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Confidential

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

June 2022

Prepared by:

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(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:	Natural Gas Pipe Route
MHI Status:	Proposed
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:	R1067-2 Tetra4 Pipe Route
Assessment Date:	27th May 2022
Report Date:	20th June 2022
Expiry Date:	NA

Report Summary Sheet

Client: **Tetra4**	**Client Contract No.** **3678**
Title of Report: MHI Risk Assessment on the Natural Gas Pipe Route at Tetra4 near Virginia in the Free State	
Summary: (Brief description of report) This report deals with the risks associated with the natural gas Pipe Route at Tetra4 near Virginia in the Free State	
Indexing Terms: (keywords) MHI Risk Assessment Methane Vapour Cloud Explosion (VCE) Jet Flame	
Work Carried Out By: (Team initials or names) HM	
Job No:	**1067**

Document Revision Record

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1	31st May 2022	Draft	HM	
2	20th June 2022	Report	HM	

ABBREVIATIONS AND DEFINITIONS

CH_4 – Methane

CNG – Compressed Natural Gas

LNG – Liquefied Natural Gas

VCE – Vapour Cloud Explosion

f/p/y - fatality/person/year

MMSCFD - Million Standard Cubic Feet per Day

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Appendix C: CV-Dr HFB Minnaar

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 an MHI risk assessment on the natural gas pipe route at Tetra4 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 0.3bar and routed to the LNG facility at Tetra4. There are approximately 300 wells. From the wells the natural gas is fed via below surface lines to blowers and from the blowers it is fed to compressor stations at a pressure of 50kPa. From the compressor stations the natural gas in fed via an underground line to the LNG facility at a pressure of 23bar (design 30bar) through a 10inch line.

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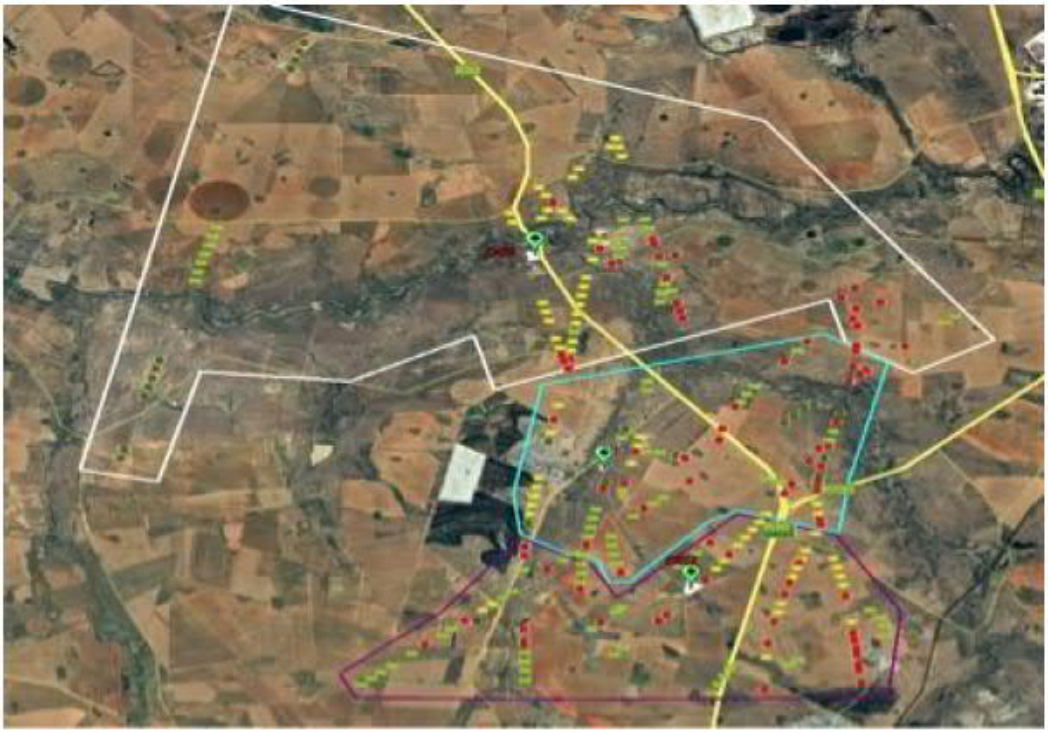

Well locations

For the risk assessment the following scenarios were considered.

1) VCE due to a full bore rupture of the pipeline between CS1/CS2 and the plant.
2) .Jet flame due to 25mm hole in the pipeline between CS1/CS2 and the plant.

Since there is no fatality risk at the compressor stations CS1 and CS2, for the scenarios as discussed, no fatality risk is foreseen for the pipelines between the blowers and the compressor stations. Due to the pipelines being below surface, a jet flame is only foreseen at the compressors before the line goes below surface.

Apart from a possible burn injury by an operator due to being exposed to and accidental jet flame at a compressor station, there is no individual fatality risk.

The natural gas pipelines does not pose any societal risk.

It follows from the previous paragraphs that an accidental release of methane will not impact on any residential area or sensitive receptor and will not pose a fatality risk to an employee or the public.

Since the pipeline route does not pose any risk that will result in the facility
being classified as an MHI no site emergency plan is required for this risk assessment

An accident on the pipeline route will not have any impact other than possible loss of product on the LNG facility of Tetra4.

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 in the area of the pipeline route other than to prevent possible damage to the under surface pipelines.

It is concluded as follows:

a) The hazardous installations addressed in this report are the only hazardous installations on the pipeline route.
b) The maximum extend of the 1% consequence lethality zone is not applicable.
c) The pipeline route does not pose any fatality risk to the public.
d) The societal risk is zero.
e) There should not be any restriction on land-use planning in the area of the pipeline route other than to prevent possible damage to the under surface pipelines.
f) Tetra4 Pipeline Route should ***NOT*** be classified as an MHI.
g) Future development of the pipeline route do not have to subjected to an MHI risk assessment given that the maximum pressure in any part of the pipeline route does not exceed 30bar.

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 an MHI risk assessment on the natural gas pipe route at Tetra4 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:

- ALOHA (atmospheric dispersion)

2.0 DESCRIPTION

The Tetra4 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 0.3bar and routed to the LNG facility at Tetra4. There are approximately 300 wells. From the wells the natural gas is fed via below surface lines to blowers and from the blowers it is fed to compressor stations at a pressure of 50kPa. From the compressor stations the natural gas in fed via an underground line to the LNG facility at a pressure of 23bar (design 30bar) through a 10inch line.

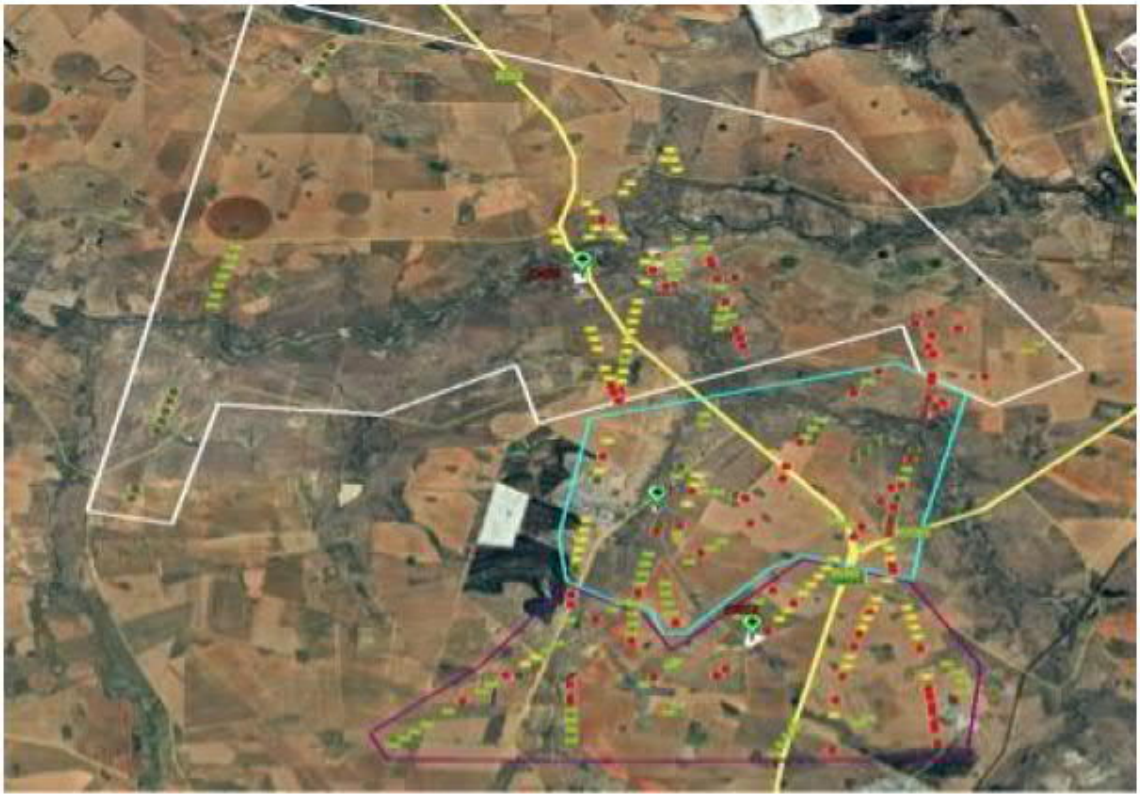

Figure 2.1 Well locations

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

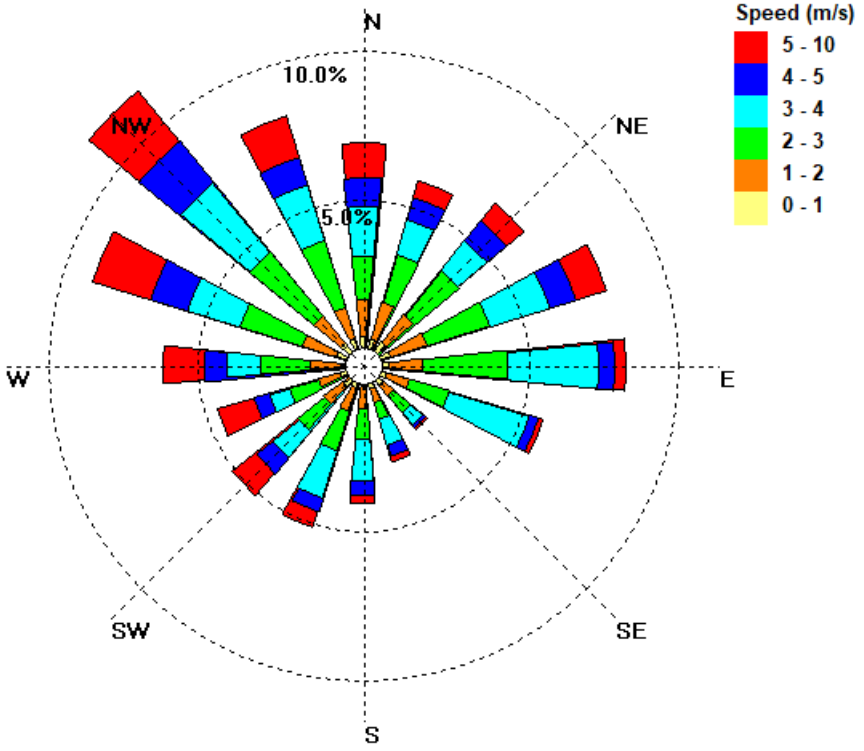

Figure 2.2a Wind rose generated from the meteorological data for Tetra4 for a complete year

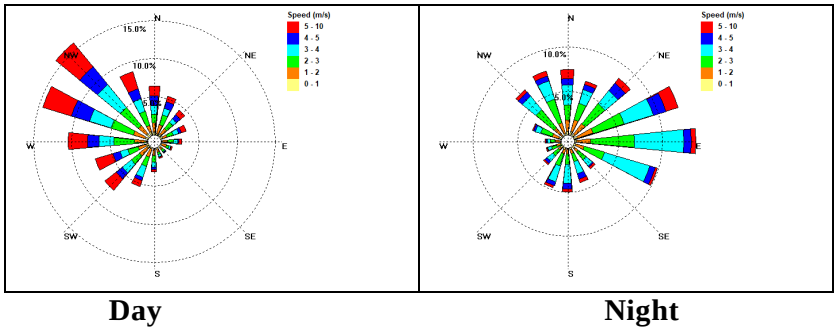

Figure 2.2b Wind roses generated from the meteorological data for Tetra4, for day and night respectively

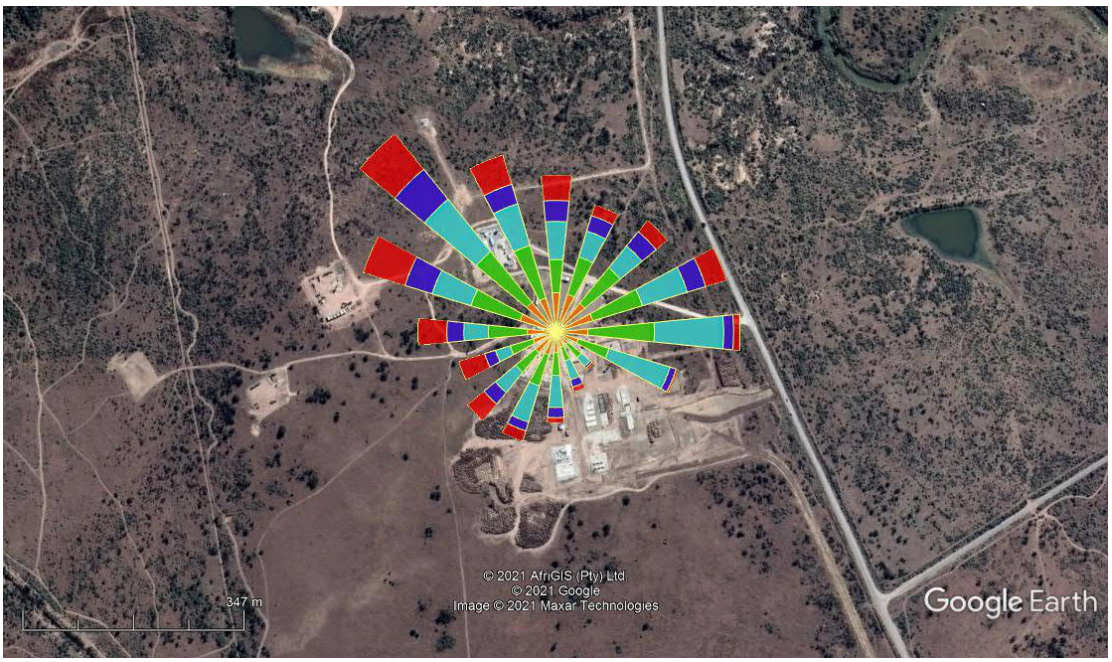

Figure 2.3 Wind rose superimposed on the Tetra4 site

3.0 RISK ASSESSMENT

3.1 Hazard Identification

The following hazardous substances will be stored on site.

Two blow surface pipelines from compressor stations C1 and C2 to the plant each carrying 15MMSCFD.

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 Site Layout and Description

The site layout is shown in Figure 3.1.

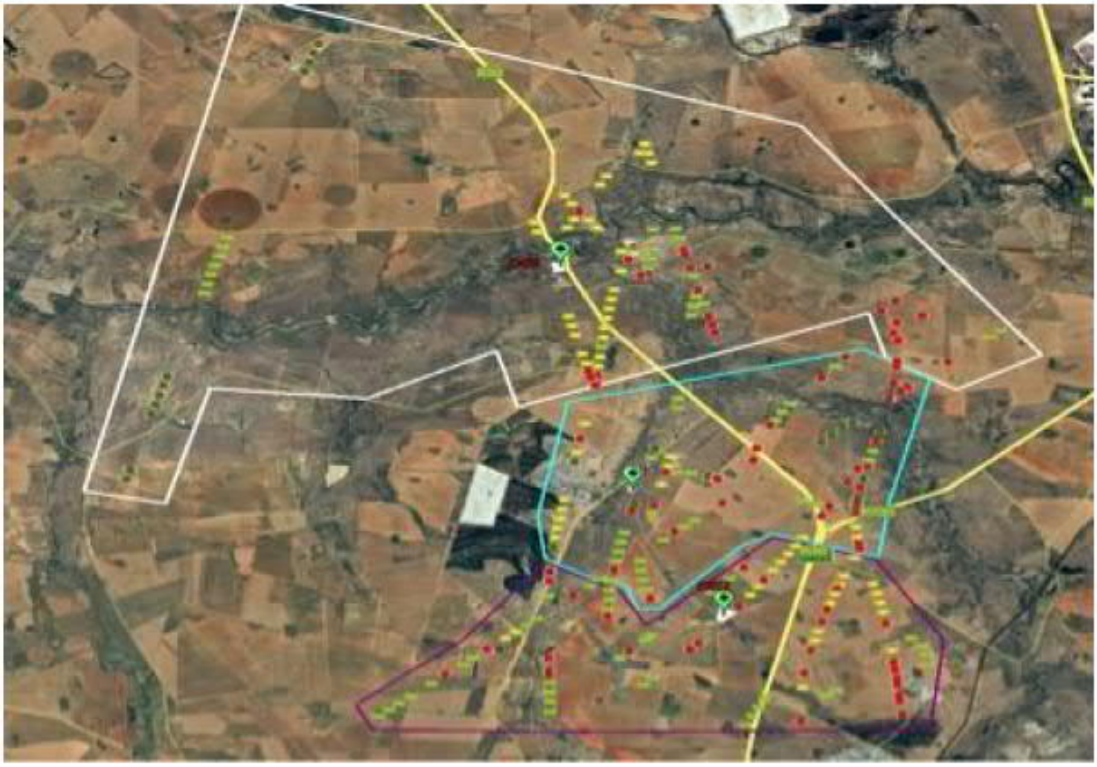

Figure 3.1a Site layout (wells)

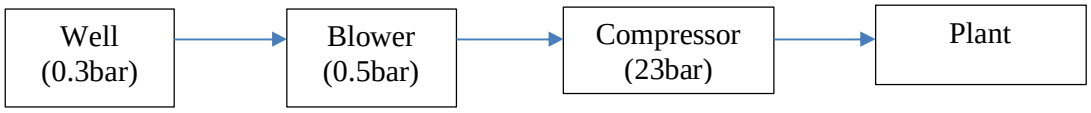

Figure 3.1b Natural gas pipeline block diagram

3.2 Hazard Analysis

3.2.1 Accidental release of CH_4

For the risk assessment the following scenarios were considered.

3) VCE due to a full bore rupture of the pipeline between CS1/CS2 and the plant.
4) .Jet flame due to 25mm hole in the pipeline between CS1/CS2 and the plant.

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

3.3 Consequence Analysis

3.3.1 Scenario 1

Rupture of a 10inch pipeline between CS1/CS2 and the plant resulting in a VCE.

For this scenario the overpressure (blast force) from the vapour cloud, ignited by a spark never exceeded 0.35bar or 0.14bar for any of the atmospheric stabilities 3B, 5D, 5E or 1.5F.

- At this overpressure of 0.35bar, fatalities and severe damage to buildings and processing equipment may take place
- At this overpressure of 0.14bar, minor damage to process equipment and less than 1% fatalities may occur.

3.3.2 Scenario 2

A jet flame from a 25mm at hole at 30bar in the pipeline between CS1/CS2 and the plant.

For this scenario the thermal radiation from the jet flame, for any of the atmospheric stabilities 3B, 5D, 5E or 1.5F, is less than 10meters for 37kW/m^2 and 12.5kW/m^2.

- 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 intensity (12.5kW/m^2) is sufficient to ignite wood or melt plastic and may result in 1% fatalities within one minute.

3.4 Frequency Analysis

The following failure probabilities were used:

$$P_{Scenario\ 1} = 1 \times 10^{-7} \text{ (Bevi)}$$

$$P_{Scenario\ 2} = 5 \times 10^{-7} \text{ (Bevi)}$$

3.5 Risk Calculation

Since there are no fatality risk at the compressor stations CS1 and CS2, for the scenarios as discussed, no fatality risk is foreseen for the pipelines between the blowers and the compressor stations. Due to the pipelines being below surface, a jet flame is only foreseen at the compressors before the line goes below surface.

3.5.1 Individual Risk

Apart from a possible burn injury by an operator due to being exposed to and accidental jet flame at a compressor station, there is no individual fatality risk.

The ALARP (as low as reasonably practicable) risk decision making frameworks as per SANS 1461:2018, are shown in Figure 3.2.

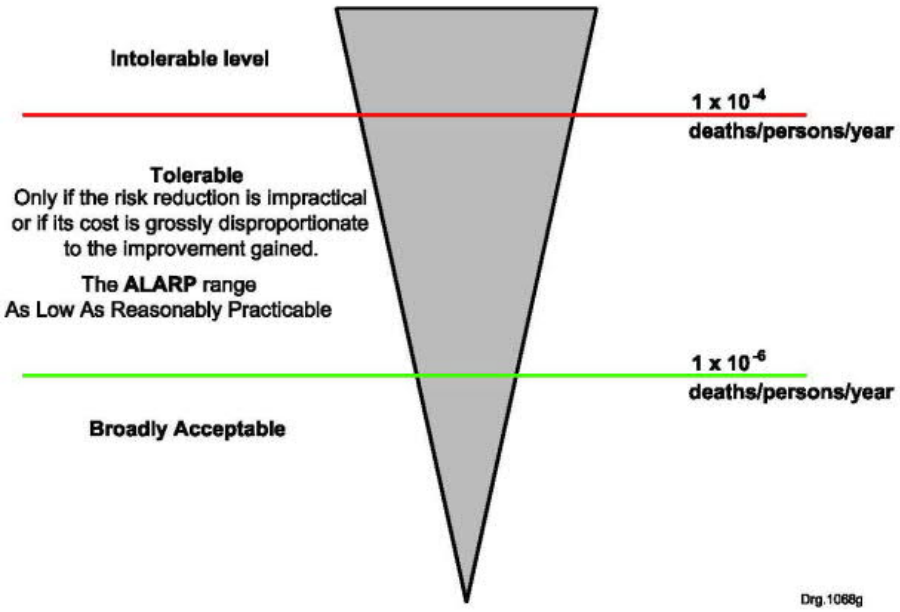

Figure 3.2a The Public ALARP Risk Decision Making Framework

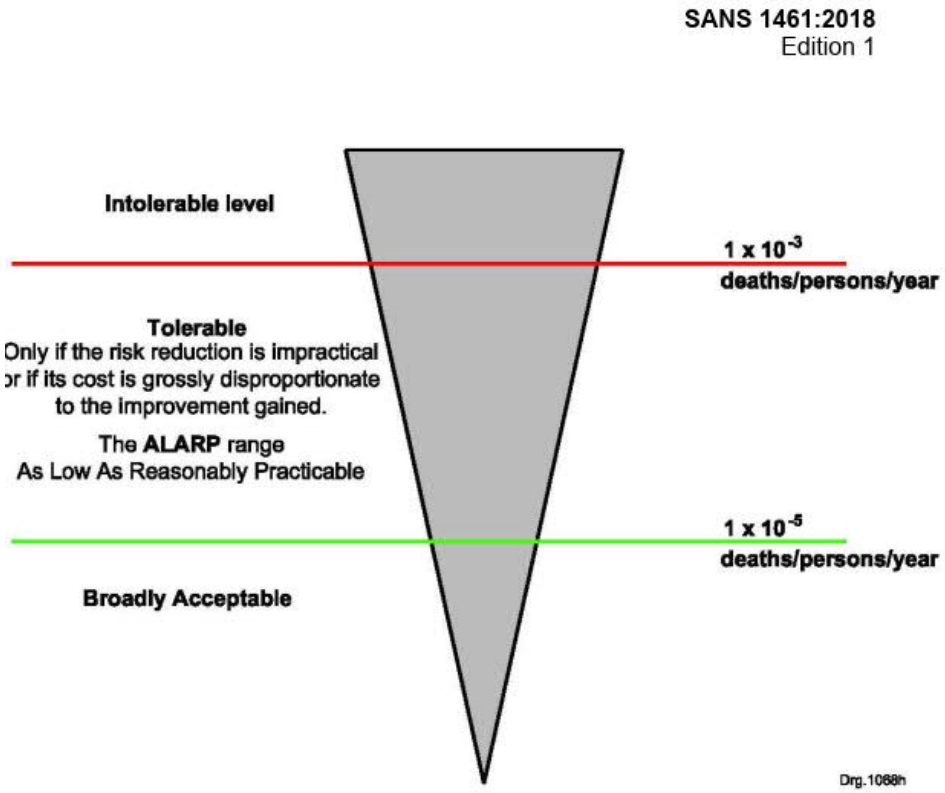

Figure 3.2b The Employee ALARP Risk Decision Making Framework

3.5.2 Societal Risk

The natural gas pipelines does not pose any societal risk.

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 and will not pose a fatality risk to an employee or the public.

4.0 SITE EMERGENCY PLAN

Since the pipeline route does not pose any risk that will result in the facility being classified as an MHI no site emergency plan is required for this risk assessment

5.0 INFLUENCE ON OTHER MHI FACILITIES

An accident on the pipeline route will not have any impact other than possible loss of product on the CNG/LNG facility 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 in the area of the pipeline route other than to prevent possible damage to the under surface pipelines.

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 pipeline route.
b) The maximum extend of the 1% consequence lethality zone is not applicable.
c) The pipeline route does not pose any fatality risk to the public.
d) The societal risk is zero.
e) There should not be any restriction on land-use planning in the area of the pipeline route other than to prevent possible damage to the under surface pipelines.
f) Tetra4 Pipeline Route should ***NOT*** be classified as an MHI.
g) Future development of the pipeline route does not have to subjected to an MHI risk assessment given that the maximum pressure in any part of the pipeline route does not exceed 30bar.

9.0 REFERENCES

1. CPR 14E. 2005. Methods for the calculation of physical effects
2. 4 CPR 18E. 2005. Guidelines for Quantitative Risk Assessments
3. SANS 1461:2018. Major Hazard Installation Risk Assessments.
4. BEVI Risk Assessment Reference Manual
5. EPCM Route Study Document No.: 21001-VP4-PR-CS-002

Appendix A

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 B

Accreditation Certificates

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South African National Accreditation System

CERTIFICATE OF ACCREDITATION

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

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:	Quality Manager: / Technical Manager:	Technical Signatory
Dr HFB Minnaar	Dr HFB Minnaar Dr HFB Minnaar	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 C

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.