQ): 10,000 lbs

TSCA: Toxic Substance Control Act

Methane is listed on the TSCA inventory.

OSHA - OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION:

29 CFR Part 1910.119: Process Safety Management of Highly Hazardous Chemicals

Methane is not listed in Appendix A as a highly hazardous chemical. However, any process that involves a flammable gas on site in one location, in quantities of 10,000 pounds
(4,553 kg) or greater is covered under this regulation unless it is used as fuel.

STATE REGULATIONS:

CALIFORNIA:

Proposition 65: This product is not a listed substance which the State of California requires warning under this statute.

SECTION 16. OTHER INFORMATION

NFPA RATINGS:		HMIS RATINGS:	
HEALTH:	= 1	HEALTH:	= 0
FLAMMABILITY:	= 4	FLAMMABILITY:	= 4
REACTIVITY:	= 0	REACTIVITY:	= 0
SPECIAL:	= SA*		

*SA denotes “Simple Asphyxiant” per Compressed Gas Association recommendation.

Appendix C

Site Emergency Plan

TETRA4 (Pty) Ltd.

Molopo Construction Phase 1

CNG Plant Emergency Procedure Report

Document Number: 16-003-EP-RPT-001

Revision: B

EPCM Consultants SA (Pty) Ltd

Unit 31Ground Level

Cambridge Office Park

5 Bauhinia Street

Highveld Technopark

Job title	Molopo Construction Phase 1	Job number	
		16-003	
Document title	Process Review	File reference	
		16-003-PR-RPT-001-Rev B	
Document ref	16-003-PR-RPT-001-Rev B		

Revision	Date	Filename	16-003-EP-RPT-001-Rev A		
A	10-04-2016	Revision Description	Final Draft issued for internal revision.		
			Prepared by	Checked by	Approved by
		Name	E. Putter	A. Odendaal	T. Cowan
		Signature			
B	11-04-2016	Filename	16-003-EP-RPT-001-Rev B		
		Description	Final Report issued to TETRA4.		
			Prepared by	Checked by	Approved by
		Name	E. Putter	A. Odendaal	T. Cowan
		Signature			
C		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
D		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Signature			

Issue Document Verification with Document ✓

Table of Contents

List of Abbreviations

Abbreviation	Definition
BLEVE	Boiling Liquid Expanding Vapour Explosions
CNG	Compressed Natural Gas
EPCM	EPCM Consultants SA (Pty) Ltd
LNG	Liquid Natural Gas
PLC	Programmable Logic Controller
SOP	Standard Operating Procedure
TETRA4	Tetra4 (Pty) Ltd

List of Tables

1. Introduction

EPCM Consultants SA (Pty) Ltd is the turnkey contractor appointed by TETRA4 (Pty) Ltd for the completion of a Compressed Natural Gas (CNG) Plant. Station A is the truck loading facility and Station B is the dispensing facility. The gas will be trucked from Station A to station B.

The plant receives Natural Gas directly from a low pressure well, using two compressors to generate CNG at pressures up to 250 Barg.

2. Purpose

The purpose of a site emergency procedure report is to define the actions during emergencies and unforeseen incidents.

This report is specifically for a small plant used to compress Natural Gas in order to produce CNG. The report serves as a guide for different decisions to be made during an emergency.

3. Overview of the Emergency Procedure

When an emergency occurs at the CNG plant this procedure sets out the flow of decisions to be made in order to isolate and evacuate. Ultimately to contain the gas in order to bring the situation under control whilst ensuring safety.

4. CNG General Hazards

CNG can pose the following potential hazards:

- Asphyxiation: Possible if large quantity of leaked gas is inhaled.
- Explosion: Possible when contained in a confined space.
- Flame not clearly visible when ignited.
- Damage to the environment, structures and equipment.
- General fire in the area.

4.1. Vapour Cloud Characteristics

CNG vapours become flammable when mixed with air. Severe fires, thermal radiation and explosions can result when such mixtures ignite.

The vapours do not disperse easily and being heavier than air, will hug ground contours and will tend to flow along natural paths and fill depressions, ditches and pits. In favourable conditions, flammable vapours can travel for long distances from the point of release. They might also enter a building and be contained, particularly in basements and cellars.

When the Natural Gas expands to ambient pressure and ambient temperature the vapour cloud will rise as it becomes lighter than the surrounding air. This means that the gas will get trapped under roof structures and enclosures causing a high fire risk.

4.2. Vapour Cloud Ignition

- Ignition of CNG vapours in a confined space can produce over-pressures strong enough to cause severe damage.
- Ignition of a diluted cloud may produce limited thermal radiation.
- Vapour with downwind plume will produce a long, thin cigar shaped vapour cloud.
- Can travel considerable distances before concentrations fall below the air to methane combustion mixture percentage.
- The danger distance decreases as wind speed increases because it dilutes the gas.

4.3. Jet Flame

A jet flame occurs when there is a high pressure gas leak in combination with a combustion source. This causes a high velocity flame capable of extreme thermal damage.

4.4. Boiling Liquid Expanding Vapour Explosions (BLEVE)

- A BLEVE involving an LNG cascade is highly unlikely as the site is not generating LNG.
- The outer shell will prevent direct flame impingement on the inner tank.
- Mechanical insulation between outer- and inner wall drastically slows heat transfer to CNG.

5. Scope

The emergency procedure covers the CNG facility including the metering station, cascades, filling post, compressor houses, trailer tubes and impact from Heartlands process emergencies.

5.1. Controllable emergency

A controllable emergency is any emergency where CNG personnel can prevent harm to other personnel, neighbouring facilities, and equipment by following standard operating procedures (SOP's) such as shutting down equipment, isolating system or initiating the Emergency Shutdown System.

Controllable emergencies include:

- CNG release contained within containments that do not result in fire.
- Over-pressure of gas process piping.
- Small fires that do not involve flammable gases.
- Electrical fires that do not involve flammable gases.
- Loss of electrical power.
- Unexpected CNG point of transfer disconnection.
- Minor vehicle accidents.
- Securing the site prior to severe weather conditions.
- Security breaches that do not result in substantial damage to the station.

5.2. Uncontrollable emergency

An uncontrollable emergency is any emergency in which the CNG personnel cannot prevent harm to personnel or equipment by taking reasonable actions such as shutting down equipment, isolating the system or initiating the Emergency Shutdown System.

Uncontrollable Emergencies include:

- CNG release resulting in an unconfined fire.
- Flammable gas leaks from significant failure of a pipeline or equipment.
- Building or equipment fires that contains or can contain flammable gases.
- Severe weather conditions that can cause damage to equipment and systems or loss of CNG containment.
- An act of sabotage that may result in structural failure of the CNG storage cascade or rupture of a major pipeline.

6. Specific emergencies

Emergency situations and events will vary widely and will require various levels of management to direct the handling of the emergency and subsequent restoration of operations and reporting. Numerous emergencies can occur at several different CNG equipment.

List of possible situations that could result in an emergency in the CNG plant:

- Bushfire spreading in the area that involves or threatens the CNG plant.
- Detection of methane (measured with the gas leak detection system).
- Uncontrollable escape of CNG.
- CNG pressure that is outside prescribed limits.
- Damage to our CNG facilities by third parties.
- Natural disasters.

6.1. Booster Compressor (Hydrovane)

Table 1: Table of Emergency Action for Booster Compressor

Situation	Emergency Action
Major Gas Leak	This is unlikely due to the extremely low pressure leading to the compressor
Abnormal Noise from Compressor	Shut down the Booster Compressor from either the control panel located on the compressor or the control panel found in the control room. The entire plant should be shut down shortly after.

6.2. BBR 4 Stage Intermech Compressor

Table 2: Table of Emergency Action for BBR Compressor

Situation	Emergency Action
Major Gas Leak	The BBR Compressor has a leak detection system located inside the body. This leak detection unit will shuts down the compressor. The entire plant needs to be shut down when any of the leak detection systems are triggered.
Abnormal Noise from Compressor	Shut down the BBR Compressor from either the control panel located on the compressor or the control panel found in the control room. The entire plant should be shut down shortly after.
Relief Valve Venting	Shut down the BBR Compressor from either the control panel located on the compressor or the control panel found in the control room. The entire plant should be shut down shortly after.

6.3. Fill Post

Any and all sources of ignition will not be permitted in a 5m radius of the fill post during operation.

Table 3: Table of Emergency Action for Fill Post

Situation	Emergency Action
Major Gas Leak	The fill post is operating under extremely high pressures meaning that a gas leak will heard. This is also downstream from the odourisation unit, meaning that the operator will be able to smell a gas leak. The entire plant needs to be shut down as soon as a gas leak is detected.

6.4. Trailer

When the trailer is parked at station A or Station B and it is at full capacity, it shall be treated as a storage vessel.

Any and all sources of ignition will not be permitted in a 5m radius of the fill post during operation.

Table 4: Table of Emergency Action for Trailer

<table>
<tr><th>Situation</th><th>Preventative Action</th></tr>
<tr><td>Whip lashing (high pressure) during coupling or decoupling of the trailer at the filling point.</td><td rowspan="4">During the loading of CNG from the filling post to the trailers, the hand or emergency brake of the vehicle shall be set, and chock blocks shall be used to prevent rolling of the vehicle.

Note that this is only a precaution and not an emergency action.</td></tr>
<tr><td>Whip lashing (high pressure) during switching to the next trailer.</td></tr>
<tr><td>Exposure to a possible methane vapour cloud explosion during coupling of the trailer at the filling point resulting in serious burns.</td></tr>
<tr><td>Exposure to a possible methane vapour cloud explosion during filling of trailer and the vent valve not properly closed.</td></tr>
</table>

6.5. Dispenser Unit

Any and all sources of ignition will not be permitted in a 5m radius of the Dispenser Unit during operation.

Table 5: Table of Emergency Action for Dispenser Unit

Situation	Emergency Action
Major Gas Leak	The dispenser unit is operating under extremely high pressures meaning that a gas leak will heard. This is also downstream from the odourisation, meaning that the operator will be able to smell a gas leak. The entire plant needs to be shut down when a gas leak is found.

7. Emergency shut down device (ESD)

There is an ESD Valve located upstream near the wellhead. This ESD Valve is a fail-close system, meaning that if either the electric-line or the air-line is severed due to any accident, the valve will close causing the entire plant to stop.

Pressing the Emergency Shutdown System will take the following actions:

- Alarm beacon is illuminated.
- Alarm horn is activated.
- Methane detection circuit on the fire alarm control panel is activated.
- Fire alarm control panel initiates communication according to the pre-programmed.
- Alarm is logged into the alarm system of the Programmable Logic Controller (PLC).
- The CNG station is shutdown.
- All air operated valves close automatically if air pressure is removed from the system.
- Electrical power to all electrical equipment is disconnected.

8. Action in Case of an Emergency

8.1. General Gas Leak

In case of a gas leak all of the equipment will be shut off and the entire plant will be shut down.

The gas leak shall then be inspected under a controlled environment to ensure safety. The leak will be identified and fixed by the maintenance team.

8.2. General Fire

In case of any and all fires the entire plant will be shut down and the evacuation procedure will be followed by the staff members.

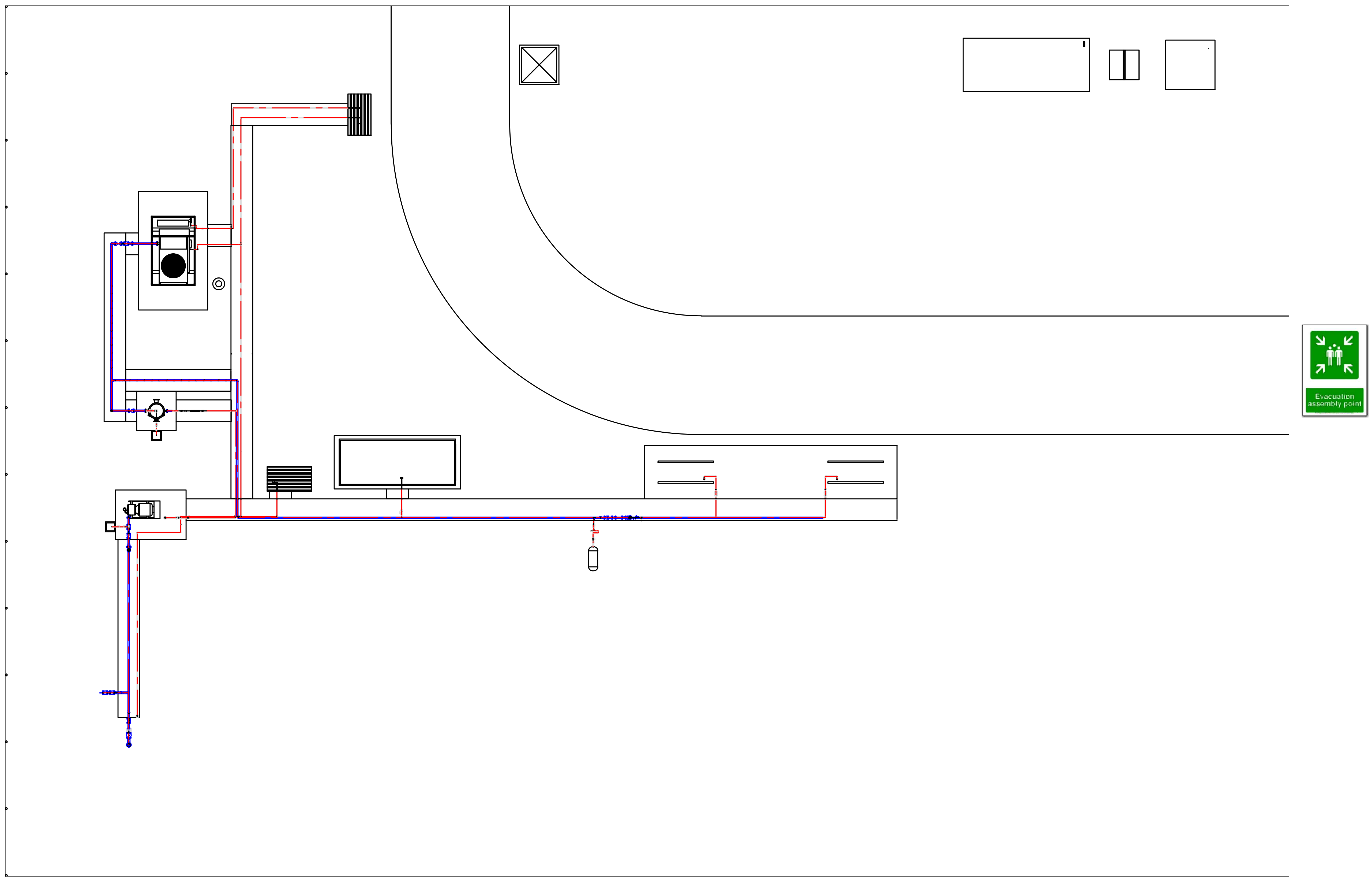
The local fire department will be contacted by the plant operator, no operator will try and extinguish a fire unless he has all the necessary training and conditioning.

9. Evacuation Procedure

In the event that a site evacuation is required, personnel shall evacuate and direct those nearby to the nearest emergency gathering point which is situated at the gate (located at the furthest position from any equipment or piping).

During an evacuation, attention shall be paid to the wind direction, always evacuate crosswind or upwind from the location of emergency. See Appendix A for the location of the emergency gathering point for both Station A and Station B.

Appendix A – Gathering Point



NOTE:

No.	DATE	REVISION	APPR.

APPROVAL	NAME	SIGNATURE	DATE
DESIGN	C. BOSCH		
DRAWN	C. BOSCH		
DESIGN CHECKED	E. PUTTER		
DRAWING CHECKED	E. PUTTER		
EPCM SA APPROVAL	T. COWAN		
CLIENT APPROVAL			
AS BUILT			

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CLIENT

MOLOPO SOUTH AFRICA

CLIENT

PROJECT LOCATION

VIRGINIA, FREESTATE

PROJECT

MOLOPO STATION A

SECTION

EMERGENCY

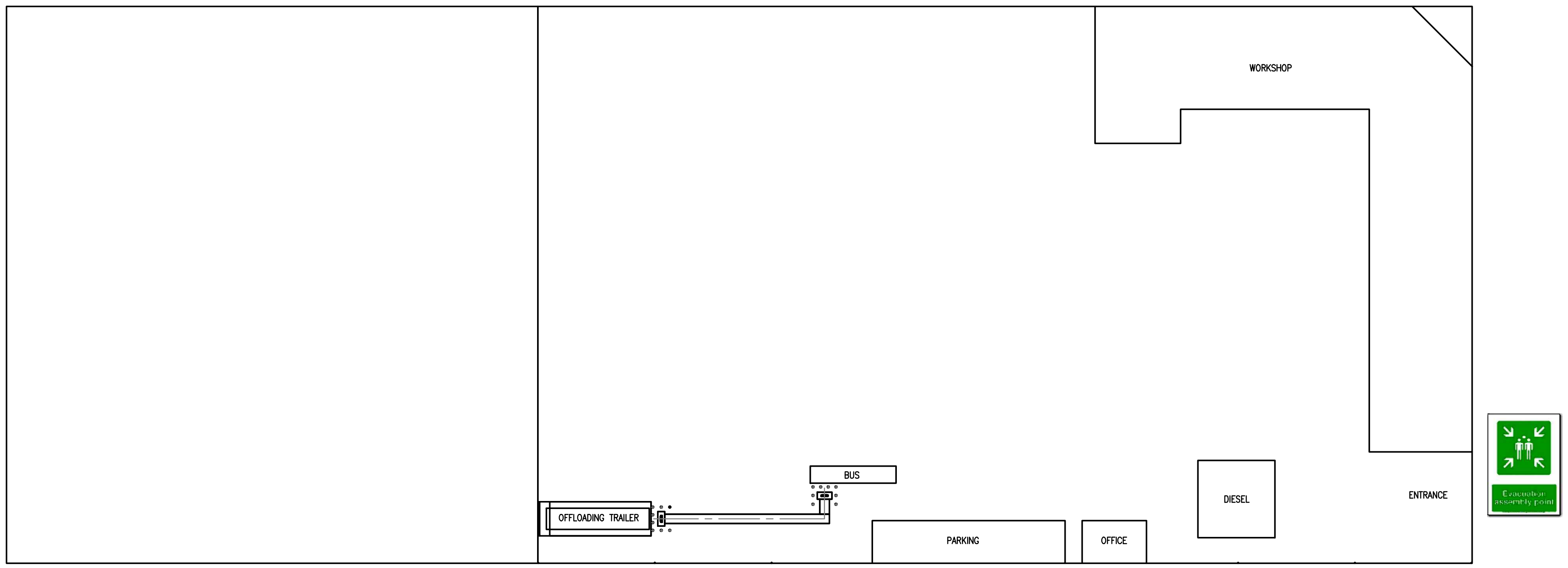
TITLE

ASSEMBLY POINT

SCALE	AS SHOWN ON A1	PRELIMINARY		CONSTRUCTION	
CAD No.		TENDER		AS BUILT	

EPCM SA Drg. No.

REVISION No.



NOTE:

No.	DATE	REVISION	APPR.
A	08.04.16		

APPROVAL	NAME	SIGNATURE	DATE
DESIGN	C. B		
DRAWN	C. B		
DESIGN CHECKED	E. P		
DRAWING CHECKED	E. P		
EPCM SA APPROVAL	T. C		
CLIENT APPROVAL			
AS BUILT			

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CLIENT

MOLOPO SOUTH AFRICA

PROJECT LOCATION

VIRGINIA, FREESTATE

PROJECT

MOLOPO STATION B

SECTION

EMERGENCY

TITLE

EVACUATION PLAN

SCALE	AS SHOWN ON A0	PRELIMINARY		CONSTRUCTION	
CAD No.		TENDER		AS BUILT	

EPCM SA Drg. No.

REVISION No.

Appendix D

Accreditation Certificates

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:-

BUREAU FOR INTERNATIONAL RISK ASSESSMENT (PTY) LTD
Co. Reg. No.: 1999/023738/07
ROODEPOORT

Facility Accreditation Number: **MHI0033**

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

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

THE ASSESSMENT OF RISK ON MAJOR HAZARD INSTALLATIONS

The facility is accredited in accordance with the recognised International Standard

ISO/IEC 17020:2012 and SANS 1461:2018

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

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

Mr M Phaloane
Acting Chief Executive Officer

Effective Date: 28 September 2020
Certificate Expires: 26 September 2022

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

ANNEXURE A

SCOPE OF ACCREDITATION

Accreditation Number: MHI0033

TYPE A

Permanent Address: Bureau for International Risk Assessment (Pty) Ltd 18 Fairchild Street Helderkruin Roodepoort 1724 Tel: (011) 768-7832 Fax: 086 518-8214 E-mail: hminnaar@bira.co.za	**Postal Address:** Postnet Suite 297 Private Bag X2 Helderkruin Roodepoort 1733 Issue No.: 06 Date of Issue: 28 September 2020 Expiry Date: 26 September 2022	
Nominated Representative: Dr HFB Minnaar	**Quality Manager:** Dr HFB Minnaar **Technical Manager:** Dr HFB Minnaar	**Technical Signatory** Dr HFB Minnaar
Field of Inspection	**Type and Range of Inspection**	**Standards and Specification**
Regulatory: The supply of services as an Inspection Authority for Major Hazard Risk Installation as defined in the Major Hazard Risk Installation Regulations, Government Notice No. R692 of 30 July 2001	Major Hazard Installation Risk assessments for the following material categories: 1) Explosive chemicals 2) Gases: i) Flammable Gases ii) Non-flammable, non-toxic gases (asphyxiants) iii) Toxic gases 3) Flammable liquids 4) Flammable solids, substances liable to spontaneous combustion, substances that on contact with water release flammable gases 5) Oxidizing substances and organic peroxides 6) Toxic liquids and solids	MHI regulation par. 5(5) (b) i) Frequency / Probability Analysis ii) Consequence Modelling iii) Hazard Identification and Analysis iv) Emergency Planning Reviews SANS 31000 SANS 31010 SANS 1461: 2018 Risk Analysis in the Process Industries, IChemE 1985 Automated Resource for Chemical Hazard Incident Evaluation Programme, US Environmental Protection Agency. Department of Transportation and Federal Emergency Management Agency. European Gas Industry Data Group Statistics, Nederlandse Gasuine, Netherlands.

Original Date of Accreditation: 27 September 2010

ISSUED BY THE SOUTH AFRICAN NATIONAL ACCREDITATION SYSTEM

Accreditation Manager

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:

BUREAU FOR INTERNATIONAL RISK ASSESSMENT (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 September 2018**
Expires: **26 September 2022**
Certificate Number: **CI MHI 0010**

Appendix E

CV – Dr HFB Minnaar

BIRA®

Bureau for
International Risk Assessments (Pty) Ltd
Reg No 9923738/07

Curriculum Vitae

DR HENNIE MINNAAR

Managing Director

Hennie Minnaar holds a B.Sc (Physics, Chemistry and Mathematics as majors) and an M.Sc (Physics) from the University of Potchefstroom and a Ph.D (Physics) from the University of South Africa (UNISA).

After he obtained his B.Sc, he joined the Antartic Expedition (SANAE 14) as physicist and as an employee of the University of Potchefstroom. He also was leader of the scientific group and deputy leader of the SANAE 14 expedition.

He started his industrial career in 1978 with the DENEL group of companies, where he held the position of Manager Production and Process Development before he joined NECSA in 1983 as risk analyst responsible for the risk analyses of several nuclear facilities in order to have them licensed. Since 1991 he was manager of the Risk Analysis Division of NECSA. During this period he was also involved in the international benchmark exercise of two consequence/atmospheric dispersion codes, namely COSYMA and MACCS.

In February 1997 he joined IRCA as Managing Director Technical Services, responsible for Risk Assessment, Environmental Impact Analysis. There he has been involved in several risk assessment studies covering more or less every aspect of the mining, process and business industries.

In March 2000 he became the proprietor of BIRA, specializing in risk assessment consulting and training for all industries. The cliental of BIRA spreads over the process industries, mining industry, fabrication, casinos and commercial banking. He developed several training courses in risk assessment and several hundred people already attended these courses. Under his leadership the BIRAM software was developed, which presently is used by several major companies in South Africa. Under his leadership BIRA became an Approved Inspection Authority (AIA) for Major Hazard Installations (MHI's). As risk assessor he has carried out several MHI risk analyses in the industry.