

Appendix 15. Major Accidents and Disasters

15.1. COMAH Land Use Planning Assessment (AWN, 2026)



Trinity
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COMAH Land Use Planning Assessment

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TABLE OF CONTENTS

GLOSSARY OF TERMS	ii
NON TECHNICAL SUMMARY	iii
1. INTRODUCTION	1
2. DESCRIPTION OF PROPOSED DEVELOPMENT AND SITE LOCATION	2
2.1 Development Description	2
2.1.1 Gas Turbine Generator	7
2.1.2 Natural Gas Supply	7
2.1.3 Secondary Fuel Storage	7
2.1.4 LPG Storage	8
2.2 Surface Water	8
2.3 Fire Water Supply	8
2.4 Contaminated Firewater Retention	9
2.5 Surrounding Area and Identified COMAH Receptors	9
2.6 Properties of Dangerous Substances	11
2.6.1 Natural Gas	11
2.6.2 Diesel	11
LPG (Propane)	12
2.6.3	12
2.6.4 Small Volume Dangerous Substances	12
2.7 COMAH Status Determination	13
3. INTRODUCTION TO RISK ASSESSMENT	15
3.1 Risk Assessment – An Introduction	15
3.2 Land Use Planning and Risk Assessment	15
3.3 Individual Risk Criteria	16
3.4 Environment and Land Use Planning	16
3.5 Societal Risk Assessment Methodology	17
4. LAND USE PLANNING ASSESSMENT METHODOLOGY AND CRITERIA	18
4.1 Assessment Methodology	18
4.1.1 Physical Effects Modelling	18
4.1.2 Risk Assessment Methodology	18
4.2 Thermal Radiation Criteria	18
4.3 Overpressure Criteria	20
4.4 Flash Fire Criteria	24
4.5 Modelling Parameters	24
4.5.1 Weather Conditions	24
4.5.2 Surface Roughness	25
5. IDENTIFICATION OF MAJOR ACCIDENT HAZARDS	26
5.1 Major Accident Hazards at Proposed Gas Turbine Enclosure	26
5.1.1 Turbine Enclosure Vapour Cloud Explosion Scenario	26
5.1.2 Pipeline Release Scenario	26
5.1.3 Major Accidents to the Environment (MATTE)	26
5.1.4 Secondary Fuel Tank Rupture with Bund Overtop and Off-site Pool Fire	27
5.1.5 Major Accident Scenarios	27
6. LAND USE PLANNING ASSESSMENT OF MAJOR ACCIDENT HAZARDS	29
6.1 Natural Gas VCE at OCGT Turbine Enclosures	29

6.1.1	OCGT VCE Model Inputs	29
6.1.2	OCGT VCE Model Outputs	29
6.1.3	OCGT VCE Frequency	31
6.2	Natural Gas Pipeline Release	31
6.2.1	Natural Gas Pipeline Release Model Inputs	31
6.2.2	Natural Gas Pipeline Release Discharge Model Outputs	32
6.2.3	Natural Gas Pipeline Release: Predicted Phenomena	32
6.2.4	Natural Gas Pipeline Release and Jet Fire	33
6.2.5	Natural Gas Pipeline Release: Fireball Results	35
6.2.6	Natural Gas Pipeline Release: VCE Results	38
6.2.7	Natural Gas Pipeline Release: Flash Fire Results	39
6.2.8	Event Frequencies	41
6.3	LPG Tank Release	43
6.3.1	LPG Tank Release: Model Inputs	43
6.3.2	LPG Release: Predicted Phenomena	43
6.3.3	LPG Tank Rupture and Fireball	43
6.3.4	LPG Tank Release: VCE Results	46
6.3.5	LPG Tank Release and Jet Fire	48
6.3.6	LPG Tank Release and Flash Fire	50
6.3.7	LPG Tank Release Frequencies	52
6.4	LPG Road Tanker Release	52
6.4.1	LPG Road Tanker Release: Model Inputs	52
6.4.2	LPG Release: Predicted Phenomena	54
6.4.3	LPG Road Tanker Release and Fireball	54
6.4.4	LPG Road Tanker Release: VCE Results	56
6.4.5	LPG Road Tanker Release and Jet Fire	59
6.4.6	LPG Road Tanker Release and Flash Fire	61
6.4.7	LPG Road Tanker Release Frequencies	63
6.5	Diesel Tank Release	64
6.5.1	Pool Fire Model Inputs	64
6.5.2	Pool Fire Thermal Radiation Consequences	65
6.5.3	Diesel Tank Release Frequencies	66
7.	INDIVIDUAL RISK CONTOURS	67
8.	SOCIETAL RISK ASSESSMENT	71
9.	CONCLUSION	73
10.	REFERENCES	77
	APPENDIX A. NATURAL GAS VCE FLAMMABLE MASS CALCULATION	78
	APPENDIX B. CONSEQUENCE MODELLING CURVES	79

LIST OF TABLES

Table 1	Natural Gas Pipeline Specification	7
Table 2	Quantities of Hazardous Substances at the Proposed Development	14
Table 3	Calculation of COMAH Status at the Proposed Development	14
Table 4	Land Use Planning Matrix	16
Table 5	Heat Flux Consequences	18
Table 6	Heat Flux Consequences Indoors	19
Table 7	Conversion from Probit to Percentage	20
Table 8	Blast Damage	21
Table 9	Blast Overpressure Consequences Indoors	24
Table 10	Major Accident Scenarios at the Proposed Development	27
Table 11	OCGT VCE: Model Inputs	29
Table 12	OCGT Natural Gas VCE: Distances to Specified Overpressure Endpoints	30
Table 13	OCGT Enclosure Natural Gas VCE: Event Frequency	31
Table 14	Natural Gas Pipeline Rupture or Leak: Discharge Model Inputs	32
Table 15	Natural Gas 35 barg Pipeline Full Rupture or Leak and Jet Fire: Calculated Distances at Specified Thermal Radiation Levels (receptor height 1.5m)	34
Table 16	Natural Gas 35 barg Pipeline Release and Fireball: Fireball Model Outputs	36
Table 17	Natural Gas 35 barg Pipeline Rupture and Fireball: Distances to Specified Thermal Dose Levels (Receptor Height 1.5 metres)	36
Table 18	Natural Gas Pipeline Rupture or Leak: Vapour Cloud Explosion Ignition Location and Flammable Mass	38
Table 19	Natural Gas VCE following 35 barg Pipeline Release: Distances to Specified Overpressure Endpoints	38
Table 20	Natural Gas Pipeline Loss of Containment and Flash Fire: Distance to Flash Fire Envelope	40
Table 21	Natural Gas Pipeline Specification	41
Table 22	Natural Gas Pipeline Event Frequencies	42
Table 23	LPG Tank Release: Model Inputs	43
Table 24	LPG Tank Rupture and Fireball: Model Outputs	44

Table 25	LPG Tank Rupture and Fireball: Distances to Specified Thermal Dose Levels	44
Table 26	LPG Tank Release: Vapour Cloud Explosion Ignition Location and Flammable Mass	46
Table 27	LPG Tank Release and VCE: Distances to Specified Overpressure Endpoints	47
Table 28	LPG Tank Release and Jet Fire: Distances to Specified Thermal Radiation Levels	49
Table 29	LPG Tank Release and Flash Fire: Distance to Flash Fire Envelope	51
Table 30	LPG Tank Event Frequencies	52
Table 31	LPG Road Tanker Release: Model Inputs	53
Table 32	LPG Road Tanker Release and Fireball: Model Outputs	54
Table 33	LPG Road Tanker Release and Fireball: Distances to Specified Thermal Dose Levels	54
Table 34	LPG Road Tanker Release: Vapour Cloud Explosion Ignition Location and Flammable Mass	56
Table 35	LPG Road Tanker Release and VCE: Distances to Specified Overpressure Endpoints	58
Table 36	LPG Road Tanker Release and Jet Fire: Distances to Specified Thermal Radiation Levels	60
Table 37	LPG Road Tanker Release and Flash Fire: Distance to Flash Fire Envelope	62
Table 38	LPG Road Tanker Event Frequencies	63
Table 39	Bulk Diesel Tank Rupture: Uncontained Pool Fire Model Inputs	64
Table 40	Bulk Diesel Tank Rupture: Uncontained Pool Fire Model Outputs	65
Table 41	Bulk Diesel Tank Rupture and Uncontained Pool Fire: Thermal Radiation Results	65
Table 42	Secondary Fuel Diesel Tank Event Frequencies	66
Table 43	Societal Risk Calculation	72
Table 44	Summary of Major Accident Scenarios	73

LIST OF FIGURES

Figure 1 Individual Location-based Risk Contours for New Establishments	vi
Figure 1 Site Map with Red Line Planning Boundary for the Proposed Development	4
Figure 2 Proposed Development	5
Figure 3 Flow Diagram	6
Figure 4 Surrounding Area and COMAH Receptors	10
Figure 5 API Probability of Occupant Vulnerability	23
Figure 6 Wind Rose Athenry Synoptic Station	25
Figure 7 OCGT Enclosure VCE: Overpressure Contours Corresponding to 1% Mortality Outdoors and Indoors in CIA Cat. 3 Buildings	30
Figure 8 Above Ground 35 barg Natural Gas Pipeline Leak and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Mortality Outdoors	35
Figure 9 Natural Gas 35 barg Pipeline Rupture and Fireball: Outdoor Lethality Contours	37
Figure 10 Natural Gas 35 barg Pipeline Rupture and Fireball: 12.7 kW/m ² and 25.6 kW/m ² Contours	37
Figure 11 Natural Gas 35 barg Pipeline Rupture (Horizontal) and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours	39
Figure 12 Natural Gas 35 barg Pipeline Rupture (Horizontal): Flash Fire Footprint	40
Figure 13 LPG Tank Rupture and Fireball: Outdoor Lethality Contours	45
Figure 14 LPG Tank Rupture and Fireball: 12.7 kW/m ² and 25.6 kW/m ² Contours	45
Figure 15 LPG Tank Rupture and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours	48
Figure 16 LPG Tank Leak and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Mortality Outdoors	50
Figure 17 LPG Tank Rupture: Flash Fire Footprint	51
Figure 18 LPG Road Tanker Rupture and Fireball or BLEVE (hot): Outdoor Lethality Contours	55
Figure 19 LPG Road Tanker Rupture and Fireball or BLEVE (hot): 12.7 kW/m ² and 25.6 kW/m ² Contours	56
Figure 20 LPG Road Tanker Rupture and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours	59
Figure 21 100 mm LPG Road Tanker or Hose Leak and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Mortality Outdoors	61
Figure 22 LPG Road Tanker 100 mm Diameter Leak or Hose Rupture: Flash Fire Footprint	63

Figure 23 Bulk Diesel Tank Rupture and Uncontained Pool Fire: Worst Case 1% Mortality Outdoors Contour and Effect Area	66
Figure 24 Individual Location-based Risk Contours for New Establishments	68
Figure 25 Individual Risk Based Land Use Planning Contours	69
Figure 26 Proposed Consultation Distance (1×10^{-9} per year Individual Risk of Fatality Contour)	70
Figure 27 Individual Location-based Risk Contours for New Establishments	74
Figure 28 Individual Risk Based Land Use Planning Contours	75
Figure 29 Proposed Consultation Distance (1×10^{-9} per year Individual Risk of Fatality Contour)	75

GLOSSARY OF TERMS

AGI	Above Ground Installation
API	American Petroleum Institute
BLEVE	Boiling Liquid Expanding Vapour Explosion
CAS	Chemical Abstracts Service
CCPS	Centre for Chemical Process Safety
CIA	Chemical Industries Association
COMAH	Control of Major Accident Hazards
EIGA	European Industrial Gases Association
EPA	Environmental Protection Agency
ESD	Emergency Shutdown Device
EV	Expectation Value
GNI	Gas Networks Ireland
HSE	Health and Safety Executive (UK Authority)
HSA	Health and Safety Authority
LEL	Lower Explosion Limit
LFL	Lower Flammability Limit (synonymous with LEL)
LOC	Loss of Containment
LPG	Liquefied Petroleum Gas
LUP	Land Use Planning
MATTE	Major Accident to the Environment
OCGT	Open Cycle Gas Turbine
SEP	Surface Emissive Power
SuDS	Sustainable Drainage System
TLUP	Technical Land Use Planning
VCE	Vapour Cloud Explosion

NON TECHNICAL SUMMARY

Introduction

AWN Consulting, a Trinity Consultants Team, has been commissioned by AtkinsRéalis to complete a COMAH land use planning assessment of a proposed Open Cycle Gas Turbine Peaker Plant and associated infrastructure at Cashla, Athenry, Co. Galway, the Cashla Peaker Plant.

The assessment was prepared by Maeve McKenna, BEng (Chemical Engineering), MEngSc, CEng, MIEI. Maeve has 20 years' experience in environmental and process safety assessment and management projects, including hazard identification studies at notified COMAH establishments, and consequence and risk modelling of major accident hazards including COMAH land use planning quantitative risk assessments.

The proposed development (i.e. the section 37E planning application) will be classified as a "lower tier" COMAH establishment and as such will be subject to the provisions of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015.

An assessment of the acceptability of individual and societal risk arising from major accident hazards associated with the operation of the proposed development was completed. The assessment was completed in accordance with the Health and Safety Authority's *Guidance on technical land-use planning advice for planning authorities and COMAH establishment operators* (HSA, 2023).

Description

There are 4 no. key elements to the project subject of the EIAR, namely:

- ▶ Peaker Plant
- ▶ Rathmorrissey AGI
- ▶ GNI146 Rathmorrissey Gas Pipeline (i.e. underground gas pipeline)
- ▶ Underground Cable Grid Connection Route

The open cycle gas turbine (OCGT) generator will consist of 1 no. gas turbine powering a generator that will provide an electrical supply of 325 or 334 MW to the EirGrid 220 kV transmission system through the combustion of natural gas. Natural gas will be supplied from the Gas Networks Ireland (GNI) transmission.

A further description is provided in section 2.1. of this report.

The proposed development (i.e. the section 37E planning application) will consist of the following components:

- ▶ A single open cycle gas turbine (OCGT) plant primarily fuelled by natural gas.
- ▶ One exhaust stack with a height of 30 m and 7 m in diameter.
- ▶ Balance of plant equipment.
- ▶ Above ground installation (AGI).
- ▶ Secondary fuel storage (i.e., diesel¹) and fuel transfer facilities.
- ▶ Workshop, stores, car park and administration buildings.
- ▶ Ancillary infrastructure including internal roads, external lighting, security fencing, utilities and drainage.
- ▶ Soft landscaping to enhance site integration and visual screening.

¹ Note: The Peaker Plant facility is required to store a quantity of secondary fuel to be compliant with EirGrid's Grid Code secondary fuel specification.

The wider project subject of the EIAR consists of the following infrastructure:

- ▶ GNI 146 Rathmorrissey Gas Pipeline (underground).
- ▶ 220 kV Air-insulated Substation (AIS).
- ▶ One 220 kV electrical transformer.
- ▶ 36 m high telecoms mast.
- ▶ Ancillary grid connection infrastructure (underground cable).

Refer to Section 2.1 for further detail.

The open cycle gas turbine (OCGT) generator will consist of 1 no. gas turbine powering a generator that will provide an electrical supply of 334 MW to the EirGrid 220 kV transmission system through the combustion of natural gas. Natural gas will be supplied from the Gas Networks Ireland (GNI) transmission system via an above ground installation (AGI) that will deliver gas to the turbine in a suitable process condition via above ground pipelines.

Diesel will be provided as a secondary source of fuel for the OCGT.. Diesel will be stored in 2 No. tanks within a sealed concrete bunded area. 1 No. LPG storage tank will be provided. The LPG will support gas turbine start-up with secondary diesel if required.

Natural gas and LPG are classified as a Flammable gas (Category 1). Diesel is classified as a flammable liquid and vapour (category 3) and is also hazardous to the aquatic environment (long term, category 2).

Land Use Risk Assessment Methodology Criteria

The risk assessment methodology to be followed is set out in Health and Safety Authority's Guidance on technical land-use planning advice for planning authorities and COMAH establishment operators (HSA, 2023).

The approach involves five steps:

1. Identifying major accident hazards at new COMAH establishments that have the potential to give rise to serious damage to human health or the environment due to the hazardous nature of dangerous substances present at the establishment, for example fire and explosion events involving flammable gases such as hydrogen and methane (natural gas). The major accident hazards are set out in the HSA's guidance document cited above.
2. The consequences of major accident hazards (fire and explosion events) are determined using numerical modelling software. Standard industry software such as DNV PHAST or Gexcon Effects is used to estimate consequences. Heat radiation, explosion overpressure and toxic dose are converted to probability of fatality, and distances to endpoints corresponding to 1% mortality are reported.
3. Estimating the likelihood of the event which is a means of measuring how often it may occur. For land use planning purposes, the HSA's technical guidance documents specifies values for the likelihood of events such as fires and explosions.
4. Quantifying the risk of fatality from major accident scenarios. The cumulative risk for all hazards at an establishment (such as an electrolytic hydrogen production plant) is modelled by combining the consequences and likelihood in numerical risk modelling software such as Gexcon Riskcurves. Contours corresponding to individual risk of fatality are generated.
5. Quantifying societal risk from major accident scenarios which considers the overall population exposed to the consequences of a major accident, evaluated by calculating the Expectation Value which multiplies the predicted number of fatality from a major accident (N) by the likelihood of frequency of the accident occurring (F), $EV = F \times N$.

In relation to assessment criteria, for new COMAH establishments, the individual risk of fatality criteria specified by the HSA are as follows:

- ▶ Individual risk:
 - 10^{-6} /year: 1 chance per million per year or one fatality at a frequency of once every million years: Maximum tolerable risk to a member of the public (equivalent to the middle zone described above)
 - 5×10^{-6} /year: 5 chances per million per year or one fatality every 200,000 years: Maximum tolerable risk to a person at an off-site work location
- ▶ Societal risk:
 - The total off-site EV should not exceed the criterion upper limit EV of 10,000. Between EVs of 100 and 10,000, it should be demonstrated that all practicable efforts have been made to reduce the risk to a level that is as low as reasonably practicable

Major Accident Hazards

The HSA specifies the following major accident hazards for the hazardous installations at the proposed development.

Installation	Loss Of Containment scenario	Consequence/Event
Indoor equipment (release of natural gas in turbine enclosure)	Instantaneous failure	VCE ⁽¹⁾
	Continuous leak over 10 minutes	VCE
	10 mm pipe leak over 30 minutes	VCE
Natural Gas Pipeline	Rupture of Pipeline	Fireball/Jet fire
		VCE
		Flash fire
	Pipeline Leak of 0.1D	Fireball/Jet fire
		VCE
		Flash fire
LPG Tank	Instantaneous release	Fireball
		VCE
		Flash fire
	Continuous leak over 10 minutes	Jet fire
		VCE
		Flash fire
	10 mm pipe leak over 30 minutes	Jet fire
		VCE
		Flash fire
LPG Road Tanker	Instantaneous failure	Fireball
		VCE
		Flash fire
	Loss of entire contents through largest connection	Jet fire
		VCE
		Flash fire
	Rupture of unloading hose	Jet fire
		VCE
		Flash fire
	Leak of unloading hose 10% of diameter	Jet fire
		VCE
		Flash fire
	BLEVE (hot)	BLEVE ⁽¹⁾ (hot)

Installation	Loss Of Containment scenario	Consequence/Event
Diesel	Instantaneous failure	Pool fire

Note 1

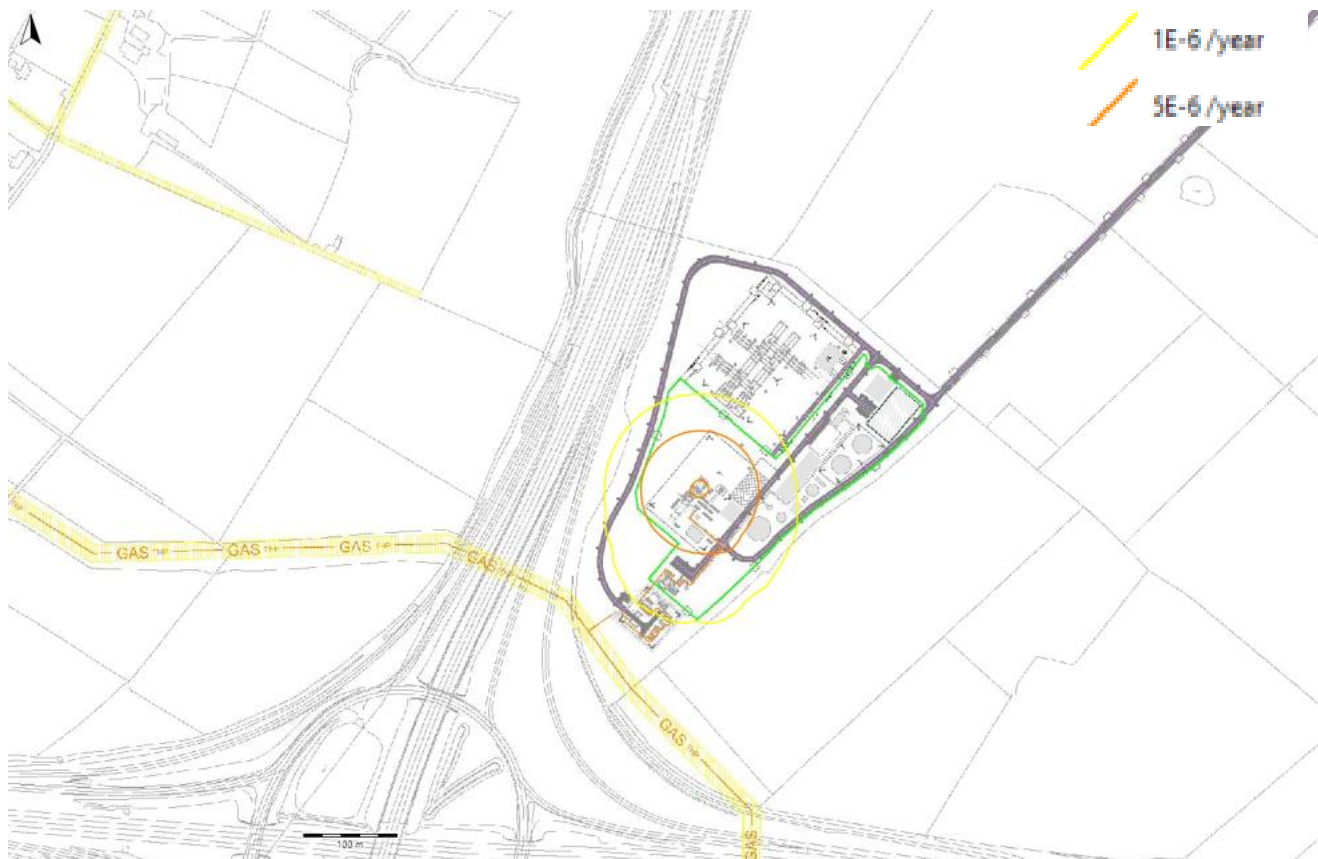
VCE Vapour Cloud Explosion

BLEVE Boiling Liquid Expanding Vapour Explosion

Assessment Results

The individual risk of fatality contours corresponding to tolerability levels for new COMAH establishments are illustrated as follows.

Figure 1 Individual Location-based Risk Contours for New Establishments



It is concluded that the individual location-based risk contours corresponding to tolerable levels for new COMAH establishments do not extend to an off-site work location or to an indoor area where the public are present. Therefore, it is concluded that the Health and Safety Authority's criteria are met, and level of off-site risk at the proposed development (i.e. the section 37E planning application) is acceptable.

A portion of the M18 to the east of the proposed development (i.e. the section 37E planning application) is within the consequence zone of a number of major accident scenarios at the proposed Peaker Plant. A Societal Risk calculation for the proposed development was completed and the Expectation Value (EV) was calculated to be **1.3**. This is <100; therefore, no further risk reduction is required.

1. INTRODUCTION

AWN Consulting, a Trinity Consultants Team, has been commissioned by AtkinsRealis to complete a COMAH land use planning assessment of a proposed Open Cycle Gas Turbine Peaker Plant and associated infrastructure at Cashla, Athenry, Co. Galway, the Cashla Peaker Plant.

The assessment was prepared by Maeve McKenna, BEng (Chemical Engineering), MEngSc, CEng, MIEI. Maeve has 20 years' experience in environmental and process safety assessment and management projects, including hazard identification studies at notified COMAH establishments, and consequence and risk modelling of major accident hazards including COMAH land use planning quantitative risk assessments.

The COMAH status is assessed in accordance with the criteria set out in Schedule 1 of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations 2015 (S.I. 209 of 2015) (COMAH Regulations 2015).

The proposed development (i.e. the section 37E planning application) will be classified as a "lower tier" COMAH establishment and as such will be subject to the provisions of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015.

This report identifies risk-based land use planning contours for the proposed development and assesses societal risk associated with the proposed development (i.e. the section 37E planning application). The individual risk contours are based on consequence assessment and risk modelling of major accident scenarios identified for the proposed development (i.e. the section 37E planning application) and the assessment has been completed in accordance with the Health and Safety Authority's

Guidance on technical land-use planning advice for planning authorities and COMAH establishment operators (HSA, 2023).

This report details the following:

- ▶ Description of development and site location
- ▶ Introduction to risk assessment
- ▶ Land Use Planning assessment methodology and criteria
- ▶ Identification of Major Accident Hazards
- ▶ Land Use Planning Assessment of Major Accident Scenarios
- ▶ Individual Risk Contours
- ▶ Societal Risk Assessment
- ▶ Conclusion

2. DESCRIPTION OF PROPOSED DEVELOPMENT AND SITE LOCATION

2.1 Development Description

Bord Gáis Energy Limited intend to apply for a 10-year permission for development (i.e. the section 37E planning application) of a gas-fired power plant (named 'Cashla Peaker Plant'). The Cashla Peaker Plant will function as a balancing asset, operating intermittently during periods of low renewable energy generation and high electricity demand. The proposed operational life is up to and including the 31st of December 2050, which is tied to Ireland's Climate Action Plan 2025.

The proposed development (i.e. the section 37E planning application) site, named the 'Cashla Peaker Plant Site' is approximately 11.54 hectares and is located within the townlands of Pollnagroagh and Rathmorrissey, Athenry, Co. Galway.

Within the **Cashla Peaker Plant Site**, the proposed development (i.e. the section 37E planning application) comprises the following infrastructure:

- a) The construction of an open-cycle gas turbine (OCGT) and generator with ancillary equipment including a 30m high stack and emissions monitoring unit, fuel storage and supply systems, cooling and air systems, compressed air and gas handling skids, a grid step-up transformer within a bund, an auxiliary transformer, a generator circuit breaker and an emergency diesel generator. The construction of ten buildings on-site including one single-storey administration building (approximately 390sqm), one single storey ESB Substation building (approximately 32.5sqm), one single-storey workshop building (approximately 750.5sqm), one single storey water treatment plant building (approximately 104sqm), fuel forwarding and unloading area (approximately 104sqm), one single-storey electrical control building (approximately 243.5sqm), one single storey gas analyser kiosk (approximately 6.25sqm), one single-storey boiler house kiosk (approximately 37sqm), one single-storey ancillary pressure reduction kiosk (approximately 26sqm) and a single-storey electrical and instrumentation kiosk (approximately 19sqm). The installation of five above-ground tanks including two bunded fuel tanks (approximately 11.1m high), one fire and service water tank (approximately 13m high), one demineralised water tank (approximately 15.4m high) and one demineralised waste tank (approximately 5m high).
- b) The construction of a Gas Networks Ireland (GNI) above ground pressure regulating installation, known as an Above Ground Installation (AGI). The AGI (named Rathmorrissey AGI) will connect to the mains transmission gas network which exists within the site. The AGI infrastructure will occupy an enclosed area of approximately 2,500 sq.m. It encompasses five single-storey buildings: the gas analyser kiosk (approximately 6.25 sqm), the boiler house kiosk (approximately 37 sqm) including 10 no boiler flues approximately 5.67 m above ground level and emergency generator, two pressure reduction kiosks – main (approximately 73 sqm) including approximately 5.24 m high vents, and ancillary (approximately 26 sqm) including approximately 3.72 high vents – and the electrical and instrumentation kiosk (approximately 19 sqm). Ancillary infrastructure will include a gas meter, filters, heat exchangers, and above-ground pipework. The compound will include lighting, 3 no. parking spaces, internal access routes, concrete bases to support the infrastructure, and stone-chipped surfacing. It will be secured by an approximately 2.4 m high fence with an access gate.

It is noted that the connection to the existing mains gas network (Mayo–Galway pipeline (BGE/85)) will be undertaken via a new transmission pipeline (named GNI146). The GNI146 gas pipeline is subject to Section 39A Consent under the Gas Act 1976, as amended.

- c) Ancillary works including the provision of a new gated vehicular entrance off the L3103, the construction of an access road from the proposed Cashla Peaker Plant Site entrance to the new entrance off the L3103, the demolition of one farm outbuilding (in ruin), construction of internal access roads, hardstanding, security fencing (2.4m high), CCTV and gates, provision of a wastewater treatment system and associated underground wastewater storage tanks, drainage (foul and storm), soakaway retention pond, propane tank, construction of underground firewater retention tanks, provision of parking (12 no. spaces including mobility and EV Parking) and laydown area, 20 no. cycle parking spaces, landscaping and all ancillary on-site development works.

As part of the application for permission, both an Environmental Impact Assessment Report (EIAR) and a Natura Impact Statement (NIS) have been prepared for the proposed development. These reports assess and outline the potential environmental effects of the project and ensure it aligns with EU regulations for environmental protection.

In addition to the above outlined proposed development, the “project”, subject of the EIAR and NIS, consists of the construction of an ESB substation compound within the Cashla Peaker Plant site. The infrastructure will include a 4-bay 220 kV substation incorporating a single-storey Air-Insulated Switchgear (AIS) substation building (approximately 388sqm) and access road; a 36m high telecommunications mast; a shunt reactor, ancillary works including lighting, security fencing (2.4m high), internal tracks, and 4 no. carparking spaces. It also consists of the construction of approximately 8.1 kilometres of an underground grid connection route and laying of cable from the proposed ESB Substation in the Cashla Peaker Plant Site to the Cashla 220kV Substation along the L7109, L71093, L7108 and L3103 roads and across the townlands of Rathmorrissy, Pollnagroagh, Moanbaun, Castlelambert, Knocknacreeva, Caraunduff, Caherbriskaun, Lisheenkyle East, Barrettspark, Cashla, Athenry, Co. Galway. The construction methodology includes three horizontal directional drilling (HDD) operations beneath the M6 and M17 motorways to minimise surface disruption. In total, the project site covers approximately 19.17 hectares. The 220kV substation and associated 220kV grid connection will be subject to a separate Strategic Infrastructure Development planning application submitted to An Coimisiún Pleanála.

The proposed development (i.e. the section 37E planning application) involves an activity that will require an Industrial Emission Licence from the Environmental Protection Agency (EPA). This ensures that the project meets all necessary environmental standards related to emissions and other factors impacting the surrounding area.

Additionally, the development (i.e. the section 37E planning application) includes the establishment of a facility where safety measures under the Major Accident Directive (Seveso) will apply. These regulations are designed to prevent and limit the consequences of potential industrial accidents, ensuring the project is both safe and compliant with industry best practices.

For detail on the statutory development description (i.e. the section 37E planning application), please refer to the (section 37E planning application) planning application form.

The redline planning boundary for the proposed development (i.e. the section 37E planning application) is presented in Figure 1 (which includes the proposed access route).

Figure 3 illustrates the layout of the proposed Peaker Plant and the operational COMAH site boundary. It is noted that the AGI and natural gas pipeline connection to the GNI distribution line are outside of the COMAH site boundary along with the 220kV AIS Substation Compound.

Figure 2 Site Map with Red Line Planning Boundary for the Proposed Development (i.e. the section 37E planning application)

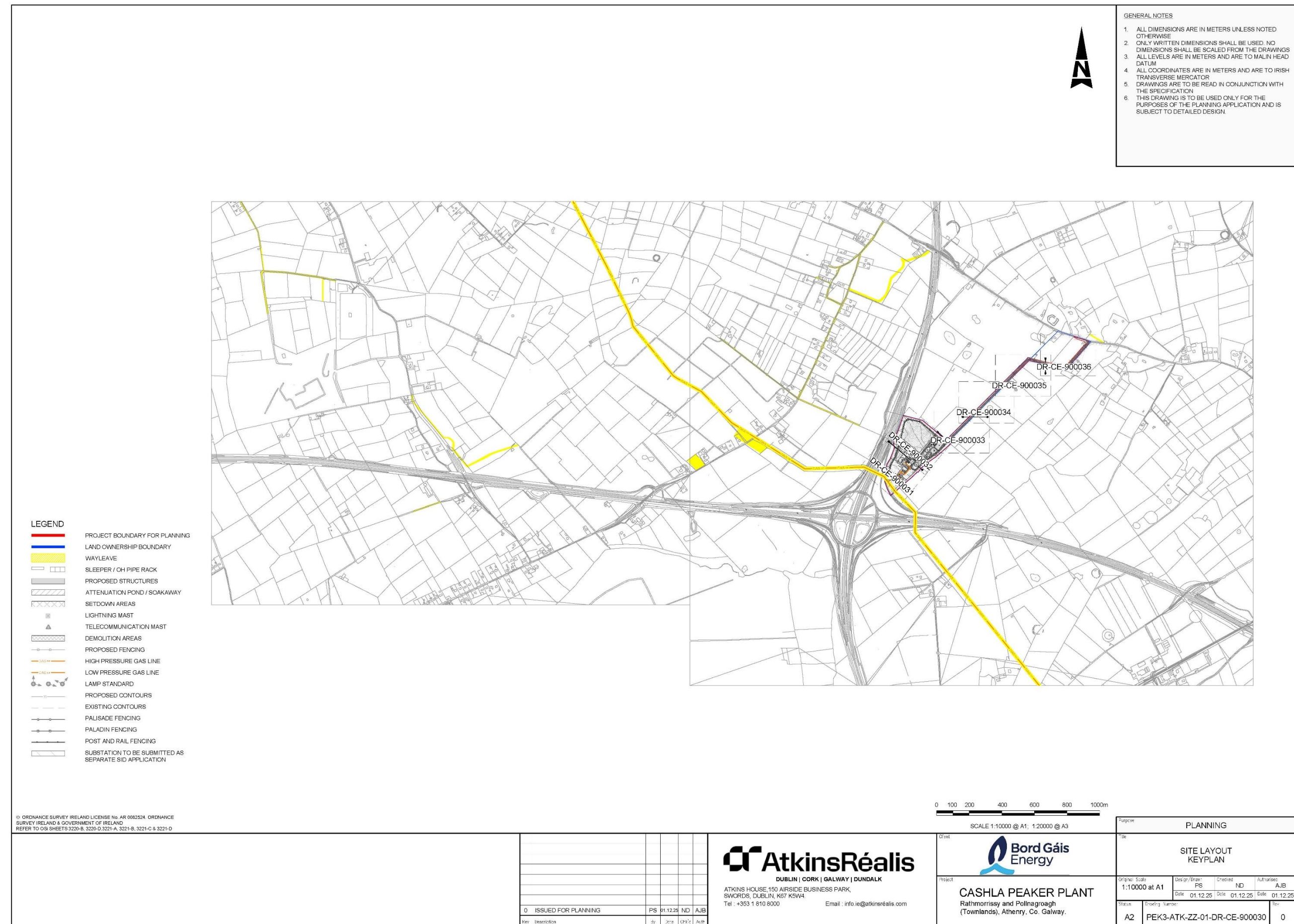


Figure 3 Proposed Development (i.e. the section 37E planning application)

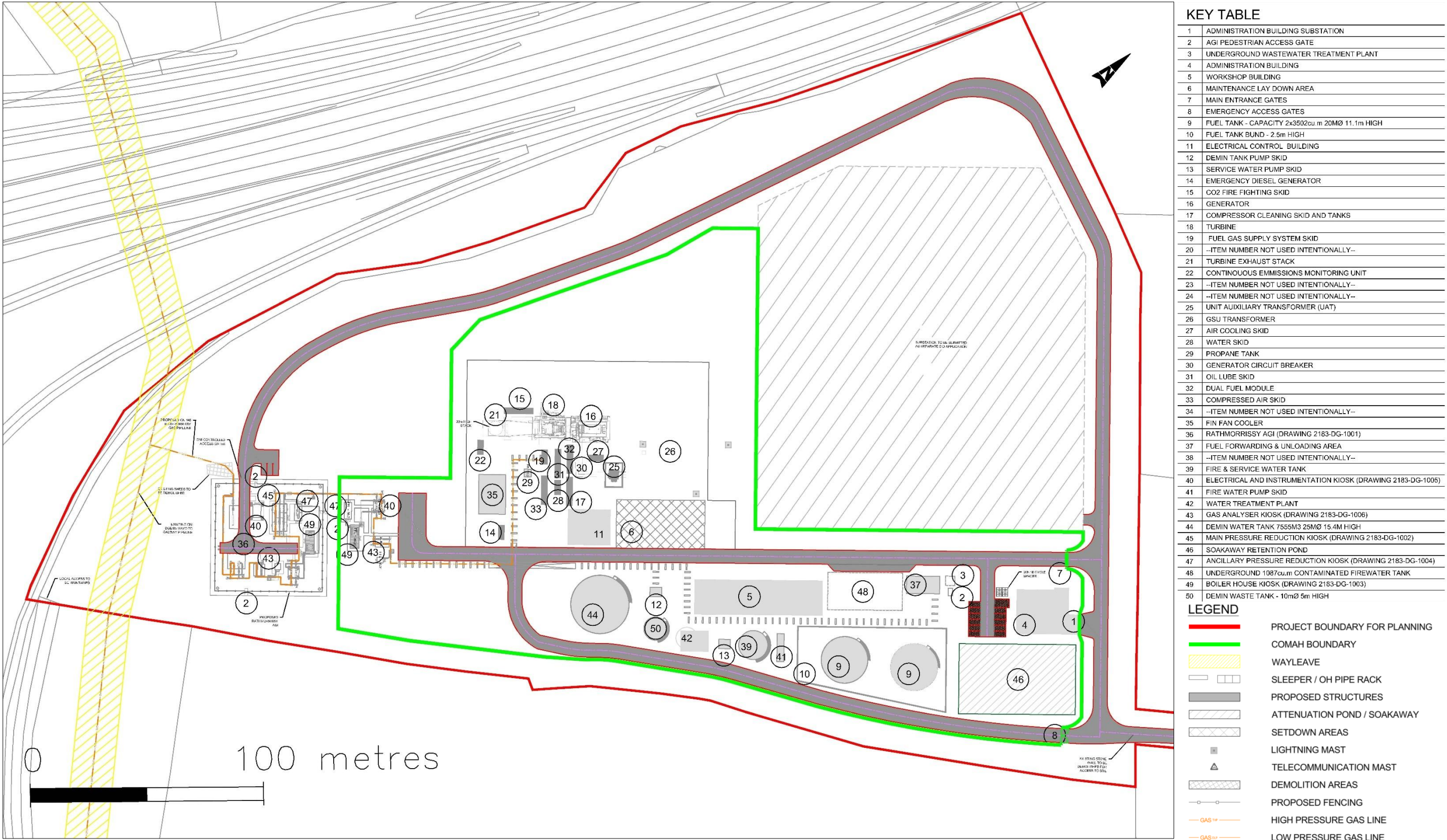
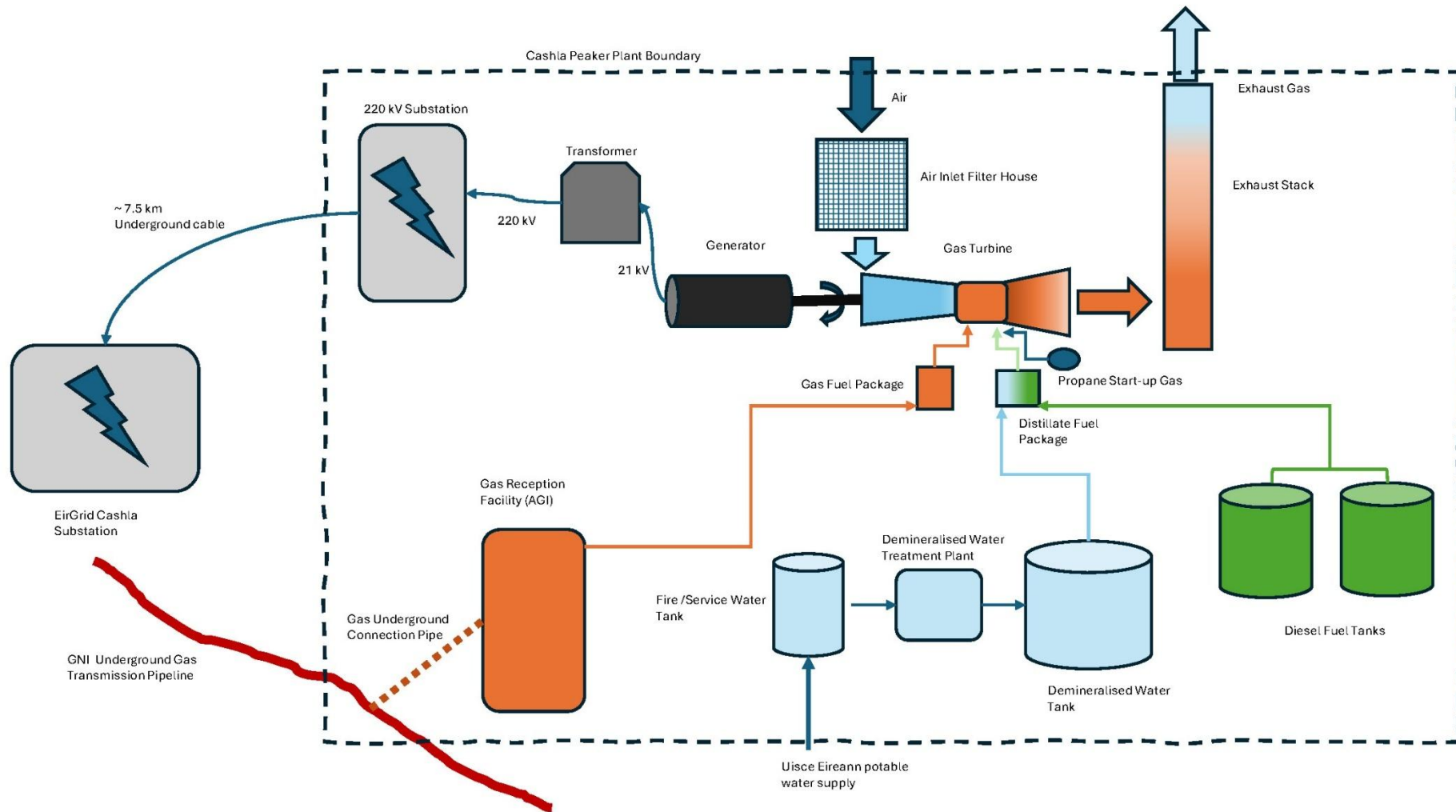


Figure 4 Flow Diagram

AtkinsRéalis - Baseline / Référence



2.1.1 Gas Turbine Generator

The gas turbine generator will consist of 1 no. gas turbine powering a generator that will provide an electrical supply to the EirGrid 220 kV transmission system.

The gas turbine draws in air through an air inlet filtration system, compresses the air to raise the pressure, heats the air by combusting it with fuel, expands the hot pressurised air through a turbine connected to an electrical generator to produce electrical power and finally exhausts the air via a vertical exhaust stack. The gas turbine combusts natural gas as the primary fuel and, if required, low sulphur diesel as a secondary backup fuel.

The gas turbine will be located within an enclosure. The volume of each OCGT enclosure excluding the turbine will be 1400 m³.

2.1.2 Natural Gas Supply

The OCGT units will primarily run on natural gas (methane) supplied from the GNI network which has a transmission pipeline running through the southern area of the site within the planning and land ownership boundary but outside of the COMAH boundary.

To supply gas to the gas turbine and generator, an above ground installation (AGI) named Rathmorrissy will be built within the Peaker Plant planning and land ownership boundary but outside of the COMAH boundary. Gas Networks Ireland (GNI) will own and operate the AGI asset with the purpose of supplying a gas connection to the proposed Peaker Plant.

The AGI will be designed and constructed in accordance with IS 328:2021 and ISEN 12186:2014 standard. The AGI equipment will be designed to EN standards for the processing of natural gas.

The AGI will perform the function of receiving the gas, metering the gas and passing it onward in a suitable process condition to the Peaker Plant's gas turbine combustion system gas supply connecting pipe. This will include regulation of the gas pressure from 85 barg down to 35 barg.

The point of connection to the GNI distribution natural gas pipeline and the proposed AGI will be outside of the operational COMAH boundary as illustrated on Figure 3.

Table 1 details the specification of natural gas pipelines on site within the COMAH Boundary.

Table 1 Natural Gas Pipeline Specification

Pipeline	Diameter (mm)	Length (m)	Maximum Operating Pressure (barg)
AGI to gas turbines (above ground)	250	167	35

2.1.3 Secondary Fuel Storage

Diesel will be provided as a secondary source of fuel for the OCGT. Backup fuel storage in the form of 6,670 m³ (or 5470 tonnes) of low sulphur diesel, in 2 No. double-skinned full containment tanks, is provided within the design of the proposed power generation plant. Diesel will be stored in 2 No. tanks within a sealed concrete bunded area. The tanks will be designed in accordance with EN 14015 inclusive of all safety features required by the standard and as the result of safety design reviews during the detailed design stage.

The bund will be reinforced concrete and will have a capacity of at least 110% of the greatest individual tank.

Secondary back-up diesel fuel will be offloaded on site from road tankers in a hard standing area with provision to collect any spilled diesel to prevent any discharge to ground.

2.1.4 LPG Storage

1 No. LPG storage tank with the capacity to contain up to 1008 kg of LPG (propane) will be provided. The LPG will support gas turbine start-up with secondary diesel if required.

The LPG tank will be refilled once every 5 years. Refilling is estimated to take 15 minutes. The maximum duration that a laden LPG road tanker will be present on site is estimated as 1 hour per delivery, or 1 hour every 5 years.

2.2 Surface Water

The drainage system will discharge into a soakaway located within the AGI boundary, Peaker Plant Storm Network. The main area of the AGI is gravel and will allow surface water to percolate away to subsoil naturally. The hardstanding areas will be collected via gullies and pipework and discharged to ground via a soakaway and petrol interceptor.

The peaker plant site will be provided with a new storm sewer network which will include Sustainable Drainage System (SuDS) measures where practicable. There are no storm sewers or culverts in the immediate site surroundings. As such, it is proposed to discharge stormwater generated by the development (i.e. the section 37E planning application) by infiltration to ground.

The peaker plant site will be an EPA (Industrial Emissions) licensed site and as such is limited in its discharge of stormwater to ground due to the possibility of contaminated firewater in the discharge. Any stormwater captured on hardstanding areas that is not contaminated will be discharged to ground via soakaway. Any stormwater which falls outside of the hardstanding areas will be allowed to be discharged to ground.

The new storm sewer network will be gravity fed and segregated into different sections to facilitate contaminated fire water collection (see Section 2.4). The areas will be controlled by actuator valves to control the flow path of the segregated areas.

2.3 Fire Water Supply

In the event of a fire and loss of electrical power, a diesel driven fire water pump will supply fire water. The pump will contain a quantity of diesel fuel in a co-located tank sufficient of sufficient volume capacity for the statutory requirement. The exact volume capacity will be calculated during the detailed design stage.

A dedicated fire-main system will be installed to encircle the entire site, designed to deliver up to 70 litres per second volume flow rate. This system will be supplied by a static firefighting and water service tank, which will hold a dedicated capacity of 540 cubic metres – sufficient to support two hours of firefighting operations. Double hydrants will be provided throughout the site and will be positioned at least 6 metres away from any structure to ensure safety and accessibility.

The potable water supply, estimated at 6 litres per second, is not intended for firefighting use. Instead, all firefighting needs are expected to be met using the water stored in the static tank. The flow rate, tank volume and time to refill the tank will be calculated at detailed design stage. The tank will be sized in accordance with the "I.S. 391:2020 Fire mains for buildings - Installation, commissioning, maintenance and testing" and "UK National Guidance Document on the Provision of Water for Firefighting", specifically for sites exceeding 5 hectares.

2.4 Contaminated Firewater Retention

Retention facilities will be provided to contain any potentially contaminated firewater produced during a fire and to provide for storage for later disposal off-site by tankers.

According to UK National guidance on water provision for firefighting², an industrial site exceeding 3 hectares should be capable of supplying a fire fighting water flow of 75 litres per second. Since Uisce Éireann cannot supply this volume, a static firefighting tank with a capacity of 540 cubic meters will be installed on site to facilitate this requirement.

To manage the contaminated firewater tank, which is also based on the 10-year, 24-hour storm runoff, the storm network will be divided into multiple individual areas. Each area will have sensor-controlled actuator valve. In the event of a fire, the firewater from the affected area will be diverted to the firewater tanks, while any rainfall during the fire in other areas will continue to flow unimpeded to the soakaway of the site. This division into separate areas helps reduce the size of the contaminated firewater storage tanks.

The maximum calculated runoff for the 10-year, 24-hour storm is 196 cubic meters, meaning the total storage tank size required will be $540 + 196 = 736$ cubic meters. In the unlikely event of a fire, the contaminated firewater will be disposed of off-site by tanker to a suitable external wastewater treatment facility.

In addition, the contaminated fire water tank will double as a holding tank for the unrecoverable demineralised production water which is an additional 350cu.m giving a total size of 1086 cu.m.

2.5 Surrounding Area and Identified COMAH Receptors

The proposed development (i.e. the section 37E planning application) is located on a greenfield site in a rural location approximately 2 km west of Athenry town.

The proposed development (i.e. the section 37E planning application) is bound by the M6/M18 motorway interchange to the west and south and by agricultural land to the north and east.

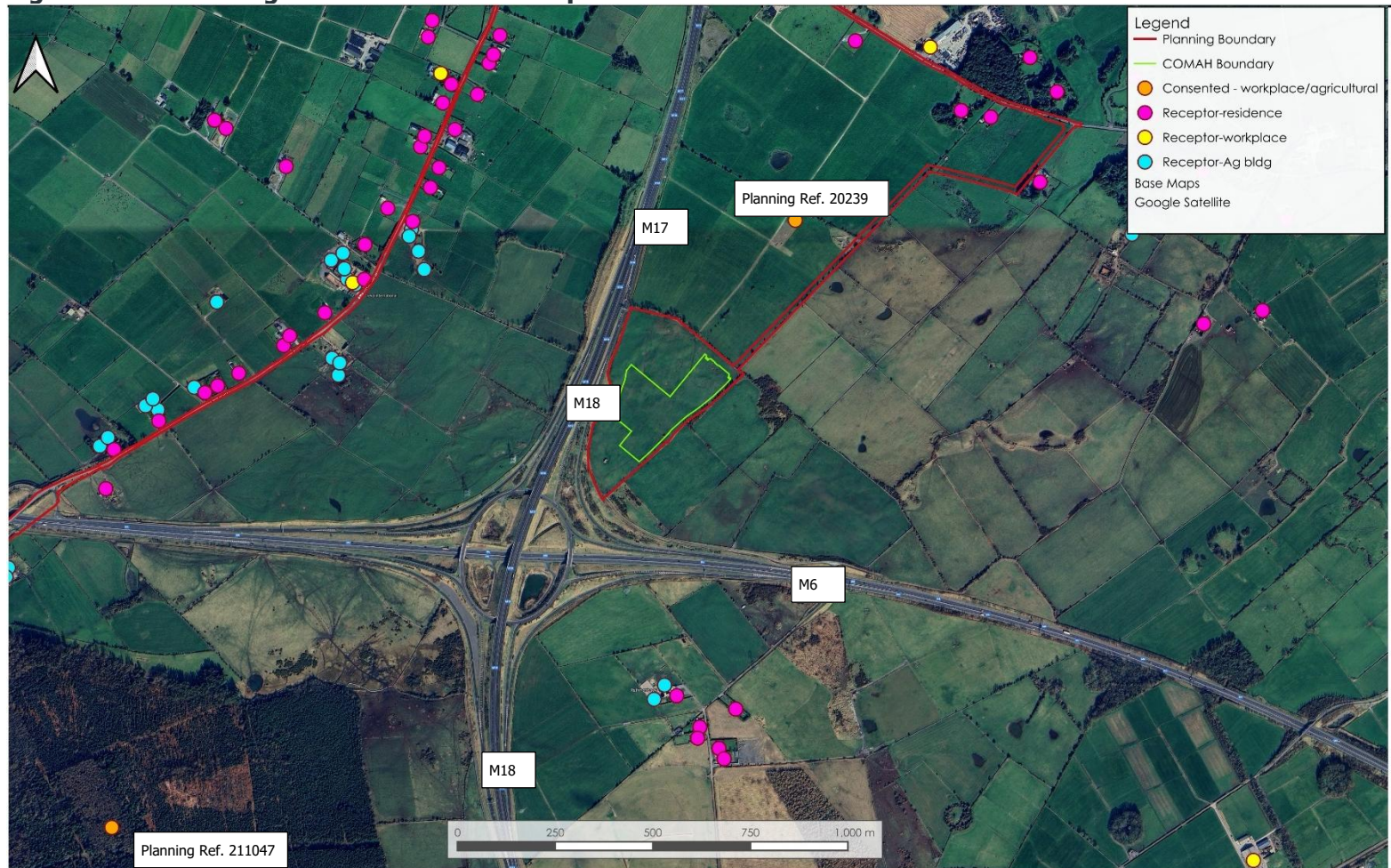
The nearest residential dwelling to the proposed development (i.e. the section 37E planning application) is in the townland of Rathmorissy approximately 530 metres to the south of the planning boundary. There are residential dwellings along the L3103 to the north and the local road to west of the M18/M17.

Planning permission has been granted for a milking parlour to the north of the proposed Peaker Plant (Galway County Council planning reference 20239). Planning permission has been granted for an Apple Data Centre south west of the interchange (Galway County Council planning reference 15488, extended by planning reference 211047).

Figure 5 illustrates the built environment in the vicinity of the proposed development (i.e. the section 37E planning application) site and identified COMAH Receptors.

² [National guidance document on the provision of water for firefighting | Water UK](#)

Figure 5 Surrounding Area and COMAH Receptors



Basemap © OpenStreetMap contributors

2.6 Properties of Dangerous Substances

2.6.1 Natural Gas

Natural gas (methane) (CAS number 74-82-8) is classified as a Flammable Gas Category 1 with hazard statement H220 extremely flammable gas.

The DIPPR© Database that is referenced in DNV PHAST proprietary consequence modelling software gives the following flammable properties for methane:

- ▶ Lower flammability limit 50,000 ppm (5% v/v)
- ▶ Upper flammability limit 150,000 ppm (15% v/v)
- ▶ Maximum surface emissive power 220 kW/m²
- ▶ Heat of combustion 802620 kJ/kmol

2.6.2 Diesel

Diesel (CAS number 64742-46-7) is classified as a flammable liquid category 3 and hazardous to the aquatic environment (long term) (Aquatic Chronic Category 2) with the following hazard statements:

- ▶ H226 Flammable liquid and vapour
- ▶ H411 Toxic to aquatic life with long lasting effects

Environmental hazards

Gas oils (including diesel) are complex mixtures of hydrocarbons ranging in carbon number from C11 to about C25. The major hydrocarbon types are iso- and cyclic-paraffins, but gas oils may contain a significant proportion of aromatics, including alkylbenzenes, alkylnaphthalenes, alkylanthracenes and other polycyclic compounds.

If gas oil is released to the environment, it will be subject to a number of loss processes. Lighter components will evaporate and be photooxidised by reaction with OH radicals. Higher molecular weight components may also be subject to photooxidation but will also adsorb to soil and sediment. In aerobic soils and sediments most gas oil components will be subject to biodegradation, but under anaerobic conditions, gas oils are more persistent. Gas oil components are predicted to bioaccumulate on the basis of their high log Kow values, but the available literature suggests that those organisms tested are able to metabolise gas oil hydrocarbons. The aquatic toxicity data on gas oils indicates that acute LL50/EL50/IL50 values for aquatic organisms are in the range 1 to 100 mg/l. However there is little available data generated using accepted protocols for oil products and the current database should be interpreted with caution. (CONCAWE, 1996)

Fire and explosion hazards

Gas oils have flash points (Pensky Marten Closed Cup) of 56°C and greater. The lower flammability limit is about 1% volume; the upper limit is about 6% volume. A typical autoginition temperature for these products is around 220°C. If ignited, gas oils can burn fiercely. However, their low vapour pressure (in comparison with lighter products) reduces the risk of flash-back or the formation of explosive atmospheres. (CONCAWE, 1996). The Classification, Labelling and Packaging Regulation assigns Flammable Liquid Category 3 classification to gas oils, diesel and light heating oils having a flash point ≥ 55 °C and ≤ 75 °C.

2.6.3 LPG (Propane)

Liquefied Petroleum Gas (propane), CAS # 74-98-6 is classified as a Flammable Gas Category 1 with hazard statement H220 extremely flammable gas.

The DIPPR© Database that is referenced in DNV PHAST gives the following flammable properties for methane:

- ▶ Lower flammability limit 21,000 ppm (2.1% v/v)
- ▶ Upper flammability limit 95,000 ppm (9.5% v/v)
- ▶ Maximum surface emissive power 160 kW/m²
- ▶ Heat of combustion 2043110 kJ/kmol

2.6.4 Small Volume Dangerous Substances

The following dangerous substances and chemical classification (based on safety data sheets provided by AtkinsRéalis, the project engineer) will be stored in small quantities:

- ▶ 100 litres of lubricating oil to top up equipment bearing lubrication systems – not classified as a hazardous substance ³
- ▶ 50 kg of lubricating grease to top up equipment bearing grease – classified as Skin Sens. 1; H317 May cause an allergic skin reaction ⁴
- ▶ 100 litres biocide for water system treatment – classified as: ⁵
 - Corrosive to metals Category 1, May be corrosive to metals
 - Acute toxicity (oral, inhalation, dermal) Category 4, Harmful if swallowed, in contact with skin or if inhaled
 - Skin corrosion Category 1B and Serious eye damage Category 1, Causes severe skin burns and eye damage
 - Skin sensitisation Category 1, May cause an allergic skin reaction
- ▶ 1000 litres of biocide for diesel treatment – classified as: ⁶
 - Flammable liquid Category 4, H227 Combustible liquid
 - Aspiration hazard Category 1, H304 May be fatal if swallowed and enters airway
 - Skin corrosion/irritation Category 2, H315 Causes skin irritation
 - Serious eye damage /irritation Category 2A – H319 Causes serious eye damage
 - Toxic to reproduction Category 1B, H360 May damage fertility or the unborn child
 - Acute hazard to the aquatic environment and Chronic hazard to the aquatic environment Category 3, H412 Harmful to aquatic life with long lasting effects
- ▶ 100 litres of corrosion inhibitor – classified as Serious eye damage/eye irritation Category 1, H318 Causes serious eye damage ⁷
- ▶ 1000 litres of weak sulphuric acid – classified as Skin corrosion/irritation Category 1A, H314 Causes severe skin burns and eye damage and Serious eye damage/eye irritation Category 1, H318 Causes serious eye damage ⁸

The following dangerous substances and chemical classification will be in use operationally:

³ Safety Data Sheet for Shell turbo Oil GT 32 Version 2.2 Revision Date 02.06.2016

⁴ Safety Data Sheet for LGMT 2, SKF, Version 4.6.0 Revision Date 07.04.2025

⁵ Safety Data Sheet for Nalco® 7330, Issuing Date 07.13.2022

⁶ Safety Data Sheet for Diesel Biocide Fuel Treatment, Reference No. PEN0000501, Version 2.1 Issued 03.05.2019

⁷ Safety Data Sheet for Veolia Hydrex 2401, Version 1.1 Issued 30.11.2023

⁸ Safety Data Sheet for Sulphuric Acid ...%, Chemos, Version number GHS 1.0, Issued 24.05.2024

- ▶ Step up transformer: 100 m³ of mineral oil or ester type fluid, e.g. Midel 7131. Mineral oil is classified as Aspiration hazard Category 1, H304 May be fatal if swallowed and enters airway⁹ and Midel 7131 is classified not classified as hazardous¹⁰
- ▶ Unit transformer: approximately 30 m³ of mineral oil or ester type fluid, e.g. Midel 7131
- ▶ Gas turbine lubricating oil system - 13 m³ of mineral oil or ester type fluid, e.g. Midel 7131
- ▶ Shunt reactor - 20 m³ of mineral oil

It is noted that the chemicals listed above are not included in the named substances in Part 1, Schedule 1 of the 2015 COMAH Regulations and the classification of the chemicals listed above is not included within the categories of dangerous substances to which the provisions of the 2015 COAH Regulations apply as listed in Part 2 of Schedule 1.

2.7 COMAH Status Determination

Schedule 1 to the COMAH Regulations 2015 describes the application of the regulations. Part 2 of Schedule 1 specifies the qualifying quantities of named dangerous substances to which lower tier status and upper tier status apply.

The secondary fuel storage tanks (2 No.) will contain up to 6,670 m³ of diesel in total, each tank will contain up to 3,335 m³. Note that the tank capacity given in Figure 3 (3502 m³) is the volumetric tank capacity which is larger than the maximum diesel inventory in each tank. CONCAWE (1996) gives a typical density of 0.81 – 0.9 tonnes/m³ for diesel. The maximum quantity on site is estimated as 6,003 tonnes based on a density of 0.9 tonnes/m³. Diesel is a named substance in Part 2, Schedule 1 of the COMAH Regulations 2015 (petroleum products).

Within the COMAH boundary, natural gas will be conveyed from downstream of the AGI to the OCGT where it will be processed to generate electricity. It will not be stored on site. The maximum quantity in pipelines at the proposed development (i.e. the section 37E planning application) is estimated as 247 kg (0.247 tonnes).

A maximum of 1008 kg (1.008 tonnes) of LPG (propane) will be stored in a bulk storage tank.

Natural gas and LPG are named substances in Part 2 of Schedule 1 of the COMAH Regulations 2015.

A maximum of 1100 kg of biocide will be stored at the proposed development (i.e. the section 37E planning application) which is classified within Category E1, Part 1 of Schedule 1 to the COMAH Regulations 2015.

The Application of the COMAH Regulations 2015 is detailed in Table 2 and the factorisation calculation to determine COMAH status is detailed in Table 3.

⁹ Safety Data Sheet for Castrol Perfecto TR UN, Version 2, Issued 11.09.2023

¹⁰ Safety Data Sheet for MIDEL® 7131 Issued February 2007

Table 2 Quantities of Hazardous Substances at the Proposed Development (i.e. S37E application)

Dangerous substance	COMAH Classification	q. Quantity	Q1 Lower tier threshold (Column 2, Part 1, Schedule 1, S.I. 209 of 2015) (tonnes)	Q2 Upper tier threshold (Column 3, Part 1, Schedule 1, S.I. 209 of 2015) (tonnes)	q/Q1 Fraction of Lower tier threshold	q/Q2 Fraction of Upper tier threshold
		tonnes				
Named Substances						
18.Liquefied flammable gases, Category 1 or 2 (including LPG) and natural gas	P2 – Flammable gases	1.255	50	200	0.025	0.006
34. Petroleum products – (Diesel) ¹¹	E2 - Aquatic Chronic 2 P5c – Flammable Liquid Cat. 3	6003	2500	25000	2.401	0.240
E1 Hazardous to the Aquatic Environment						
Biocide	E1 - Environmental	1.100	100	200	0.011	0.006

Table 3 Calculation of COMAH Status at the Proposed Development (i.e. S37E application)

Group	COMAH Categories	Rule	Lower Tier Fraction	Upper Tier Fraction
H (Health)	Part 1: H1, H2, H3 and Part 2: Acute Category 1, 2 or 3 (inhalation route), STOT SE Category 1	>1	0	0
P (Physical)	Part 1: P1 to P8 and Part 2: Explosives, flammable gases, flammable aerosols, oxidising gases, flammable liquids, self-reactive substances and mixtures, organic peroxides, pyrophoric liquids and solids, oxidising liquids and solids	>1	2.426	0.246
E (Environment)	Part 1: E1 and E2 and Part 2: hazardous to the aquatic environment acute category 1, chronic category 1 or chronic category 2	>1	2.412	0.246

The proposed development (i.e. the section 37E planning application) will store hazardous substances in excess of the Lower Tier threshold; therefore, the site will be classified as a **Lower Tier COMAH establishment**.

¹¹ Part 2, Schedule 1 of S.I. of 2015 gives qualifying quantities (tonnes) for the application of lower-tier requirements and upper-tier requirements for 34. Petroleum products and alternative fuels (a) gasolines and naphthas, (b) kerosenes (including jet fuels), (c) gas oils (including diesel fuels, home heating oils and gas oil blending streams), (d) heavy fuel oils, (e) alternative fuels serving the same purposes and with similar properties as regards flammability and environmental hazards as the products referred to in points (a) to (d). The proposed development (i.e. the section 37E planning application) will store diesel within the substances listed under item 34 (c) gas oils

3. INTRODUCTION TO RISK ASSESSMENT

3.1 Risk Assessment – An Introduction

The Centre for Chemical Process Safety (CCPS) has defined risk as (CCPS 2000): “Risk is a measure of human injury, environmental damage, or economic loss in terms of both the incident likelihood and the magnitude of the loss or injury.”

Risk is a function of the consequences of an undesired event and how likely it is to occur. It is often expressed as the product of the likelihood and the consequences:

$$\text{Risk} = \text{consequence} \times \text{likelihood}$$

In this form, risk has the units of losses per year.

Risk assessment in the chemical process sector seeks answers to the following questions:

- ▶ What are the hazards?
- ▶ What can go wrong (scenario)?
- ▶ How severe could it be (consequence)?
- ▶ How likely is it to happen (frequency)?
- ▶ How do consequence and frequency combine (risk)?
- ▶ Is the current level of risk tolerable, considering existing safeguards?
- ▶ If not, what needs to be done to reduce and manage the risk?

Risk assessment may be qualitative, semi-quantitative or quantitative, with the level of detail and analysis increasing from qualitative through to quantitative approaches. For COMAH establishments, the HSA Safety Report Assessment Guidelines (HSA, 2017) indicate that the depth of analysis should be proportionate to:

- ▶ the scale and nature of the major accident hazards presented by the establishment
- ▶ the risk posed to neighbouring populations and the environment

3.2 Land Use Planning and Risk Assessment

This land use planning assessment has been carried out in accordance with the HSA’s *Guidance on technical land-use planning advice* (HSA, 2023). This approach involves defining three zones for land use planning guidance purposes, based on the potential risk of fatality from major accident scenarios. The HSA has defined the boundaries of the Inner, Middle and Outer Land Use Planning (LUP) zones as:

1E-05/year	Risk of fatality for Inner Zone (Zone 1) boundary
1E-06/year	Risk of fatality for Middle Zone (Zone 2) boundary
1E-07/year	Risk of fatality for Outer Zone (Zone 3) boundary

The process for determining the distances to the boundaries of the inner, middle and outer zones is outlined as follows:

- ▶ Determine the consequences of major accident scenarios using the modelling methodologies described in the HSA’s *Guidance on technical land-use planning advice* (HSA, 2023).
- ▶ Determine the severity (probability of fatality) using the Probit functions specified by the HSA.
- ▶ Determine the frequency of the accident (probability of event) using data specified by the HSA.

- Determine the individual risk of fatality as follows:

Risk = Frequency x Severity

(Equation 1)

The HSA's Guidance on technical land-use planning advice (HSA, 2023) document provides guidance on the type of development appropriate to the inner, middle and outer LUP zones. The methodology sets four levels of sensitivity, with sensitivity increasing from 1 to 4, to describe the development types in the vicinity of a COMAH establishment.

The Sensitivity Levels used in the Land Use Planning Methodology are based on a rationale which allows progressively more severe restrictions to be imposed as the sensitivity of the surrounding area increases. The sensitivity levels are:

- Level 1 Based on normal working population;
- Level 2 Based on the general public – at home and involved in normal activities;
- Level 3 Based on vulnerable members of the public (children, those with mobility difficulties or those unable to recognise physical danger); and
- Level 4 Large examples of Level 3 and large outdoor examples of Level 2 and Institutional Accommodation.

Table 4 details the matrix that is used by the HSA to advise on suitable development for technical LUP purposes (HSA, 2023).

Table 4 Land Use Planning Matrix

Level of Sensitivity	Inner Zone (Zone 1)	Middle Zone (Zone 2)	Outer Zone (Zone 3)
Level 1	✓	✓	✓
Level 2	✗	✓	✓
Level 3	✗	✗	✓
Level 4	✗	✗	✗

3.3 Individual Risk Criteria

The TLUP guidelines (HSA, 2023) state the maximum tolerable risk to a member of the public is 1E-06 per year and the maximum tolerable risk to a person at an off-site work location is 5E-06 per year.

It is noted that these criteria apply to the total risk from all major accident hazards at an establishment.

3.4 Environment and Land Use Planning

The HSA's Generic TLUP Guidelines (HSA, 2023) outlined that the prevention of Major Accidents to the Environment (MATTEs) is the primary objective, and it is expected that accident pathways will be prevented. Where this is not practicable, the assessment of major accidents to the environment focuses on the specific risks to sensitive receptors within the local environment, the extent of consequences to such receptors and the ability of such receptors to recover.

Assessment is based on a Source-Pathway-Receptor model. For new establishments, the Competent Authority will focus on the removal of accident pathways to receptors (through the use of additional technical measures: appropriate containment, within the confines of current good practice and As Low as Reasonably Practicable (ALARP), for example).

3.5 Societal Risk Assessment Methodology

Where a large population is potentially exposed to the consequences of a major accident, and there is the potential for multiple fatalities from a single event, societal risk is taken into account.

To take account of societal risk, the HSA will initially obtain an estimate of the expectation value.

Expectation Value and FN Curve

The Expectation Value (EV) is the average number of persons receiving a specified level of harm. Hirst and Carter (Hirst et al., 2000) shows that:

$$EV = F \times N$$

Where F is the cumulative frequency of all events leading to N fatalities

HSE (2001) provides an upper limit value for an intolerable societal risk criterion: for a predicted accident occurring no more frequently than once in 5,000 years, there should be no more than 50 fatalities. This has gained international acceptance as an anchor point for a line (of slope -1) to create an intolerable societal risk criterion for single accidents. HSA Guidance on Technical Land Use Planning recommended using points at 200 cpm / 50 fatalities and 1000 cpm/10 fatalities to create that line. An acceptable societal risk single risk criterion line can then be drawn at frequencies that are two orders of magnitude below the intolerable line (so a frequency of 1×10^{-4} on the intolerable line becomes 1×10^{-6} on the acceptable line).

Some establishments will have the potential for fatalities to arise from a multiplicity of accident scenarios (or there may be other establishments in the vicinity, adding to the EV). In such situations, the total off-site EV should not exceed the criterion upper limit EV of 10,000. Between EVs of 100 and 10,000, it should be demonstrated that all practicable efforts have been made to reduce the risk to a level that is as low as reasonably practicable (above a developmental EV level of 450, an FN curve will be required as part of the demonstration).

4. LAND USE PLANNING ASSESSMENT METHODOLOGY AND CRITERIA

This COMAH land use planning assessment has been completed in accordance with risk-based approach set out in the HSA's *Guidance on technical land-use planning advice* (HSA, 2023). LUP assessments are completed in the following steps:

- ▶ Identify major accident scenarios with reference to the HSA guidance document (HSA, 2023).
- ▶ Consequence modelling of major accident scenarios with physical consequences.
- ▶ Assign frequencies to major accident scenarios with reference to frequency values outlined in the HSA's Guidance document (HSA, 2023).
- ▶ Assessment of individual risk and generation of individual risk contours.
- ▶ Where necessary, assessment of societal risk using societal risk indices.
- ▶ Source-pathway-receptor model for major accident scenarios with environmental consequences, environmental receptor categorisation, assessment of MATTE harm and duration, compare MATTE frequency with tolerability criteria.

4.1 Assessment Methodology

4.1.1 Physical Effects Modelling

The impacts of physical and health effects on workers and the general public outside of the proposed development (i.e. the section 37E planning application) were determined by modelling accident scenarios using Gexcon Effects version 12.5.1 and DNV Phast Version 9.1 modelling software.

4.1.2 Risk Assessment Methodology

Gexcon RiskCurves version 12.5.1 modelling software is used in this assessment to calculate individual risk of fatality contours and risk-based land use planning zones associated with major accident scenarios.

4.2 Thermal Radiation Criteria

Fire scenarios have the potential to create hazardous heat fluxes. Therefore, thermal radiation on exposed skin poses a risk of fatality.

Potential consequences of damaging radiant heat flux and direct flame impingement are categorised in Table 5 (HSA, 2023).

Thermal Heat Flux (kW/m ²)	Flux Consequences	Consequences
1 – 1.5		Sunburn
5 – 6		Personnel injured (burns) if they are wearing normal clothing and do not escape quickly
8 – 12		Fire escalation if long exposure and no protection
32 – 37.5		Fire escalation if no protection (consider flame impingement)
31.5		US DHUD, limit value to which buildings can be exposed
37.5		Process equipment can be impacted, AIChE/CCPS
Up to 350		In flame. Steel structures can fail within several minutes if unprotected or not cooled.

In relation to persons indoors, the HSA have specified the thermal radiation consequence criteria (from an outdoor fire) detailed in Table 6 (HSA, 2023).

Table 6 Heat Flux Consequences Indoors

Thermal Flux (kW/m²)	Consequences
> 25.6	Building conservatively assumed to catch fire quickly and so 100% fatality probability
< 25.6	People are assumed to escape outdoors, and so have a risk of fatality corresponding to that of people outdoors
< 12.7	People are assumed to be protected, and therefore there is a 0% fatality probability

Thermal Dose Unit (TDU) is used to measure exposure to thermal radiation. It is a function of intensity (power per unit area) and exposure time:

$$\text{Thermal Dose} = I^{1.33} t \quad (\text{Equation 2})$$

where the Thermal Dose Units (TDUs) are (kW/m²)^{4/3}.s, I is thermal radiation intensity (kW/m²), and t is exposure duration (s).

The HSA recommends that the Eisenberg Probit function (HSA, 2023) is used to determine probability of fatality to persons outdoors from thermal radiation as follows:

$$\text{Probit} = -14.9 + 2.56 \ln(I^{1.33} t) \quad (\text{Equation 3})$$

I Thermal radiation intensity (kW/m²)

t exposure duration (s)

Probit (Probability Unit) functions are used to convert the probability of an event occurring to percentage certainty that an event will occur. The Probit variable is related to probability as follows (CCPS, 2000):

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y-5} \exp\left(-\frac{u^2}{2}\right) du \quad (\text{Equation 4})$$

where P is the probability of percentage, Y is the Probit variable, and u is an integration variable. The Probit variable is normally distributed and has a mean value of 5 and a standard deviation of 1.

The Probit to percentage conversion equation is (CCPS, 2000):

$$P = 50 \left[1 + \frac{Y-5}{|Y-5|} \operatorname{erf}\left(\frac{|Y-5|}{\sqrt{2}}\right) \right] \quad (\text{Equation 5})$$

The relationship between Probit and percentage certainty is presented in Table 7 (CCPS, 2000).

Table 7 Conversion from Probit to Percentage

%	0	1	2	3	4	5	6	7	8	9
0	—	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
10	3.72	3.77	3.82	3.87	3.92	3.96	4.01	4.05	4.08	4.12
20	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
30	4.48	4.50	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
40	4.75	4.77	4.80	4.82	4.85	4.87	4.90	4.92	4.95	4.97
50	5.00	5.03	5.05	5.08	5.10	5.13	5.15	5.18	5.20	5.23
60	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.50
70	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
80	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
90	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33
%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
99	7.33	7.37	7.41	7.46	7.51	7.58	7.65	7.75	7.88	8.09

For long duration fires, such as pool fires, it is generally reasonable to assume an effective exposure duration of 60 seconds to take account of the time required to escape (HSA, 2023). It is noted that this is a conservative estimation of the time taken to escape and is used in consequence assessment as the maximum exposure duration for heat radiation.

With respect to exposure to thermal radiation outdoors, the Eisenberg Probit relationship implies:

- ▶ 1% fatality – 963 TDUs (8.02 kW/m² for 60 s exposure duration)
- ▶ 10% fatality – 1450 TDUs (10.9 kW/m² for 60 s exposure duration)
- ▶ 50% fatality – 2399 TDUs (15.9 kW/m² for 60 s exposure duration)

4.3 Overpressure Criteria

Explosions scenarios can result in damaging overpressures, especially when flammable vapour/air mixtures are ignited in a congested area.

Combustion of a flammable gas-air mixture will occur if the composition of the mixture lies in the flammable range and if an ignition source is available. When ignition occurs in a flammable region of the cloud, the flame will start to propagate away from the ignition source. The combustion products expand causing flow ahead of the flame. Initially this flow will be laminar. Under laminar or near laminar conditions the flame speeds for normal hydrocarbons are in the order of 5 to 30 m/s which is too low to produce any significant blast over-pressure. Under these conditions, the vapour cloud will simply burn, causing a flash fire. In order for a vapour cloud explosion to occur, the vapour cloud must be in a turbulent condition.

Turbulence may arise in a vapour cloud in various ways:

- ▶ By the release of the flammable material itself, for instance a jet release from a high-pressure vessel.
- ▶ By the interaction of the expansion flow ahead of the flame with obstacles present in a congested area.

Table 8 describes blast damage for various overpressure levels (HSA, 2023).

Table 8 Blast Damage

Side-on Overpressure (mbar)	Description of Damage
1.5	Annoying noise
2	Occasional breaking of large windowpanes already under strain
3	Loud noise; sonic boom glass failure
7	Breakage of small windows under strain
10	Threshold for glass breakage
20	"Safe distance", probability of 0.95 of no serious damage beyond this value; some damage to house ceilings; 10% window glass broken
30	Limited minor structural damage
35 – 70	Large and small windows usually shattered; occasional damage to window frames
>35	Damage level for "Light Damage"
50	Minor damage to house structures
80	Partial demolition of houses, made uninhabitable
70 - 150	Corrugated asbestos shattered. Corrugated steel or aluminium panels fastenings fail, followed by buckling; wood panel (standard housing) fastenings fail; panels blown in
100	Steel frame of clad building slightly distorted
150	Partial collapse of walls and roofs of houses
150-200	Concrete or cinderblock walls, not reinforced, shattered
>170	Damage level for "Moderate Damage"
180	Lower limit of serious structural damage 50% destruction of brickwork of houses
200	Heavy machines in industrial buildings suffered little damage; steel frame building distorted and pulled away from foundations
200 – 280	Frameless, self-framing steel panel building demolished; rupture of oil storage tanks
300	Cladding of light industrial buildings ruptured
350	Wooden utility poles snapped; tall hydraulic press in building slightly damaged
350 – 500	Nearly complete destruction of houses
>350	Damage level for "Severe Damage"
500	Loaded tank car overturned
500 – 550	Unreinforced brick panels, 25 - 35 cm thick, fail by shearing or flexure
600	Loaded train boxcars completely demolished
700	Probable total destruction of buildings; heavy machine tools moved and badly damaged
830	Damage level for 'total destruction'

The HSA recommends that the Hurst, Nussey and Pape Probit function (HSA, 2023) is used to determine probability of fatality to persons outdoors from overpressure as follows:

$$\text{Probit} = 1.47 + 1.35 \ln P$$

P Blast overpressure (psi)

The Hurst, Nussey and Pape Probit relationship implies:

- ▶ 1% fatality – 168 mbar
- ▶ 10% fatality – 365 mbar
- ▶ 50% fatality – 942 mbar

The HSA uses relationships published by the Chemical Industries Association (CIA) and the American Petroleum Institute (API) to determine the probability of fatality for building occupants exposed to blast overpressure. The CIA has developed relationships for 4 categories of buildings (CIA, 2020):

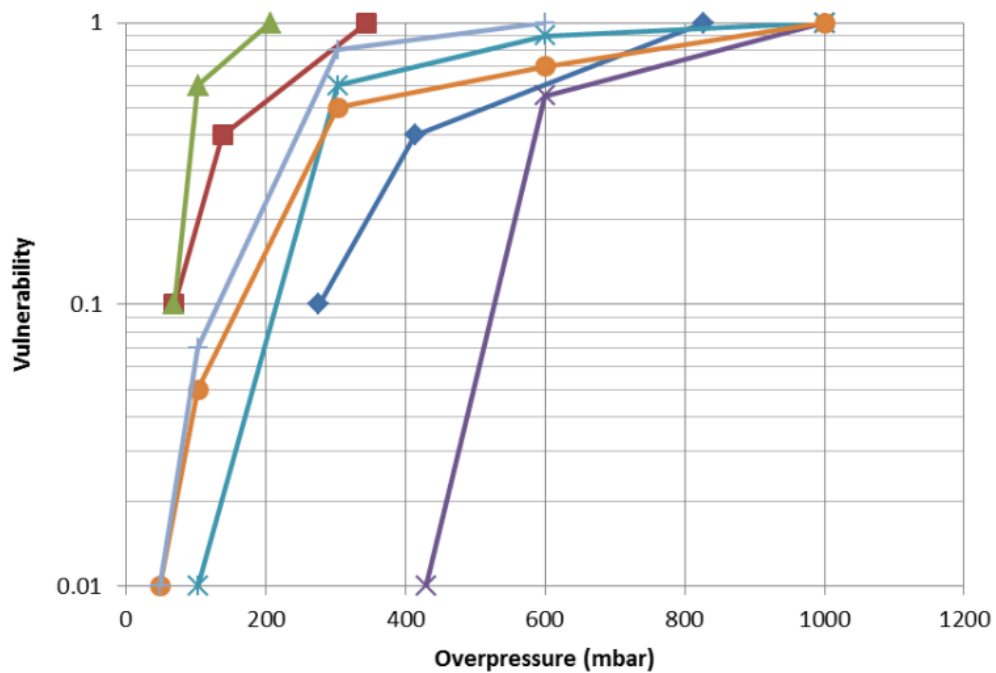
- ▶ CIA 1: hardened structure building (special construction, no windows).
- ▶ CIA 2: typical office block (four storey, concrete frame and roof, brick block wall panels).
- ▶ CIA 3: typical domestic dwelling (two storey, brick walls, timber floors); and
- ▶ CIA 4: 'portacabin' type timber construction, single storey.

The API has developed relationships for 5 categories of buildings (EIGA, 2014):

- ▶ API B1: Wood frame trailer or shack
- ▶ API B2: Steel frame/metal siding or pre-engineered building
- ▶ API B3: Unreinforced masonry bearing wall building
- ▶ API B4: Steel or concrete reinforced masonry infill or cladding
- ▶ API B5: Reinforced concrete or reinforced masonry shear wall building

Figure 6 illustrates the probability of occupant vulnerability to overpressure in CIA building categories CIA 1 – 4 and in API building types B1 – B5.

Figure 6 API Probability of Occupant Vulnerability



Graph Key:	
	CIA 1: Hardened structure building: special construction, no windows
	CIA 2: Typical office block: four story, concrete frame and roof, brick block wall panels
	CIA 3: Typical domestic buildings: two story, brick walls, timber floors
	CIA 4: Portacabin: timber construction, single story
	API B5: Reinforced concrete or reinforced masonry shear wall building
	API B3: Unreinforced masonry bearing wall building
	API B1, B2, B4: Wood frame trailer or shack, steel-frame/metal siding or pre-engineered building, steel or concrete reinforced masonry infill or cladding
NOTE—Building key items 1 - 4 are defined by CIA; items B1 - B5 are defined by API RP 752 (2003) [5, 3].	

The CIA and API relationships imply the overpressure levels corresponding to probabilities of fatality of 1%, 10% and 50% detailed in Table 9 below.

Table 9 Blast Overpressure Consequences Indoors

Probability of fatality	Overpressure Level, mbar						
	CIA 1	CIA 2	CIA 3	CIA 4	API B1 B2 and B4	API B3	API B5
1% fatality	435	100	50	50	-	-	-
10% fatality	519	183	139	115	69	69	276
50% fatality	590	284	300	242	172	97	483

For the purposes of this assessment, it is assumed that the vulnerability of building occupants to side-on overpressure, as a result of a MAH at the proposed development (i.e. the section 37E planning application), is CIA Category 3 type structures, representing residential buildings in the vicinity of the proposed development.

4.4 Flash Fire Criteria

A flash fire comprises the combustion of a flammable vapour and air mixture in which the flame passes through that mixture at less than sonic velocity, such that negligible damaging overpressure is generated.

The flash fire envelope is the lower flammable limit (LFL) concentration, determined using the unified dispersion model in PHAST Version 9.1 consequence modelling software.

Outdoor fatality levels of 100% are assumed inside the lower flammable limit (LFL) envelope, with 0% fatalities outside that envelope. Indoor fatality levels are conservatively assumed to be 10% within the flash fire envelope. (HSA, 2023)

4.5 Modelling Parameters

4.5.1 Weather Conditions

Weather conditions at the time of a major accident have a significant impact on the consequences of the event. Typically, high wind speeds increase the impact of fires, particularly pool fires, while the associated turbulence dilutes vapour clouds, reducing the impact of toxic and flammable gas releases.

Atmospheric Stability Class and Wind Speed

The following Pasquill stability/wind speed pairs are specified by the HSA in Ireland for dispersion modelling (HSA, 2023):

- ▶ Average weather conditions are represented by stability category D and a wind speed of 5 m/s, i.e., Category D5.
- ▶ Worst case conditions for toxic dispersion are represented by stability category F and a wind speed of 2 m/s, i.e., Category F2.

D5 conditions are assumed to occur 80% of the time, with F2 occurring for the remaining 20% (HSA, 2023).

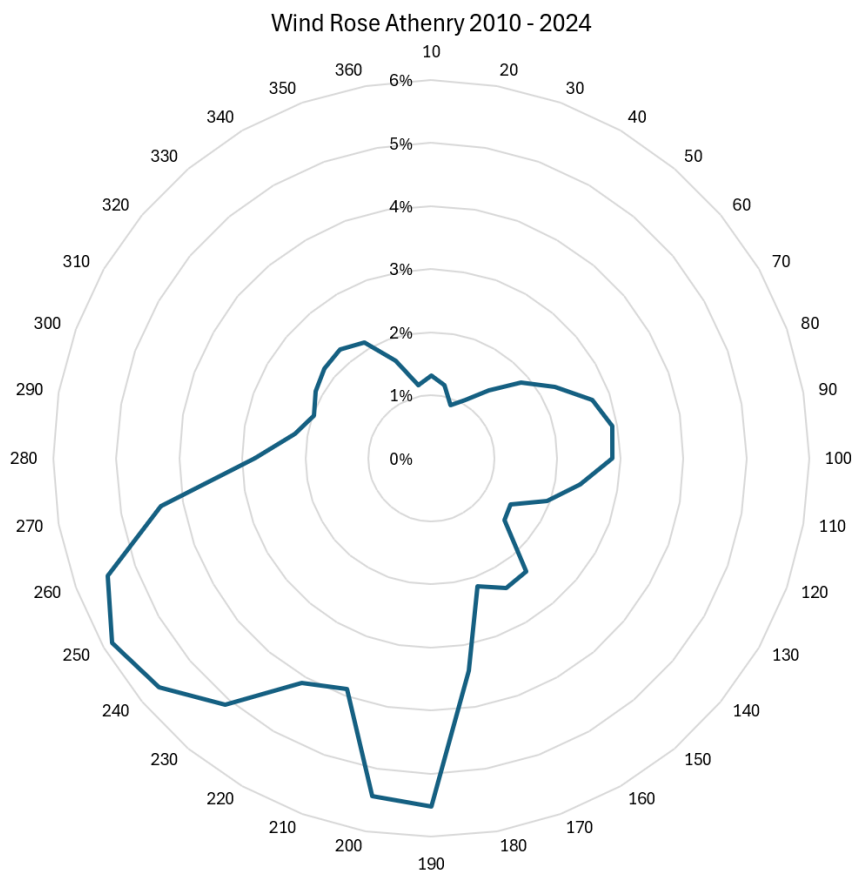
Stability Class D represents neutral conditions with little sun and high wind or overcast night. Stability Class F represents very stable conditions at night with moderate clouds and light/moderate winds.

Wind Direction and Ambient Temperature

The nearest synoptic meteorological station to the proposed development area for which long term meteorological data is available is at Athenry Synoptic Station.

Figure 7 illustrates a wind rose for Athenry Synoptic Meteorological Station. It can be seen that the prevailing wind direction is from the southwest (250°).

Figure 7 Wind Rose Athenry Synoptic Station



Ambient Temperature

The TLUP guidance states that a temperature of 15 °C is to be used for D5 conditions and 10 °C for F2 conditions.

Ambient Humidity

For this assessment, a representative ambient humidity of 60% has been assumed.

4.5.2 Surface Roughness

For TLUP purposes, a surface roughness of 0.1m was used in this assessment.

5. IDENTIFICATION OF MAJOR ACCIDENT HAZARDS

A major accident is defined in the 2015 COMAH Regulations as:

“an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment covered by these Regulations, and leading to serious danger to human health or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances”

5.1 Major Accident Hazards at Proposed Gas Turbine Enclosure

5.1.1 Turbine Enclosure Vapour Cloud Explosion Scenario

The turbine enclosure containing the OCGT, the gas turbine fuel system will contain a fail safe shut off valve and a flow control valve. All fuel system protection will be controlled using redundant gas detection sensors. The gas detection system is set to automatically isolate the gas fuel supply and trip the gas turbine before the gas concentration can reach the LEL level (normally trip set at 25% of the LEL). Gas detection will automatically increase the rate of forced ventilation. The forced ventilation continues to operate thereafter to vent the enclosure.

Both the gas detection and ventilation systems will have to fail in order for a build-up of flammable gas to occur in the turbine enclosure in the event of a loss of containment from the turbine or a natural gas pipeline within the enclosure.

In the event the leak detection system and ventilation system fails, there is the potential for a confined Vapour Cloud Explosion (VCE) as a result of a leak of natural gas within the turbine enclosures. The HSA TLUP guidance specifies the size of the flammable cloud to be taken as the volume of the region where the release may occur (i.e. turbine enclosure volume). The enclosure volume minus the volume of the turbine is 1400 m³.

Individual risks of fatality can be calculated using a Probit of $Y = 1.47 + 1.35 \ln(P)$, with P in psi (Hurst, Nussey and Pape, 1989) for the risk to people outdoors, and the Chemical Industries Association (CIA, 2020) vulnerability curves for the risk to people indoors.

5.1.2 Pipeline Release Scenario

The proposed OCGTs will be supplied with natural gas pipelines originating at the AGI. The natural gas pipework will include the provision of a series of Emergency Shutdown Devices (ESDs), in compliance with EN 14382, which will act to block incoming gas flow in the event of a pressure drop. The specification of the ESDs will be finalised at detailed design. Natural gas pipeline loss of containment scenarios will be assessed without an ESD.

5.1.3 Major Accidents to the Environment (MATTE)

The proposed diesel storage tanks will be double skinned. Section 3.6.6 of the TLUP states:

“double-skinned tanks will likely represent the lowest risk and eliminate MATTEs from consideration”

Therefore, a MATTE will not be assessed as part of this study.

5.1.4 Secondary Fuel Tank Rupture with Bund Overtop and Off-site Pool Fire

Secondary fuel (diesel) will be contained in double skinned full containment tanks. In the event of rupture of both tank walls with bund overtopping, there is the potential for diesel to migrate off site to the east. An uncontained pool fire to the east of the diesel tank bund is considered in this assessment.

5.1.5 Major Accident Scenarios

Table 10 details the major accident scenarios arising from the proposed development (S37E):

Table 10 Major Accident Scenarios at the Proposed Development (S37E)

Installation	Loss Of Containment scenario	Consequence/Event	Reference
Indoor equipment (release of natural gas in turbine enclosure)	Instantaneous failure	VCE ⁽¹⁾	Table 64, HSA TLUP Guidance Document, HSA, 2023
	Continuous leak over 10 minutes	VCE	
	10 mm pipe leak over 30 minutes	VCE	
Natural Gas Pipeline	Rupture of Pipeline	Fireball/Jet fire	Table 40/41 and Table 42, HSA TLUP Guidance Document, HSA, 2023
		VCE	
		Flash fire	
	Pipeline Leak of 0.1D	Fireball/Jet fire	
		VCE	
		Flash fire	
LPG Tank	Instantaneous release	Fireball	Table 23, HSA TLUP Guidance Document, HSA, 2023
		VCE	
		Flash fire	
	Continuous leak over 10 minutes	Jet fire	
		VCE	
		Flash fire	
	10 mm pipe leak over 30 minutes	Jet fire	
		VCE	
		Flash fire	
LPG Road Tanker	Instantaneous failure	Fireball	Table 24, HSA TLUP Guidance Document, HSA, 2023
		VCE	
		Flash fire	
	Loss of entire contents through largest connection	Jet fire	
		VCE	
		Flash fire	

Installation	Loss Of Containment scenario	Consequence/Event	Reference
	Rupture of unloading hose	Jet fire	Table 25, HSA TLUP Guidance Document, HSA, 2023
		VCE	
		Flash fire	
	Leak of unloading hose 10% of diameter	Jet fire	
		VCE	
		Flash fire	
	BLEVE (hot)	BLEVE ⁽¹⁾ (hot)	Table 26, HSA TLUP Guidance Document, HSA, 2023
Diesel	Instantaneous failure	Pool fire	

Major accident scenarios within the COMAH boundary are considered within the assessment.

Note 1

VCE Vapour Cloud Explosion

BLEVE Boiling Liquid Expanding Vapour Explosion

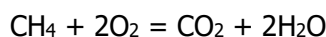
6. LAND USE PLANNING ASSESSMENT OF MAJOR ACCIDENT HAZARDS

6.1 Natural Gas VCE at OCGT Turbine Enclosures

6.1.1 OCGT VCE Model Inputs

DNV PHAST Version 9.1 consequence modelling software was used to calculate the Multi Energy model overpressures resulting from a VCE in one of the turbine enclosures.

It is assumed that an accidental release of natural gas occurs in a turbine enclosure. In order for a vapour cloud explosion to occur, the concentration of natural gas must lie between the lower and upper flammable limits. It is assumed that the concentration within the turbine enclosure is a stoichiometric mixture of air and flammable gas. The complete combustion equation for methane is:



The volume of the OCGT enclosure excluding the turbine will be 1400 m³.

The mass fraction of methane within this volume was calculated as 0.056 and the total flammable mass was calculated as 92.87 kg (see Appendix A for calculation).

The current indicative model inputs are provided, these will be confirmed during the detailed engineering design phase. Any significant change to these inputs will be assessed appropriately.

The VCE model inputs are detailed in Table 11.

Table 11 OCGT VCE: Model Inputs

Parameter	Units	Value	Source
Chemical name		methane	-
Temperature	°C	10	30-year average at nearest synoptic meteorological station (Dublin Airport)
Available Volume of OCGT enclosure	m ³	1400	AtkinsRéalis (Project Engineer)
Flammable mass	kg	92.87	See Appendix A for calculation
Fraction of flammable cloud confined	-	1	Confined VCE within turbine enclosure
Curve number	-	7	Very Strong Deflagration: Confined conditions and low ignition energy

6.1.2 OCGT VCE Model Outputs

Consequence decay curves are provided in Appendix B.

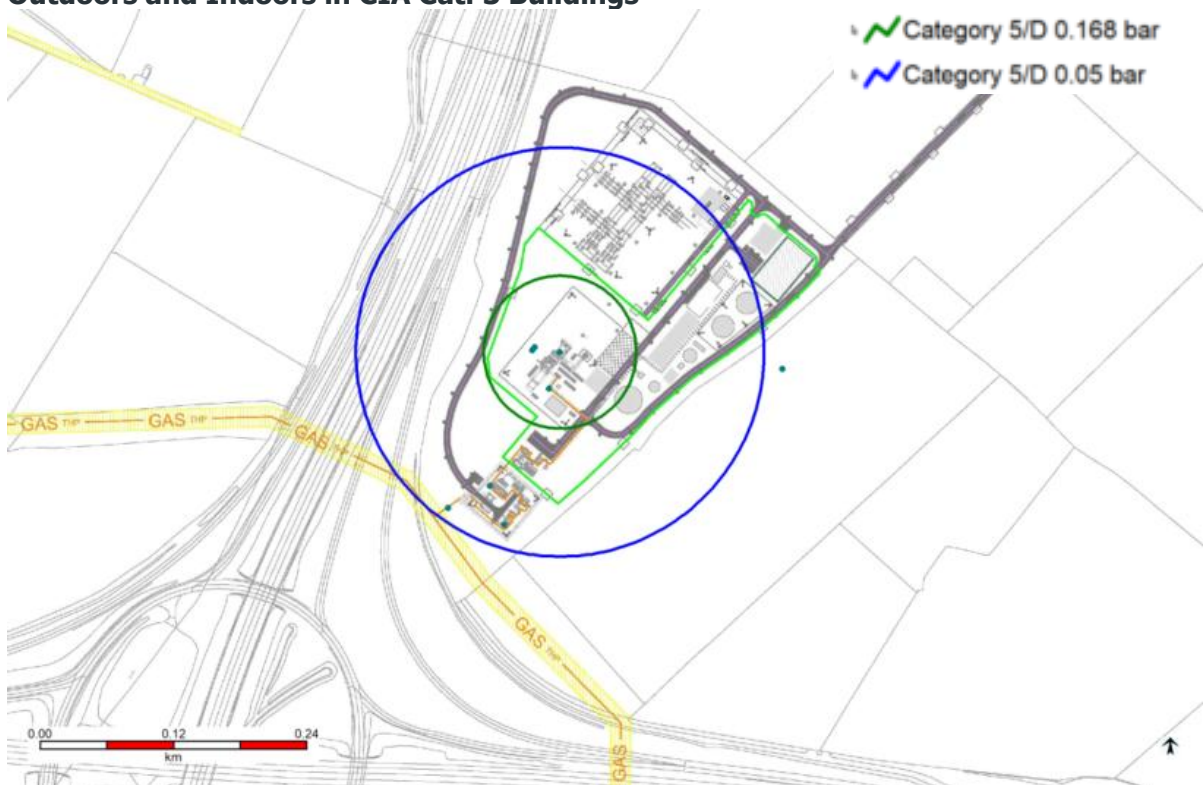
Table 12 details the distances to specified overpressure endpoints.

Figure 8 illustrates the overpressure contours corresponding to %1 mortality outdoors and indoors in CIA Cat. 3/4 buildings.

Table 12 OCGT Natural Gas VCE: Distances to Specified Overpressure Endpoints

Peak overpressure (mbar)	Consequences	OCGT Turbine Distance (m)
Damage		
10	Threshold for glass breakage	783
20	'Safe distance', probability of 0.95 of no serious damage beyond this value; some damage to house ceilings; 10% window glass broken	419
35	Damage level for 'light damage'	253
170	Damage level for 'moderate damage'	68
350	Damage level for 'severe damage'	44
830	Total destruction	23
Outdoor mortality		
168	1% mortality outdoors	68
Indoor mortality CIA3		
50	1% mortality indoors in residential dwellings (CIA3)	183

Figure 8 OCGT Enclosure VCE: Overpressure Contours Corresponding to 1% Mortality Outdoors and Indoors in CIA Cat. 3 Buildings



The following is concluded for a VCE in an OCGT turbine enclosure:

- ▶ The overpressure contour corresponding to 1% mortality outdoors (168 mbar) does not extend over the COMAH site boundary
- ▶ The overpressure contour corresponding to 1% fatality indoors in CIA Cat. 3/4 buildings (representative of residential dwellings (Cat. 3) and kiosk structures at the AGI (Cat. 4)) could

extend over the COMAH site boundary to kiosk structures at the AGI. This contour extends to the M17/M18 motorway.

6.1.3 OCGT VCE Frequency

The HSA specifies a likelihood of 5E-06 per year when assessing an instantaneous release from a process vessel; for modelling purposes. A 100% ignition probability indoors is to be assumed.

In order for there to be a build-up of natural gas in the enclosure, the leak detection and blocking system has to fail. This system has redundant sensors and is designed to stop gas supply to the turbine when gas is detected at 25% of the LEL. The purple book (Committee for Prevention of Disasters, 2005) states that the failure on demand of a blocking system, such as the one proposed, is 0.01 per demand. This will be applied to the 'release through a 10mm pipe scenario as a mitigation measure.

Table 13 details the events and corresponding frequencies that could lead to a VCE within the OCGT enclosure.

Table 13 OCGT Enclosure Natural Gas VCE: Event Frequency

LOC scenario	LOC frequency		Consequence	Conditional Prob.	Event freq. (per year)
Equipment rupture/leak in turbine enclosure	5E-06	/yr	VCE	-	5E-06
Release over 10 minutes in turbine enclosure	1E-05	/yr	VCE	-	1E-05
Release through 10mm pipe in turbine enclosure	5E-04	/yr	VCE	0.01	5E-06

The total frequency for a VCE within the OCGT enclosure is **2.0E-05 per year**.

6.2 Natural Gas Pipeline Release

The above ground natural gas pipeline that lies within the COMAH boundary commences at the pressure regulator at the AGI and terminates at the turbine and is 200 metres in length. 167 metres of this pipeline falls within the COMAH site boundary. It is possible that a rupture or leak could occur at any point along any of the natural gas pipeline.

The consequences from a vertical or horizontal release from the above ground 35 barg pipeline that commences at the pressure regulator at the AGI and terminates at the turbine, are assessed.

6.2.1 Natural Gas Pipeline Release Model Inputs

The pipeline release (rupture or leak) model inputs are detailed in Table 14. The natural gas modelling does not include valve closure at the AGI.

The Phast Version 9.1 long pipeline model was used to model a release of natural gas following rupture of a pipeline or a leak from a pipeline (10% diameter).

Table 14 Natural Gas Pipeline Rupture or Leak: Discharge Model Inputs

Parameter	Pipeline rupture	Pipeline leak, 10% diameter	Source/Assumption
Scenario	Pipeline rupture	Pipeline leak, 10% diameter	-
Material	Methane	Methane	-
Pipeline diameter	250 mm	250 mm	-
Hole Size	250 mm	25 mm	-
Pipe inflow	26.2 kg/s	26.2 kg/s	150% of Maximum Flow to OCGT
Length of pipeline	200 m	200 m	Length of pipeline from pressure regulation station at AGI to turbine
Pressure	35 barg	35 barg	Pipeline pressure
Averaging time	Flammable – 18.75 s	Flammable – 18.75 s	DNV PHAST
Short Duration Effects	30 second cut off time for flammable effects	30 second cut off time for flammable effects	Assumed
Exposure duration	60 s	60 s	HSA recommended (HSA, 2023)
Release height	1 m 0 m	1 m 0 m	Above ground pipeline Below ground pipeline
Release direction	Vertical Horizontal (above ground only)	Vertical Horizontal (above ground only)	HSA TLUP (HSA 2023)
Effect height	1.5 m	1.5 m	Average height of person
Wind speed	5 m/s 2 m/s	5 m/s 2 m/s	Recommended by HSA as representative modelling conditions
Pasquill Stability Factor	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	
Temperature	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	HSA TLUP (HSA 2023)

The natural gas pipeline breach is assumed to occur at the gas turbine.

6.2.2 Natural Gas Pipeline Release Discharge Model Outputs

For a natural gas pipeline release, the long pipeline discharge model, in Phast Version 9.1, is used with a time varying release. Appendix B contains graphs showing the release rate of natural gas vs. time following natural gas pipeline rupture or leak scenarios.

6.2.3 Natural Gas Pipeline Release: Predicted Phenomena

The unified dispersion model in DNV PHAST Version 9.1 predicts the following phenomena for the pipeline release scenarios:

- ▶ Pipeline Rupture (horizontal): Jet fire or fireball (immediate ignition), VCE or flash fire (delayed ignition)
- ▶ Pipeline Rupture (vertical): Jet fire or fireball (immediate ignition), flash fire (delayed ignition), no VCE hazard arises for a vertical release
- ▶ Pipeline leak (horizontal), 10% diameter: Jet fire or fireball (immediate ignition), flash fire or VCE (delayed ignition) (no VCE hazard arises for a vertical release)
- ▶ Pipeline leak (vertical), 10% diameter: Jet fire or fireball (immediate ignition), flash fire (delayed ignition) (no VCE hazard arises for a vertical release)

6.2.4 Natural Gas Pipeline Release and Jet Fire

The (DNV Recommended) jet fire cone model was used to calculate the thermal radiation consequences from natural gas jet fires at the proposed development (i.e. the section 37E planning application).

As per HSA TLUP guidelines (HSA, 2023), jet fire results are presented for vertical releases from pipelines. Jet fire results are also presented for horizontal releases for loss of containment scenarios from above ground natural gas pipelines.

Consequence decay curves are provided in Appendix B.

Table 15 details distances to specified thermal radiation levels, at a receiver height of 1.5m, associated with

- ▶ 1%, mortality outdoors
- ▶ 0% mortality and 100% mortality indoors

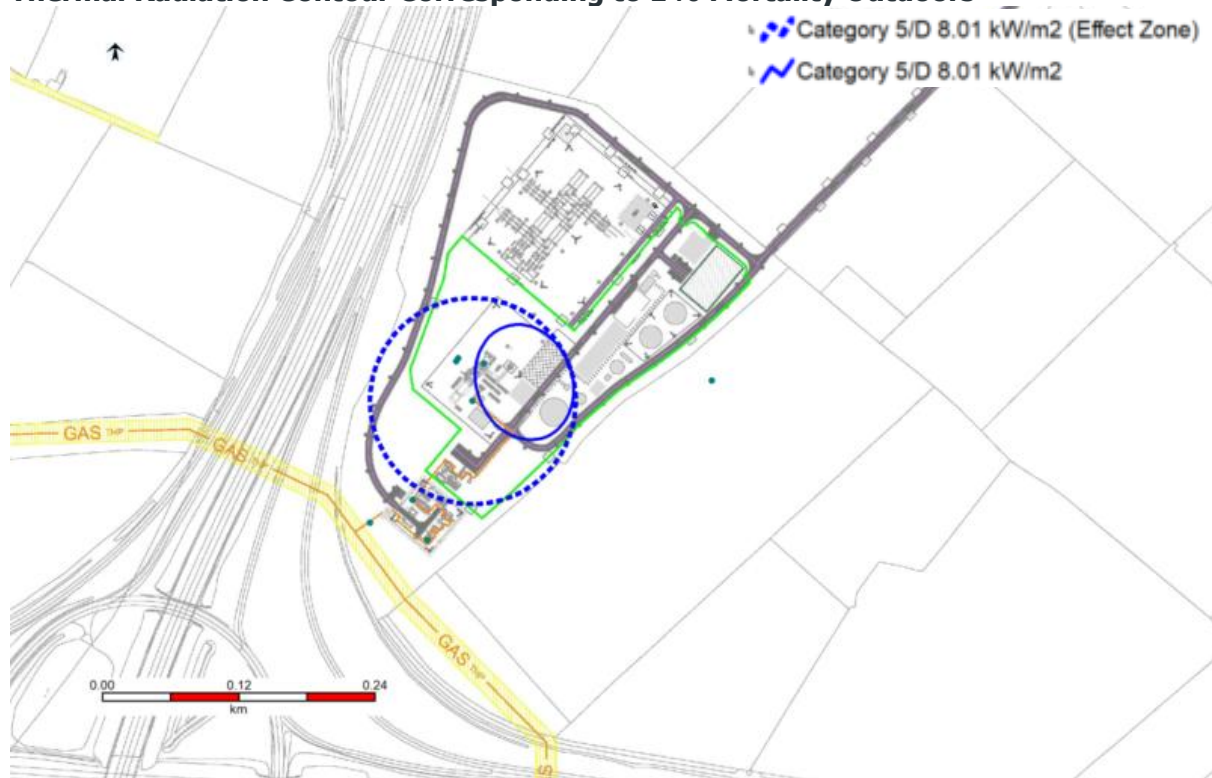
Table 15 Natural Gas 35 barg Pipeline Full Rupture or Leak and Jet Fire: Calculated Distances at Specified Thermal Radiation Levels (receptor height 1.5m)

Consequence	Thermal Radiation (kW/m ²)	Distance to Consequence/Thermal Radiation Level (metres)							
		Above Ground Pipeline Rupture and Jet Fire Horizontal Release		Above Ground Pipeline leak, 10% diameter and Jet Fire Horizontal Release		Above Ground Pipeline Rupture and Jet Fire Vertical Release		Above Ground Pipeline leak, 10% diameter and Jet Fire Vertical Release	
		D5	F2	D5	F2	D5	F2	D5	F2
1% mortality outdoors	8.02	90	90	23	24	43	29	12	6
0% mortality indoors	12.7	82	81	22	22	29	Not reached	8	Not reached
100% mortality indoors	25.6	73	70	20	20	Not reached	Not reached	Not reached	Not reached

Figure 9 illustrates the thermal radiation contour and effect areas corresponding to 1% fatality outdoors for a jet fire following pipeline rupture of the 35 barg gas pipeline near the turbine natural gas intake for a horizontal release, and a receiver height 1.5m for weather category D5 (representative worst case scenario).

The thermal radiation contour is illustrated for the prevailing wind direction (see Figure 7) and the effect area takes account of all possible wind directions.

Figure 9 Above Ground 35 barg Natural Gas Pipeline Leak and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Mortality Outdoors



It is concluded that in the event of a jet fire following a release from the above ground 35 barg natural gas pipeline, the thermal radiation level corresponding to 1% mortality outdoors extends over the COMAH site boundary to the AGI access road. This road will be minimally trafficked and no fatalities are predicted to arise.

6.2.5 Natural Gas Pipeline Release: Fireball Results

The HSE fireball model is used in this study. This is a static fireball model and assumes that the fireball is located on the ground with no lift-off. For short duration, flammable effects, the mass released within the first 30 seconds contributes to a fireball event.

Table 16 Natural Gas 35 barg Pipeline Release and Fireball: Fireball Model Outputs

Output	Pipeline Rupture Vertical Release		Pipeline leak, 10% diameter Vertical Release		Pipeline Rupture Horizontal Release		Pipeline leak, 10% diameter Horizontal Release	
	D5	F2	D5	F2	D5	F2	D5	F2
Flammable Mass (kg)	1085	1085	86	86	1085	1085	86	86
Duration of Fireball (s)	4.6	4.6	2.0	2.0	4.6	4.6	2.0	2.0
Fireball Radius (m)	30	30	12.8	12.8	30	30	12.8	12.8

Consequence decay curves are provided in Appendix B.

Table 17 details the distances to thermal dose levels associated with specified levels of probability of fatality based on the Eisenberg Probit equation described in Section 4.2 and assuming 100% fatality within the fireball radius.

Table 17 Natural Gas 35 barg Pipeline Rupture and Fireball: Distances to Specified Thermal Dose Levels (Receptor Height 1.5 metres)

Criterion	Thermal Dose Level	Thermal Radiation	Distance to Thermal Dose/Radiation Level (metres)							
			Pipeline Rupture Vertical Release		Pipeline leak, 10% diameter Vertical Release		Pipeline Rupture Horizontal Release		Pipeline leak, 10% diameter Horizontal Release	
			D5	F2	D5	F2	D5	F2	D5	F2
1% fatality outdoors (based on fireball duration)	963	-	64	65	20	20	64	65	20	20
100% fatality outdoors	Fireball radius	-	30	30	12.8	12.8	30	30	12.8	12.8
Building protected below this level, 0% fatality probability	-	12.7	136	138	61	62	136	138	61	62
Building will catch fire quickly, 100% fatality probability	-	25.6	96	97	43	44	96	97	43	44

Figure 10 illustrates the thermal radiation contours corresponding to 1% mortality and 100 % mortality outdoors and Figure 11 illustrates the thermal radiation contours corresponding to 12.7 kW/m² and 25.6 kW/m² following rupture of the 35 barg natural gas pipeline.

Figure 10 Natural Gas 35 barg Pipeline Rupture and Fireball: Outdoor Lethality Contours

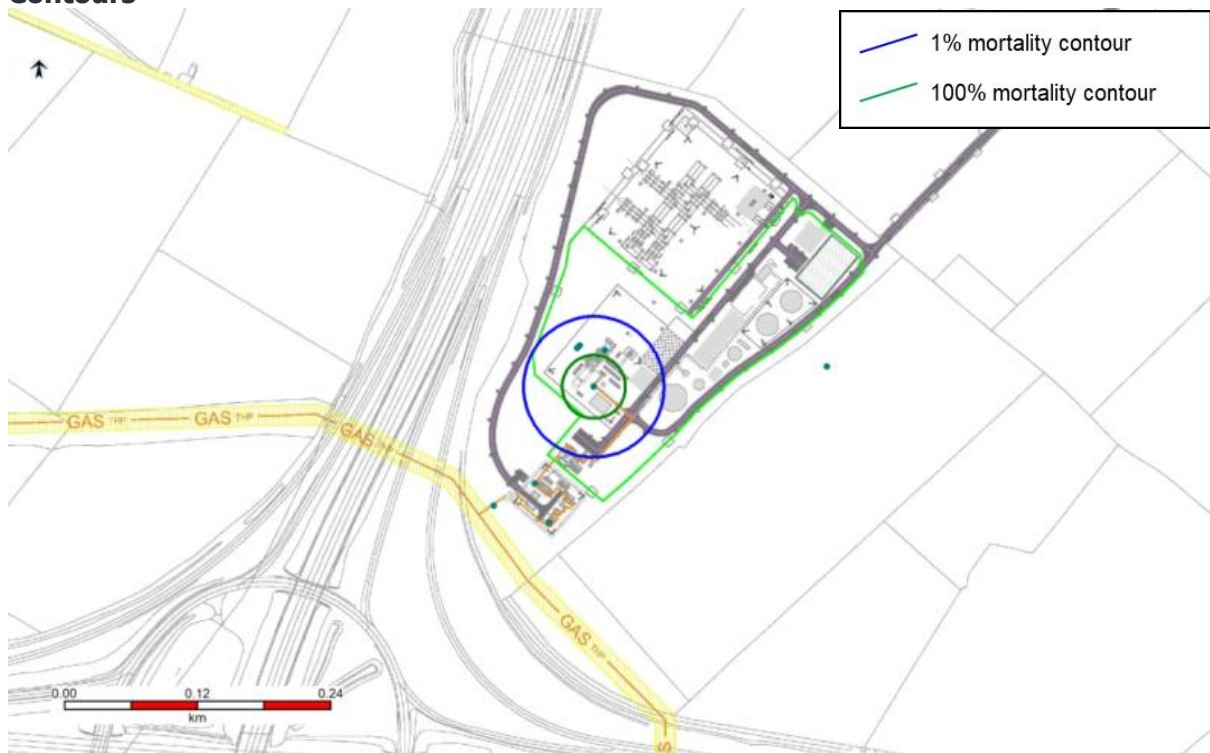
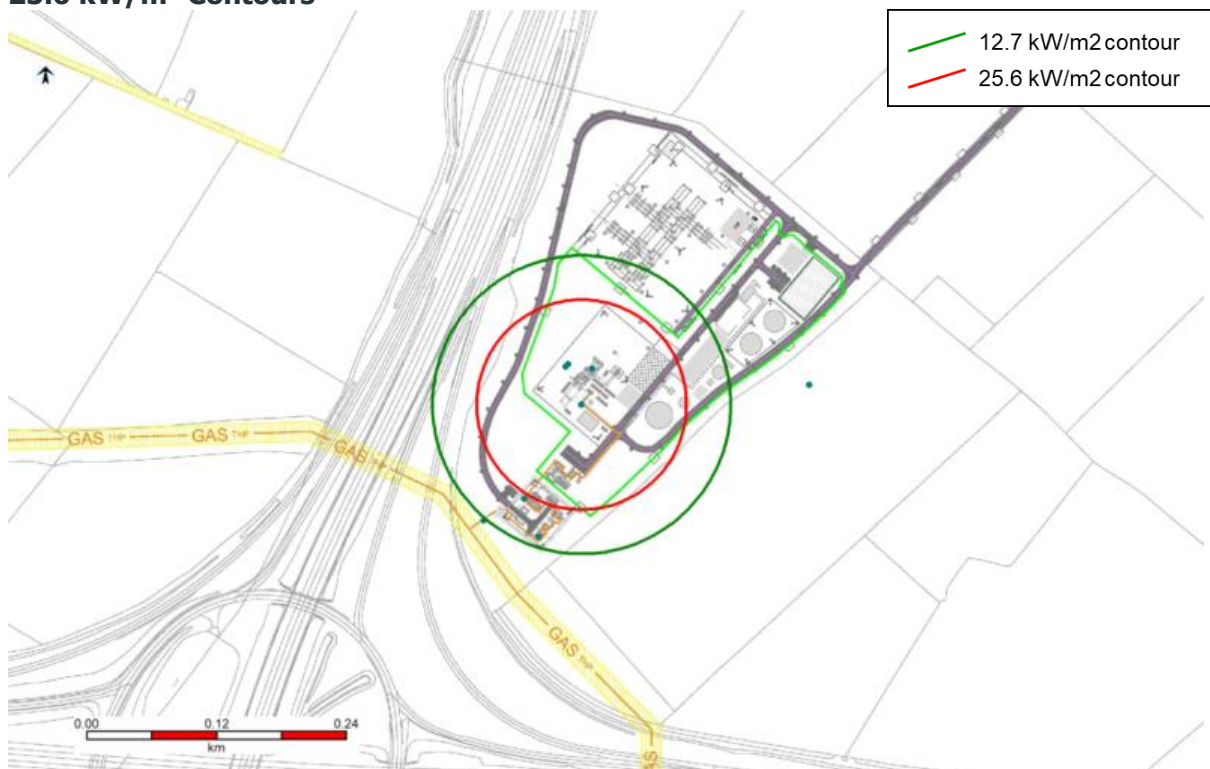


Figure 11 Natural Gas 35 barg Pipeline Rupture and Fireball: 12.7 kW/m² and 25.6 kW/m² Contours



In the event of a fireball following rupture of the 35 barg natural gas pipeline it is concluded that the 25.6 kW/m² thermal radiation contour, may extend over the COMAH boundary to the motorway and to the boiler house kiosk and pressure reduction kiosk at the AGI. There is the potential for fatalities at the AGI if personnel are present. The AGI will be normally unoccupied.

6.2.6 Natural Gas Pipeline Release: VCE Results

The DNV PHAST unified dispersion model was used to predict the flammable mass that would arise in the event of a natural gas pipeline rupture or leak. A VCE hazard is not predicted to arise in the event of a vertical release from an underground or above ground natural gas pipeline. Ignition location and flammable mass for horizontal pipeline release are summarised in Table 18.

Table 18 Natural Gas Pipeline Rupture or Leak: Vapour Cloud Explosion Ignition Location and Flammable Mass

Loss of containment scenario description	Ignition location	Flammable Mass	
		Category D5	Category F2
Above Ground 35 barg natural gas pipeline rupture	Distance at which maximum flammable mass arises if congested region occurs at that distance	21.0 kg at 50 metres downwind of release point	23.2 at 50 metres downwind of release point
Above Ground 35 barg natural gas pipeline leak, 0.1D		No VCE hazard predicted/mass within flammable range	0.25 kg at 10 metres downwind of release point

The TNO Multi Energy model was used to model the overpressure consequences in the event a VCE following rupture of a natural gas pipeline. An explosion strength of 7 was applied to 20% of the stoichiometric cloud volume.

Consequence decay curves are provided in Appendix B.

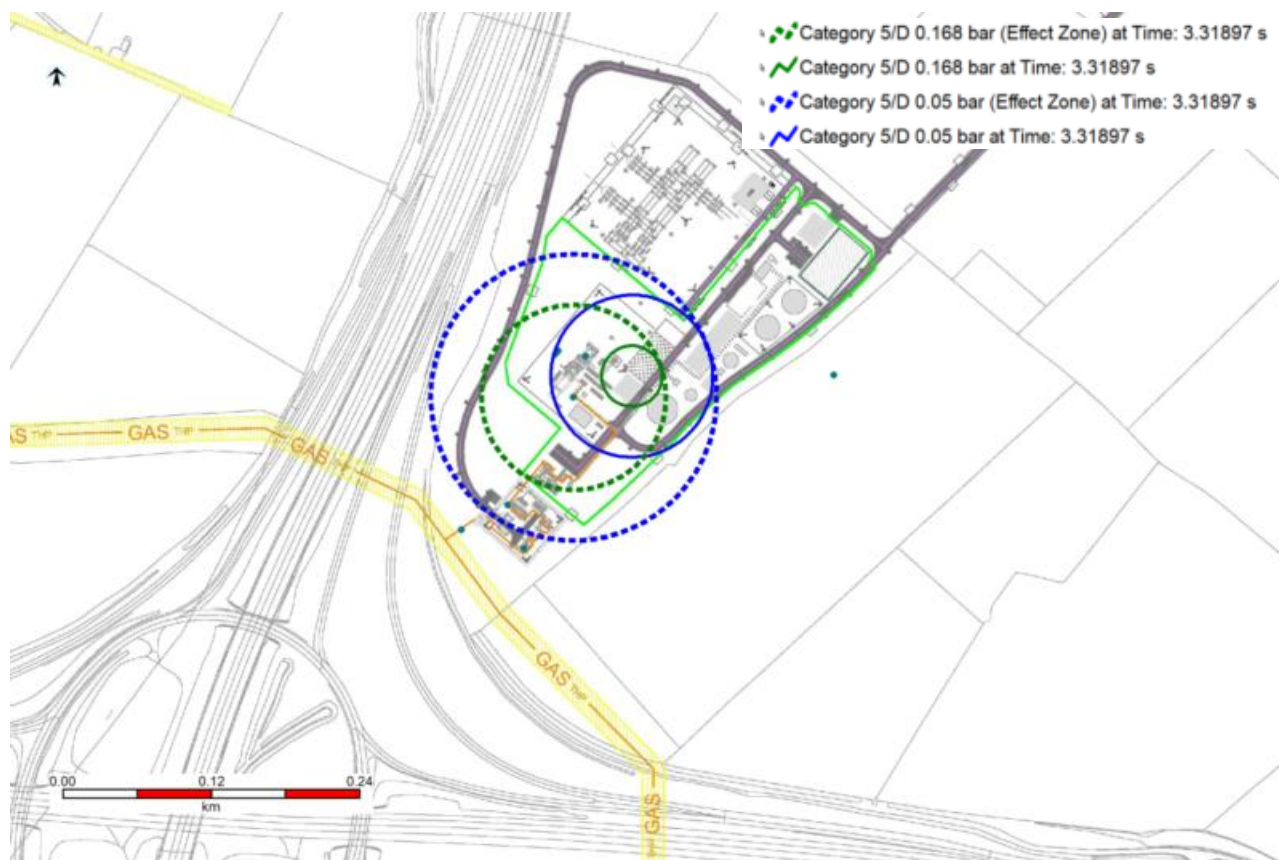
Table 19 details the distances to specified overpressure endpoints.

Table 19 Natural Gas VCE following 35 barg Pipeline Release: Distances to Specified Overpressure Endpoints

Peak overpressure (mbar)	Consequences	Distance to Overpressure Level (metres)			
		Above Ground Pipeline Rupture Horizontal Release		Above Ground Pipeline Leak Horizontal Release	
		D5	F2	D5	F2
168	1% mortality outdoors	74	75	No VCE hazard	16
50	1% mortality indoors CIA Category 3	115	118	No VCE hazard	25

Figure 12 illustrates the overpressure contour and effect zone corresponding to 1% fatality outdoors and 1% fatality indoors CIA Cat. 3 following a pipeline rupture (horizontal) and VCE following rupture of the 35 barg natural gas pipeline. The shape of the contour is shown for the prevailing wind direction (see Figure 7) as well as the effect area which takes account of all possible wind directions.

Figure 12 Natural Gas 35 barg Pipeline Rupture (Horizontal) and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours



In the event of a VCE following rupture of the 35 barg natural gas pipeline, it is concluded that the overpressure consequences corresponding to 1% fatality outdoor may extend over the COMAH boundary but will not extend to any occupied locations. The overpressure contour corresponding to 1% fatality indoors (CIA Cat. 3) extends to the kiosks at the AGI. There is the potential for fatalities at the AGI if personnel are present. The AGI will be normally unoccupied.

The overpressure consequences corresponding to 1% fatality indoors (CIA Cat. 3) may also extend to the nearest carriageway at the motorway interchange.

6.2.7 Natural Gas Pipeline Release: Flash Fire Results

The DNV PHAST Version 9.1 unified dispersion model predicts the flash fire footprints, at a receiver height of 1.5m, illustrated on the following figures for natural gas pipeline release scenarios.

Flash Fire consequence graphs are provided in Appendix B.

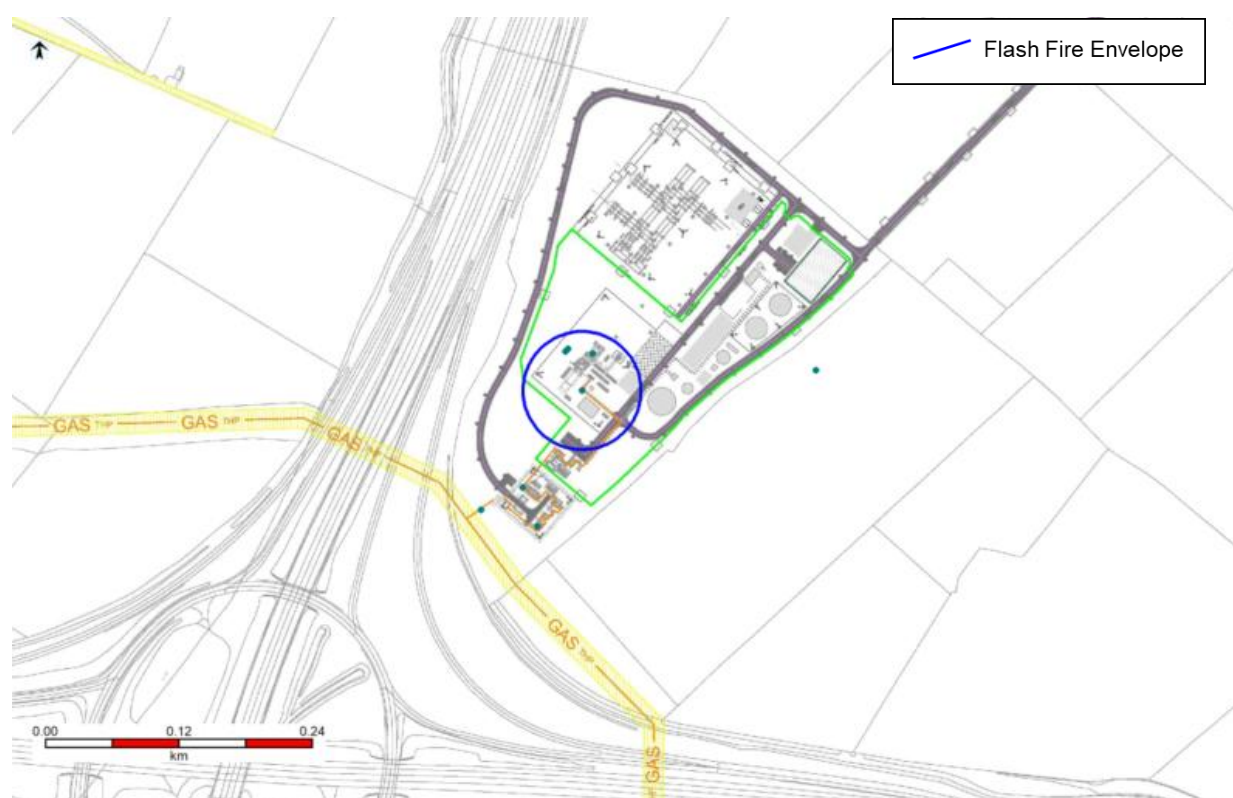
Table 20 summarises flash fire results following a loss of containment of natural gas from a gas pipeline at the proposed development (i.e. the section 37E planning application).

Table 20 Natural Gas Pipeline Loss of Containment and Flash Fire: Distance to Flash Fire Envelope

Loss of containment scenario description	Flash Fire Envelope	
	Category D5	Category F2
Above Ground 35 barg natural gas pipeline rupture, horizontal release	56 metres at 1.5 metres receptor height (maximum distance at any receptor height for flash fire)	52 metres at 1.5 metres receptor height (maximum distance at any receptor height for flash fire)
Above Ground 35 barg natural gas pipeline rupture, vertical release	0.36 metres at 1.5 metre receptor height 3.7 metres max. distance to LFL at 21 metres above ground level	0.32 metres at 1.5 metre receptor height 2.7 metres max. distance to LFL at 25 metres above ground level
Above Ground 35 barg natural gas pipeline leak, 0.1D, horizontal release	maximum 9.8 metres flash fire envelope at height of release	maximum 10.7 metres flash fire envelope at height of release
Above Ground 35 barg natural gas pipeline leak, 0.1D, vertical release	0.16 metres at 1.5 metre receptor height 0.9 metres max. distance to LFL at 6.7 metres above ground level	0.14 metres at 1.5 metre receptor height 0.8 metres max. distance to LFL at 8 metres above ground level

Figure 13 illustrates the flash fire footprint following rupture of the 35 bar natural gas pipeline (horizontal release direction) for the worst case weather conditions (D5).

Figure 13 Natural Gas 35 barg Pipeline Rupture (Horizontal): Flash Fire Footprint



It is concluded that in the event of rupture or leak of a natural gas pipeline, the flash fire footprint will not extend to any off site receptors.

6.2.8 Event Frequencies

Table 40 of the HSA's TLUP guidelines (HSA, 2023) gives the following pipeline loss of containment frequencies for above ground natural gas pipelines within an establishment of diameter > 150 mm:

- ▶ Pipeline rupture frequency: 1E-07 per m per year
- ▶ Pipeline leak (10% diameter) frequency: 5E-07 per m per year

Methane is categorised as of low reactivity and the following ignition probabilities are specified in Table 42 of the HSA's TLUP guidelines (HSA, 2023):

- ▶ Fireball/Jet fire: 0.1
- ▶ Flash fire: $0.9 \times 0.6 = 0.54$
- ▶ VCE: $0.9 \times 0.4 = 0.36$

Table 21 details the natural gas pipeline specifications for the pipelines on site.

Table 21 Natural Gas Pipeline Specification

Pipeline	Diameter (mm)	Length (m)	Maximum Operating Pressure (barg)
35 barg pipeline to turbines (above ground)	250	167	35

Table 22 summarises the event frequencies for a major accident at the natural gas pipeline.

Table 22 Natural Gas Pipeline Event Frequencies

Installation	LOC scenario	LOC frequency		Modifier	LOC frequency /year	Consequence	Conditional probability	Event frequency
Above Ground Natural Gas Pipeline (section within COMAH boundary downstream of AGI regulator) 35 barg, 250 mm diameter, 167 metre length	Pipeline rupture	1.00E-07	/m/yr	167	1.67E-05	Jet fire/Fireball	0.1	1.67E-06
						Flash fire	0.54	9.02E-06
						VCE	0.36	6.01E-06
	Pipeline leak (10% diameter)	5.00E-07	/m/yr	167	8.35E-05	Jet fire/Fireball	0.1	8.35E-06
						Flash fire	0.54	4.51E-05
						VCE	0.36	3.01E-05

6.3 LPG Tank Release

6.3.1 LPG Tank Release: Model Inputs

DNV Phast 9.1 was used to model a release from a bulk storage tank containing LPG (propane). Model inputs are detailed in Table 23.

Table 23 LPG Tank Release: Model Inputs

Parameter	Instantaneous Release	Continuous Release Over 10 Minutes	10 mm leak over 30 minutes	Source/Assumption
Scenario	Instantaneous Release	Continuous leak over 10 minutes	10 mm leak over 30 minutes	-
Material	Propane	Propane	Propane	-
Mass of Propane	1008 kg	1008 kg	1008 kg	Project Engineer
Pressure	27.5 barg (1.1 x MAWP)	25 barg (MAWP)	25 barg (MAWP)	-
Averaging time	Flammable – 18.75 s	Flammable – 18.75 s	Flammable – 18.75 s	DNV Phast
Exposure duration for long duration fire scenarios	60 s	60 s	60 s	HSA recommended (HSA, 2023)
Release height	1 m	1 m	1 m	Cylinder height
Effect height	1.5 m	1.5 m	1.5 m	Average height of person
Wind speed	5 m/s (daytime), 2 m/s (nighttime)	5 m/s (daytime), 2 m/s (nighttime)	5 m/s (daytime), 2 m/s (nighttime)	Recommended by HSA as representative modelling conditions
Pasquill Stability Factor	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	
Temperature	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	HSA guidance (HSA 2023)

The maximum Surface Emissive Power for LPG is set at 275 kW/m².

6.3.2 LPG Release: Predicted Phenomena

DNV Phast Version 9.1 predicts the following phenomena for each release scenario:

- ▶ Instantaneous Release: BLEVE/Fireball (immediate ignition), vapour cloud explosion or flash fire (delayed ignition)
- ▶ Continuous Release over 10 minutes: Jet fire (immediate ignition), vapour cloud explosion or flash fire (delayed ignition)
- ▶ 10 mm leak over 30 minutes: Jet fire (immediate ignition), vapour cloud explosion or flash fire (delayed ignition)

6.3.3 LPG Tank Rupture and Fireball

The HSE fireball model is used in this study. This is a static fireball model and assumes that the fireball is located on the ground with no lift-off.

Consequence decay curves are provided in Appendix B.

Table 24 details the model outputs for a fireball following LPG tank release.

Table 24 LPG Tank Rupture and Fireball: Model Outputs

Output	LPG Tank Rupture	
	D5	F2
Flammable Mass (kg)	847	772
Duration of Fireball (s)	4.2	4.1
Fireball Radius (m)	27.4	26.5

Consequence decay curves are provided in Appendix B.

Table 25 details the distances to thermal dose levels associated with specified levels of probability of fatality based on the Eisenberg Probit equation described in Section 4.2.

Table 25 LPG Tank Rupture and Fireball: Distances to Specified Thermal Dose Levels

Criterion	Thermal Dose Level	Thermal Radiation	LPG Tank Rupture	
	TDUs	kW/m ²	D5	F2
1% fatality outdoors (based on fireball duration)	963	-	42	40
100% fatality outdoors	Fireball radius	-	27	27
Building protected below this level, 0% fatality probability	-	12.7	98	94
Building will catch fire quickly, 100% fatality probability	-	25.6	68	66

Figure 14 illustrates the thermal radiation contours corresponding to 1% mortality and 100 % mortality outdoors and Figure 15 illustrates the thermal radiation contours corresponding to 12.7 kW/m² and 25.6 kW/m² following rupture of the LPG tank.

Figure 14 LPG Tank Rupture and Fireball: Outdoor Lethality Contours

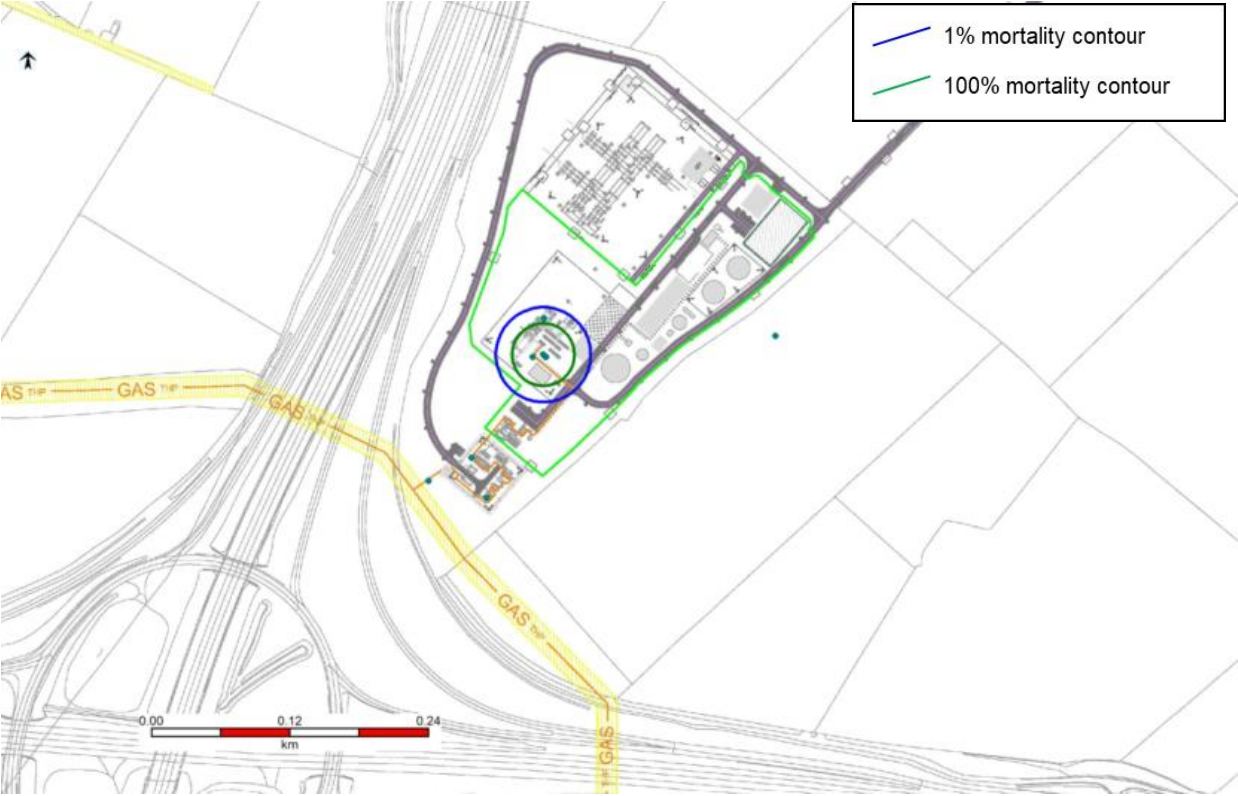
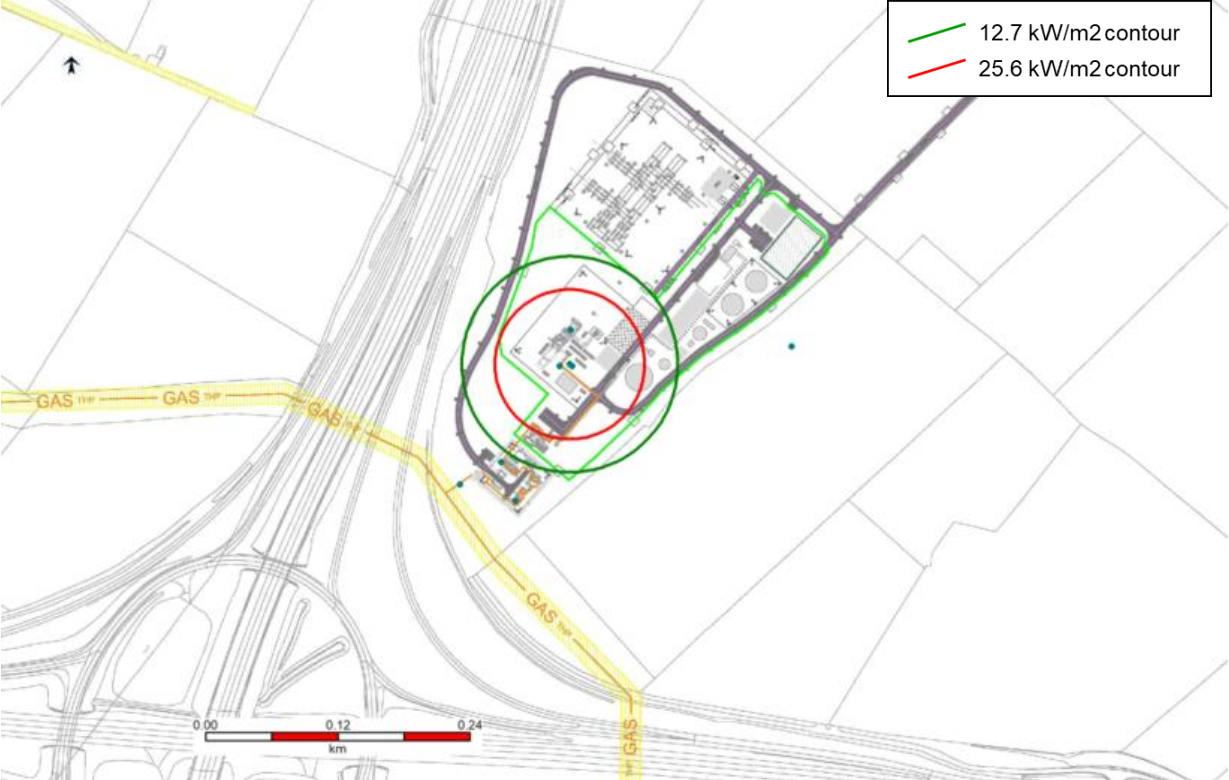


Figure 15 LPG Tank Rupture and Fireball: 12.7 kW/m² and 25.6 kW/m² Contours



It is concluded that in the event of rupture of the LPG tank the thermal dose corresponding to 1% fatality extends slightly beyond the COMAH boundary to the west but does not extend to any receptor locations.

The 12.7 kW/m² thermal radiation contour may extend over the COMAH boundary to the motorway. No injuries or fatalities are predicted at this location.

6.3.4 LPG Tank Release: VCE Results

The DNV PHAST unified dispersion model was used to predict the flammable mass that would arise in the event of rupture of the LPG tank or a leak from the LPG tank. Ignition location and flammable mass are summarised in Table 26.

Table 26 LPG Tank Release: Vapour Cloud Explosion Ignition Location and Flammable Mass

Loss of containment scenario description	Ignition location	Flammable Mass	
		Category D5	Category F2
LPG tank rupture	Confined area is close to source, ignition location at source	80 kg	80 kg
LPG tank continuous release over 10 minutes, horizontal release	Confined area is close to source, ignition location at source	0.39 kg	0.54 kg
LPG tank continuous release over 10 minutes, vertical release	Confined area is close to source, ignition location at source	0.20 kg	0.38 kg
LPG tank 10 mm leak, horizontal release	Confined area is close to source, ignition location at source	0.75 kg	0.93 kg
LPG tank 10 mm leak, vertical release	Confined area is close to source, ignition location at source	0.58 kg	0.67 kg

The TNO Multi Energy model was used to model the overpressure consequences in the event a VCE following the loss of containment of LPG from a bulk storage tank. An explosion strength of 7 was applied to 20% of the stoichiometric cloud volume.

Consequence decay curves are provided in Appendix B.

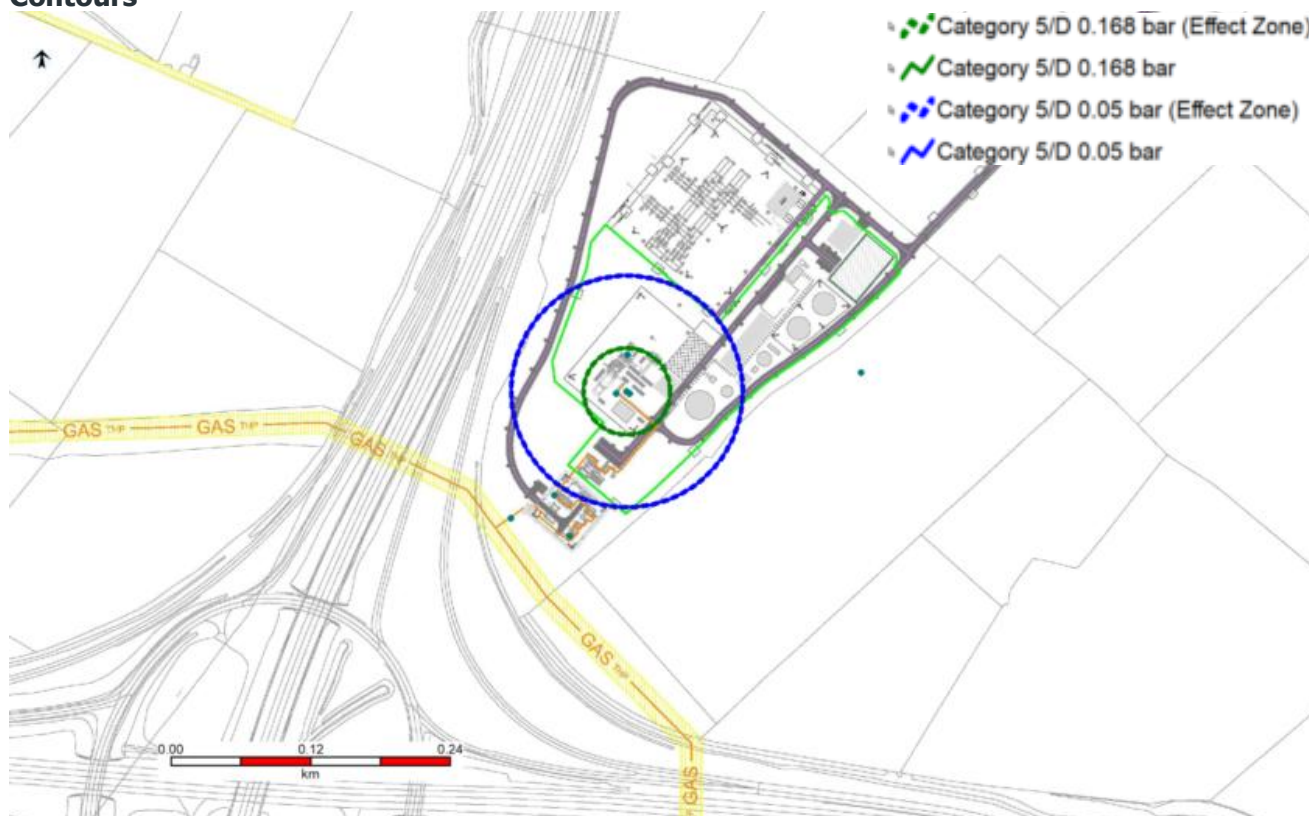
Table 27 details the distances to specified overpressure endpoints.

Table 27 LPG Tank Release and VCE: Distances to Specified Overpressure Endpoints

Peak overpressure (mbar)	Consequences	Distance to Overpressure Level (metres)									
		LPG Tank Rupture		Continuous Release Over 10 Minutes – Horizontal release direction		Continuous Release Over 10 Minutes – Vertical release direction		10 mm Leak over 30 minutes – Horizontal release direction		10 mm Leak over 30 minutes - Vertical release direction	
		D5	F2	D5	F2	D5	F2	D5	F2	D5	F2
168	1% mortality outdoors	37	37	6.3	7.0	5.0	6.3	7.8	8.4	6.1	7.5
50	1% mortality indoors CIA Category 3	99	99	16.8	18.6	13.5	16.7	21.0	22.5	16.2	20.1

Figure 16 illustrates the overpressure contour and effect zone corresponding to 1% fatality outdoors and 1% fatality indoors CIA Cat. 3 following a pipeline rupture (horizontal) and VCE following rupture of the LPG tank. The shape of the contour is shown for the prevailing wind direction (see Figure 7) as well as the effect area which takes account of all possible wind directions.

Figure 16 LPG Tank Rupture and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours



In the event of a VCE following rupture of the LPG tank, it is concluded that the overpressure consequences corresponding to 1% fatality outdoors do not COMAH boundary. The overpressure contour corresponding to 1% fatality indoors (CIA Cat. 3) extends over the COMAH boundary. It does not extend to any building however it extends to the nearest carriageway at the motorway interchange.

6.3.5 LPG Tank Release and Jet Fire

The (DNV Recommended) jet fire cone model was used to calculate the thermal radiation consequences following the release of LPG from the bulk LPG tank.

Consequence decay curves are provided in Appendix B.

Table 28 details the distances to thermal radiation levels associated with specified levels of probability of fatality from a jet fire.

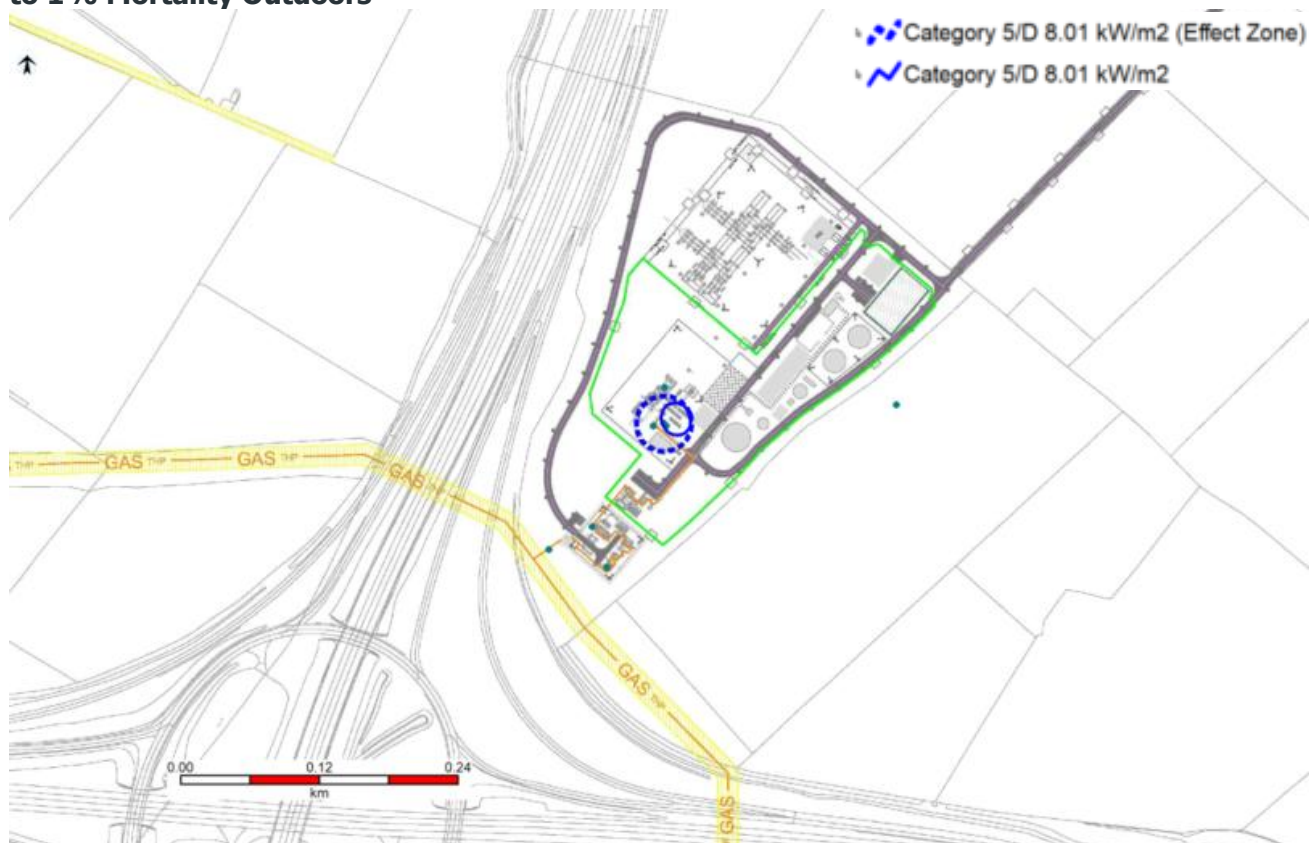
Table 28 LPG Tank Release and Jet Fire: Distances to Specified Thermal Radiation Levels

Criterion	Thermal Radiation Level	LPG Tank Continuous Release Over 10 Minutes (Entire Contents) Horizontal Release Direction		LPG Tank Continuous Release Over 10 Minutes (Entire Contents) Vertical Release Direction		LPG Tank 10 mm Leak Over 30 Minutes Horizontal Release Direction		LPG Tank 10 mm Leak Over 30 Minutes Vertical Release Direction	
		Distance D5	Distance F2	Distance D5	Distance F2	Distance D5	Distance F2	Distance D5	Distance F2
	kW/m ²	m	m	m	m	m	m	m	m
1% fatality	8.02	24	28	15	16	29	33	18	19
Building protected below this level, 0% fatality probability	12.7	22	26	12	12	26	30	15	14
Building will catch fire quickly, 100% fatality probability	25.6	19	23	9	6	23	27	11	7

Figure 17 illustrates the thermal radiation contour and effect areas corresponding to 1% fatality outdoors for a jet fire following a leak of LPG from the LPG tank for a horizontal release, and a receiver height 1.5m for weather category D5 (representative worst case scenario).

The thermal radiation contour is illustrated for the prevailing wind direction (see Figure 7) and the effect area takes account of all possible wind directions.

Figure 17 LPG Tank Leak and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Mortality Outdoors



It is concluded that in the event of a jet fire following a leak from the LPG Tank, the thermal radiation level corresponding to 1% mortality outdoors does not extend over the COMAH site boundary and no off site effects are predicted to arise.

6.3.6 LPG Tank Release and Flash Fire

The DNV PHAST Version 9.1 unified dispersion model predicts the flash fire footprints, at a receiver height of 1.5m.

Flash Fire consequence graphs are provided in Appendix B.

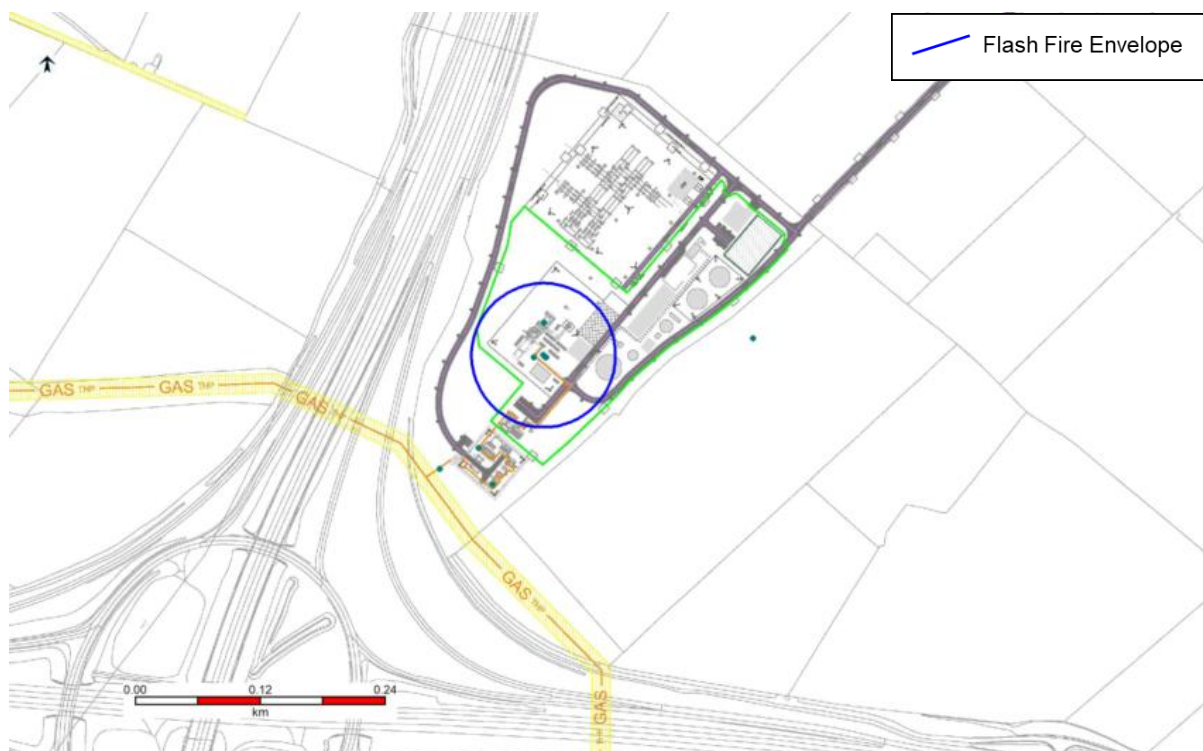
Table 29 summarises flash fire results following a loss of containment of LPG from a bulk storage tank at the proposed development (i.e. the section 37E planning application).

Table 29 LPG Tank Release and Flash Fire: Distance to Flash Fire Envelope

Loss of containment scenario description	Flash Fire Envelope	
	Category D5	Category F2
LPG Tank rupture	58 metres at 1.5 metre receptor height	37 metres at 1.5 metre receptor height
LPG Tank continuous release of entire contents over 10 minutes – horizontal release	11.5 metres at height of release (maximum distance to LFL)	14.5 metres at height of release (maximum distance to LFL)
LPG Tank continuous release of entire contents over 10 minutes – vertical release	0.12 metres at 1.5 metre receptor height, Max. 1.5 metres flash fire envelope at 6 metres above ground level	0.1 metres at 1.5 metre receptor height, Max. 1.2 metres flash fire envelope at 8.6 metres above ground level
LPG tank 10 mm leak – horizontal release	12.5 metres at 1.5 metre receptor height, Max. 15.5 metres flash fire envelope at 0.9 metres above ground level	14.7 metres at 1.5 metre receptor height, Max. 18.5 metres flash fire envelope at 0.75 metres above ground level
LPG tank 10 mm leak – vertical release	0.12 metres at 1.5 metre receptor height, Max. 1.8 metres flash fire envelope at 7 metres above ground level	0.1 metres at 1.5 metre receptor height, Max. 1.4 metres flash fire envelope at 10 metres above ground level

Figure 18 illustrates the flash fire footprint following rupture of the LPG tank for the worst case weather conditions (D5).

Figure 18 LPG Tank Rupture: Flash Fire Footprint



In the event of rupture of the LPG tank, the flash fire envelope will extend over the COMAH boundary to the AGI access road which is within the site ownership boundary. This road has low levels of traffic and no fatalities are predicted to occur.

6.3.7 LPG Tank Release Frequencies

Table 23 of the HSA's TLUP guidelines (HSA, 2023) gives release and event frequencies for LPG tank loss of containment scenarios. See Table 30 as follows.

Table 30 LPG Tank Event Frequencies

LOC scenario	LOC frequency		Modifier	LOC freq. /year	Consequence	Event freq. (per year)
Instantaneous Release	5E-07	/yr per tank	1 tank	5.00E-07	Fireball	3.50E-07
					VCE	6.00E-08
					Flash fire	9.00E-08
Continuous Leak Over 10 Minutes	5E-07	/yr per tank	1 tank	5.00E-07	Jet Fire	3.50E-07
					VCE	6.00E-08
					Flash fire	9.00E-08
10 mm Pipe Leak Over 30 Minutes	1E-05	/yr per tank	1 tank	1.00E-05	Jet Fire	7.00E-06
					VCE	1.20E-06
					Flash fire	1.80E-06

6.4 LPG Road Tanker Release

6.4.1 LPG Road Tanker Release: Model Inputs

DNV Phast 9.1 was used to model a release from an LPG road tanker. Model inputs are detailed in Table 23.

The maximum Surface Emissive Power (SEP) for LPG is set at 275 kW/m².

Table 31 LPG Road Tanker Release: Model Inputs

Parameter	Instantaneous Release	Loss of Entire Contents Through Largest Connection	Rupture of Unloading Arm	Leak of Unloading Arm of 10% of Diameter	BLEVE (Hot)	Source/Assumption
Scenario	Instantaneous Release	Loss of Entire Contents Through Largest Connection	Rupture of Unloading Arm	Leak of Unloading Arm of 10% of Diameter	BLEVE (Hot)	-
Material	Propane	Propane	Propane	Propane	Propane	-
Mass of Propane	28000 kg	28000 kg	28000 kg	28000 kg	28000 kg	Conservative assumption that large LPG Road Tanker will deliver LPG to site
Pressure	33 barg (1.1 x MAWP)	30 barg (MAWP)	30 barg (MAWP)	30 barg (MAWP)	30 barg (MAWP)	Typical MAWP for LPG road tanker
Release diameter	n/a	100 mm assumed in absence of detailed design	100 mm assumed in absence of detailed design	10 mm	-	
Averaging time	Flammable – 18.75 s	Flammable – 18.75 s	Flammable – 18.75 s	Flammable – 18.75 s	Flammable – 18.75 s	DNV Phast
Exposure duration for long duration fire scenarios	60 s	60 s	60 s	60 s	60 s	HSA recommended (HSA, 2023)
Release height	1 m	1 m	1 m	1 m	1 m	Cylinder height
Effect height	1.5 m	1.5 m	1.5 m	1.5 m	1.5 m	Average height of person
Wind speed	5 m/s (daytime), 2 m/s (nighttime)	5 m/s (daytime), 2 m/s (nighttime)	5 m/s (daytime), 2 m/s (nighttime)	5 m/s (daytime), 2 m/s (nighttime)	5 m/s (daytime), 2 m/s (nighttime)	Recommended by HSA as representative modelling conditions
Pasquill Stability Factor	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	D (daytime conditions) F (stable nighttime conditions)	
Temperature	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	10 degC (F2) 15 degC (D5)	HSA guidance (HSA 2023)

6.4.2 LPG Release: Predicted Phenomena

DNV Phast Version 9.1 predicts the following phenomena for each release scenario:

- ▶ Instantaneous Release: Fireball (immediate ignition), vapour cloud explosion or flash fire (delayed ignition)
- ▶ Loss of entire contents through largest connection: Jet fire (immediate ignition), vapour cloud explosion or flash fire (delayed ignition)
- ▶ Rupture of Unloading Arm: Jet fire (immediate ignition), vapour cloud explosion or flash fire (delayed ignition)
- ▶ Leak of Unloading Arm of 10% of Diameter: Jet fire (immediate ignition), vapour cloud explosion or flash fire (delayed ignition)
- ▶ Hot BLEVE

6.4.3 LPG Road Tanker Release and Fireball

The HSE fireball model is used in this study. This is a static fireball model and assumes that the fireball is located on the ground with no lift-off.

Consequence decay curves are provided in Appendix B.

Table 32 details the model outputs for a fireball following LPG tank release.

Table 32 LPG Road Tanker Release and Fireball: Model Outputs

Output	LPG Road Tanker Rupture		LPG Road Tanker BLEVE (hot)	
	D5	F2	D5	F2
Flammable Mass (kg)	23342.8	21269	23342.8	21269
Duration of Fireball (s)	12.8	12.4	12.8	12.4
Fireball Radius (m)	83	80	83	80

Consequence decay curves are provided in Appendix B.

Table 25 details the distances to thermal dose levels associated with specified levels of probability of fatality based on the Eisenberg Probit equation described in Section 4.2.

Table 33 LPG Road Tanker Release and Fireball: Distances to Specified Thermal Dose Levels

Criterion	Thermal Dose Level	Thermal Radiation	LPG Road Tanker Rupture		LPG Road Tanker BLEVE (hot)	
	TDUs	kW/m ²	D5	F2	D5	F2
1% fatality outdoors (based on fireball duration)	963	-	194	184	194	184
100% fatality outdoors	Fireball radius	-	83	80	83	80
Building protected below this level, 0% fatality probability	-	12.7	278	268	278	268
Building will catch fire quickly, 100% fatality probability	-	25.6	193	186	193	186

Figure 19 illustrates the thermal radiation contours corresponding to 1% mortality and 100 % mortality outdoors and Figure 20 illustrates the thermal radiation contours corresponding to 12.7 kW/m² and 25.6 kW/m² following rupture of the LPG tank.

Figure 19 LPG Road Tanker Rupture and Fireball or BLEVE (hot): Outdoor Lethality Contours

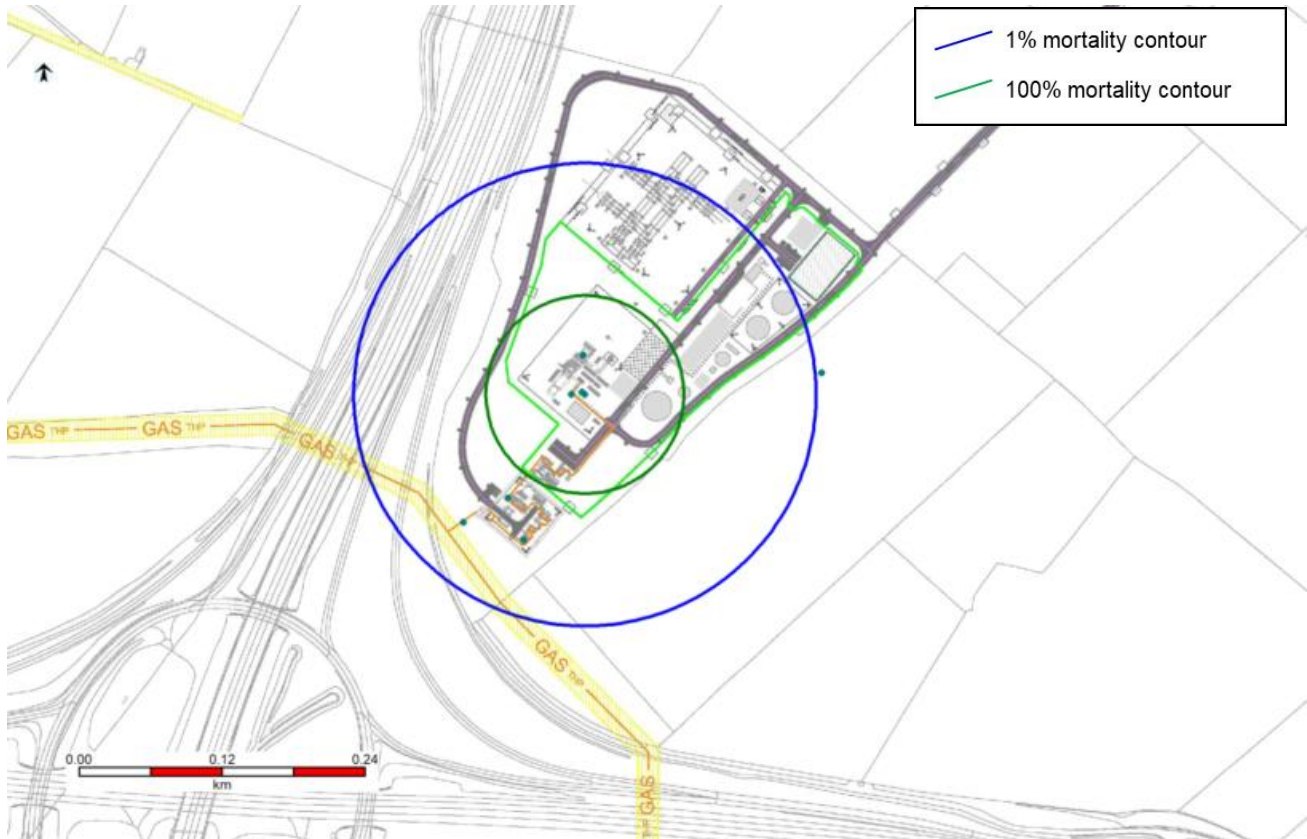
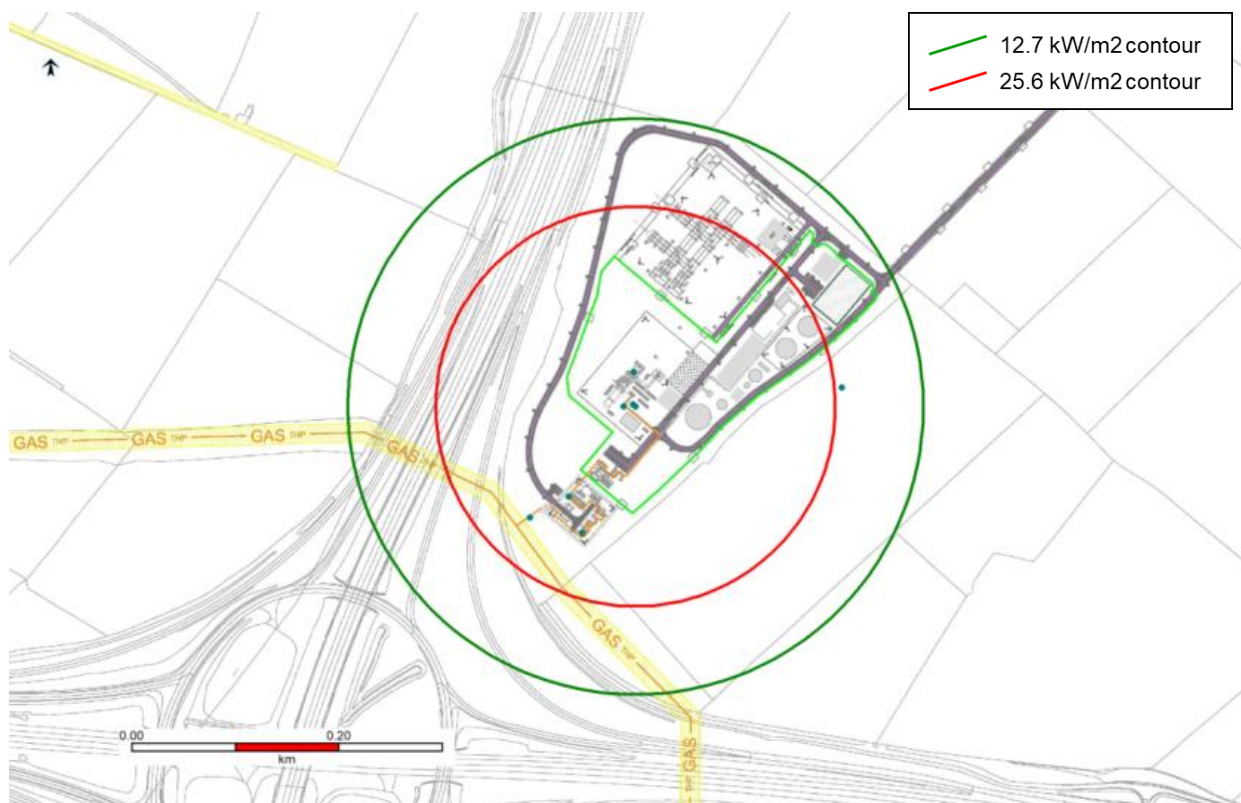


Figure 20 LPG Road Tanker Rupture and Fireball or BLEVE (hot): 12.7 kW/m² and 25.6 kW/m² Contours



It is concluded that the thermal dose corresponding to 1% fatality extends beyond the site boundary to the M18 motorway.

The 25.6 kW/m² thermal radiation contour extends to the kiosk structures at the AGI which is not normally occupied.

6.4.4 LPG Road Tanker Release: VCE Results

The DNV PHAST unified dispersion model was used to predict the flammable mass that would arise in the event of rupture of an LPG road tanker or a leak from an LPG road tanker or loading hose. Ignition location and flammable mass are summarised in Table 34.

Table 34 LPG Road Tanker Release: Vapour Cloud Explosion Ignition Location and Flammable Mass

Loss of containment scenario description	Ignition location	Flammable Mass	
		Category D5	Category F2
LPG road tanker rupture	Confined area is close to source, ignition location at source	2036 kg	2032 kg
Loss of Entire Contents Through Largest Connection – Horizontal release direction	Confined area is close to source, ignition location at source	98 kg	77 kg

Loss of containment scenario description	Ignition location	Flammable Mass	
		Category D5	Category F2
Loss of Entire Contents Through Largest Connection – Vertical release direction	Confined area is close to source, ignition location at source	104 kg	86 kg
Rupture of Unloading Hose– Horizontal release direction	Confined area is close to source, ignition location at source	98 kg	77 kg
Rupture of Unloading Hose– Vertical release direction	Confined area is close to source, ignition location at source	104 kg	86 kg
Leak of Unloading Hose of 10% of Diameter – Horizontal release direction	Confined area is close to source, ignition location at source	0.93 kg	1.25 kg
Leak of Unloading Hose of 10% of Diameter – Vertical release direction	Confined area is close to source, ignition location at source	0.39 kg	0.74 kg

The TNO Multi Energy model was used to model the overpressure consequences in the event a VCE following the loss of containment of LPG from a road tanker or loading hose. An explosion strength of 7 was applied to 20% of the stoichiometric cloud volume.

Consequence decay curves are provided in Appendix B.

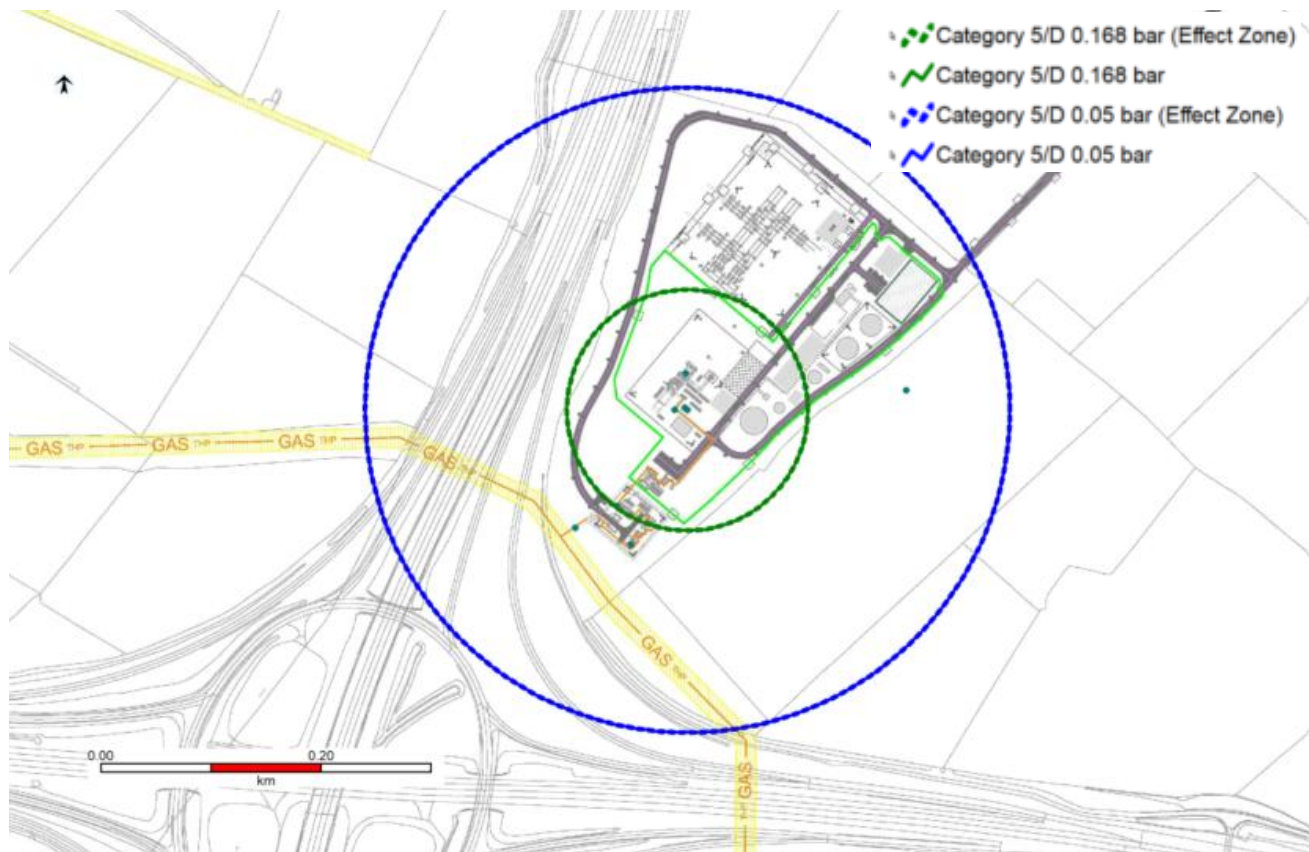
Table 35 details the distances to specified overpressure endpoints.

Table 35 LPG Road Tanker Release and VCE: Distances to Specified Overpressure Endpoints

Peak overpressure (mbar)	Consequences	Distance to Overpressure Level (metres)													
		LPG Road Tanker Rupture		Loss of Entire Contents Through Largest Connection – Horizontal Release Direction		Loss of Entire Contents Through Largest Connection – Vertical Release Direction		Rupture of Unloading Arm – Horizontal Release Direction		Rupture of Unloading Arm – Vertical Release Direction		Leak of Unloading Arm of 10% of Diameter – Horizontal Release Direction		Leak of Unloading Arm of 10% of Diameter – Vertical Release Direction	
		D5	F2	D5	F2	D5	F2	D5	F2	D5	F2	D5	F2	D5	F2
168	1% mortality outdoors	109	109	40	37	41	38	40	37	41	38	8	9	6	8
50	1% mortality indoors CIA Category 3	292	292	107	98	109	102	107	98	109	102	22	25	17	21

Figure 21 illustrates the worst case overpressure contours corresponding to 1% fatality outdoors and 1% fatality indoors CIA Cat. 3 following rupture of an LPG road tanker leading to a VCE.

Figure 21 LPG Road Tanker Rupture and VCE: 1% Fatality Outdoors and 1% Fatality Indoors CIA. 3 Contours



It is concluded that the overpressure consequences corresponding to 1% fatality outdoors or 1% fatality indoors (CIA Cat. 3), in the event of a VCE following rupture of an LPG tanker, extend off site to the M18 motorway and to the kiosk structures at the AGI which is not normally occupied.

6.4.5 LPG Road Tanker Release and Jet Fire

The (DNV Recommended) jet fire cone model was used to calculate the thermal radiation consequences following the release of LPG from the bulk LPG tank.

Consequence decay curves are provided in Appendix B.

Table 36 details the distances to thermal radiation levels associated with specified levels of probability of fatality from a jet fire.

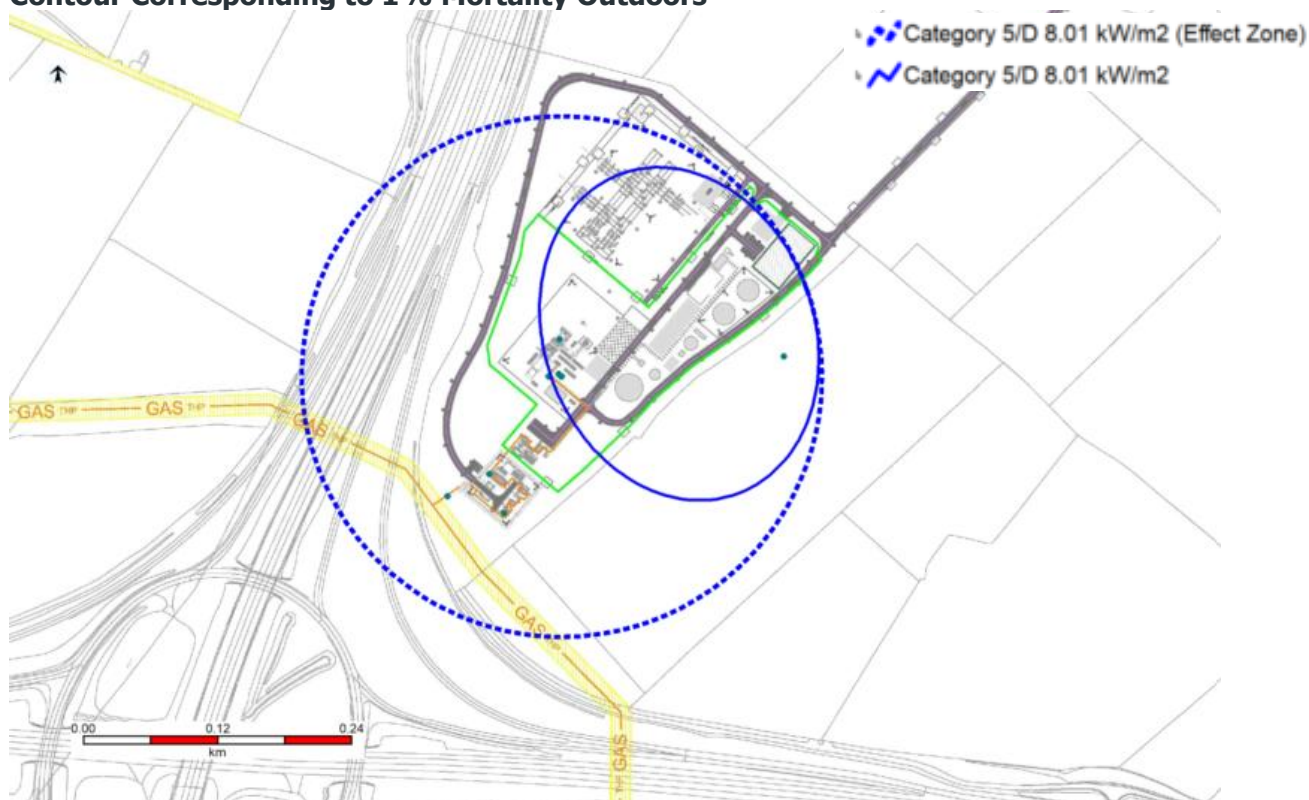
Table 36 LPG Road Tanker Release and Jet Fire: Distances to Specified Thermal Radiation Levels

Criterion	Thermal Radiation Level kW/m ²	Distance to Thermal Radiation Level (metres)											
		Loss of Entire Contents Through Largest Connection – Horizontal Release Direction (100 mm diameter leak)		Loss of Entire Contents Through Largest Connection – Vertical Release Direction (100 mm diameter leak)		Rupture of Unloading Arm – Horizontal Release Direction (100 mm diameter leak)		Rupture of Unloading Arm – Vertical Release Direction (100 mm diameter leak)		Leak of Unloading Arm of 10% of Diameter – Horizontal Release Direction (10 mm diameter leak)		Leak of Unloading Arm of 10% of Diameter – Vertical Release Direction (10 mm diameter leak)	
		D5	F2	D5	F2	D5	F2	D5	F2	D5	F2	D5	F2
1% fatality	8.02	233	271	116	119	233	271	116	119	30	34	19	20
Building protected below this level, 0% fatality probability	12.7	208	245	91	81	208	245	91	81	27	32	14	15
Building will catch fire quickly, 100% fatality probability	25.6	178	214	51	19	178	214	51	19	24	28	6	7

Figure 22 illustrates the thermal radiation contour and effect areas corresponding to 1% fatality outdoors for a jet fire following a 100 mm diameter road tanker leak or hose rupture for a horizontal release, and a receiver height 1.5m for weather category D5 (representative worst case scenario).

The thermal radiation contour is illustrated for the prevailing wind direction (see Figure 7) and the effect area takes account of all possible wind directions.

Figure 22 100 mm LPG Road Tanker or Hose Leak and Horizontal Jet Fire: Thermal Radiation Contour Corresponding to 1% Mortality Outdoors



It is concluded that in the event of a jet fire following a leak from the an LPG Road Tanker, the thermal radiation level corresponding to 1% mortality outdoors extend over the COMAH site boundary to the M18 motorway and the AGI which is not normally occupied.

6.4.6 LPG Road Tanker Release and Flash Fire

The DNV PHAST Version 9.1 unified dispersion model predicts the flash fire footprints, at a receiver height of 1.5m.

Flash Fire consequence graphs are provided in Appendix B.

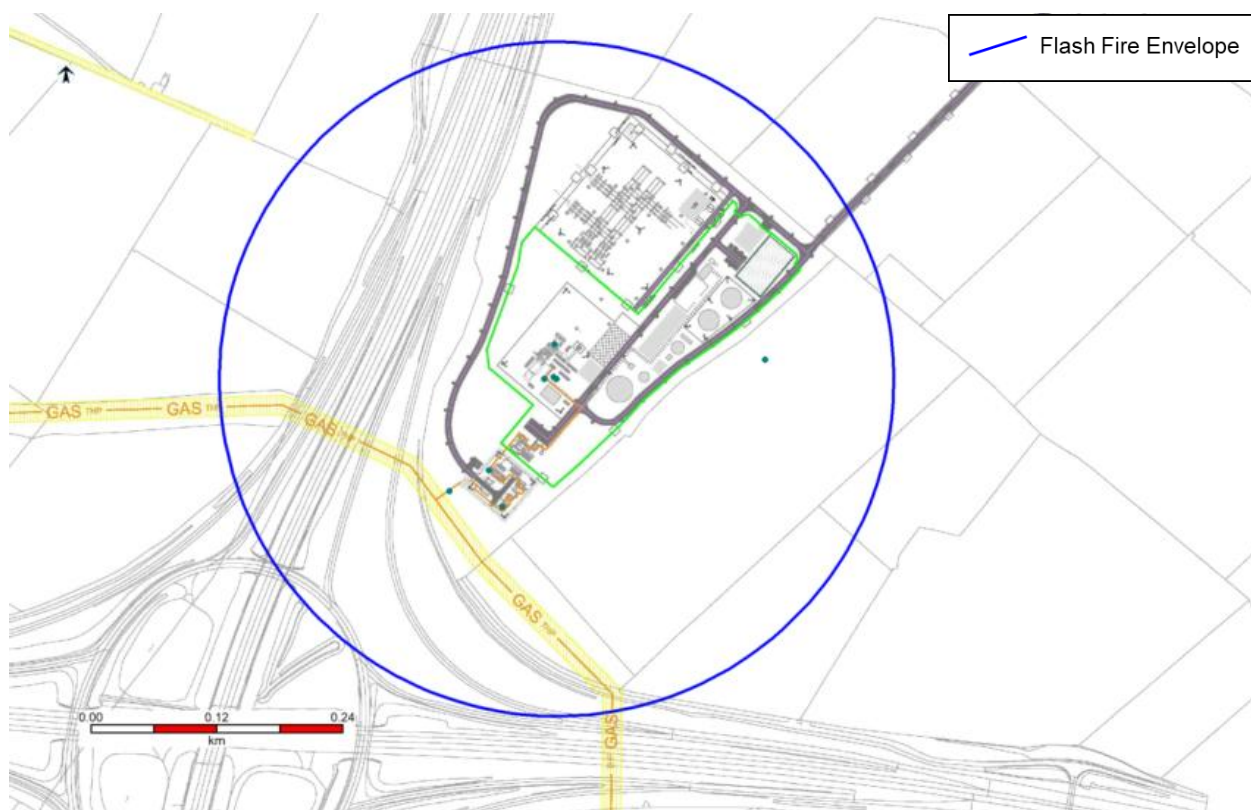
Table 37 summarises flash fire results following a loss of containment of LPG from a road tanker at the proposed development (i.e. the section 37E planning application).

Table 37 LPG Road Tanker Release and Flash Fire: Distance to Flash Fire Envelope

Loss of containment scenario description	Flash Fire Envelope	
	Category D5	Category F2
LPG Road Tanker rupture	285 metres at 1.5 metre receptor height, Max. 300 metres flash fire envelope at ground level 59 s after release	191 metres at 1.5 metre receptor height, Max. 350 metres flash fire envelope at ground level 154 s after release
Loss of Entire Contents Through Largest Connection – Horizontal Release Direction	310 metres at 1.5 metre receptor height, Max. 320 metres flash fire envelope at ground level	252 metres at 1.5 metre receptor height, Max. 256 metres flash fire envelope at ground level
Loss of Entire Contents Through Largest Connection – Vertical Release Direction	0.5 metres at 1.5 metre receptor height, Max. 34 metres flash fire envelope at 56 metres above ground level	0.4 metres at 1.5 metre receptor height, Max. 20 metres flash fire envelope at 71 metres above ground level
Rupture of Unloading Arm – Horizontal Release Direction	310 metres at 1.5 metre receptor height, Max. 320 metres flash fire envelope at ground level	252 metres at 1.5 metre receptor height, Max. 256 metres flash fire envelope at ground level
Rupture of Unloading Arm – Vertical Release Direction	0.5 metres at 1.5 metre receptor height, Max. 34 metres flash fire envelope at 56 metres above ground level	0.4 metres at 1.5 metre receptor height, Max. 20 metres flash fire envelope at 71 metres above ground level
Leak of Unloading Arm of 10% of Diameter – Horizontal Release Direction	13.5 metres at 1.5 metre receptor height, Max. 16.6 metres flash fire envelope 0.9 metres above ground level	15.7 metres at 1.5 metre receptor height, Max. 19.2 metres flash fire envelope at 0.75 metres above ground level
Leak of Unloading Arm of 10% of Diameter– Vertical Release Direction	0.13 metres at 1.5 metre receptor height, Max. 1.9 metres flash fire envelope at 7.3 metres above ground level	0.1 metres at 1.5 metre receptor height, Max. 1.5 metres flash fire envelope at 10.5 metres above ground level

Figure 23 illustrates the flash fire footprint following a 100 mm diameter leak from an LPG Road Tanker or hose rupture for the worst case weather conditions (D5).

Figure 23 LPG Road Tanker 100 mm Diameter Leak or Hose Rupture: Flash Fire Footprint



It is concluded that the flash fire envelope could extend to the M18 motorway and AGI which is not normally occupied.

6.4.7 LPG Road Tanker Release Frequencies

Table 24 of the HSA's TLUP guidelines (HSA, 2023) gives the loss of containment and event (fireball, jet fire, VCE, flash fire) frequencies for LPG road tanker loss of containment scenarios. Table 25 of the HSA's TLUP guidance document (HSA, 2023) gives loss of containment frequencies for road tanker offloading activities.

Table 38 summarises the event frequencies for a major accidents associated with an LPG road tanker at the proposed development (i.e. the section 37E planning application).

Table 38 LPG Road Tanker Event Frequencies

LOC scenario	LOC frequency		Modifier	LOC freq. /year	Consequence	Event freq. (per year)
Instantaneous Release	5E-07	/yr per road tanker	2.28E-05 fraction (laden LPG road tanker on site for 1 hour every 5 years)	1.14E-11	Fireball	7.99E-12
					VCE	1.37E-12
					Flash fire	2.05E-12
Loss of entire contents through	5E-07	/yr per tank	2.28E-05 fraction	1.14E-11	Jet fire	7.99E-12
					VCE	1.37E-12

largest connection			(laden LPG road tanker on site for 1 hour every 5 years)		Flash fire	2.05E-12
Rupture of unloading hose	4E-06	/hr	0.05 fraction (unloading will occur for 0.25 hours every 5 years)	2.00E-07	Jet fire	1.40E-07
					VCE	2.40E-08
					Flash fire	3.60E-08
Leak of unloading hose 10% of diameter	4E-05	/hr	0.05 fraction (unloading will occur for 0.25 hours every 5 years)	2.00E-06	Jet fire	1.40E-06
					VCE	2.40E-07
					Flash fire	3.60E-07
BLEVE (hot)	5.80E-10	/hr	0.2 fraction (laden LPG road tanker on site for 1 hour every 5 years)	1.16E-10	BLEVE (hot)	1.16E-10

6.5 Diesel Tank Release

6.5.1 Pool Fire Model Inputs

In the event of catastrophic rupture of both the inner and outer shell of a bulk diesel storage tank, there is the potential for a portion of the released material to overtop the bund and migrate off site to the east. On ignition a pool fire may occur. Pool fire model inputs are summarised in Table 39.

It is assumed that 50% of the tank contents overtops the bund. The pool radius is calculated by

Radius (metres) = $6.85 \times V^{0.44537}$ up to a maximum of 50 metres.

The maximum inventory of fuel in a bulk diesel storage tank is 3335 m³, 50% of which is 1667 m³ which equates to a pool radius of 187 metres, therefore a maximum pool radius of 50 metres is applied.

Table 39 Bulk Diesel Tank Rupture: Uncontained Pool Fire Model Inputs

Parameter	Units	Catastrophic rupture
Substance	-	Diesel (modelled in DNV PHAST as Diesel Fuel Oil)
Volume of fuel	m ³	1667 (50% of tank contents assumed to overtop the bund)
Pool radius	m	50
Maximum Surface Emissive Power	kW/m ²	130
Wind speed	-	5 m/s 2 m/s
Receiver height	m	1.5

The maximum SEP for diesel is set at 130 kW/m².

6.5.2 Pool Fire Thermal Radiation Consequences

The two-zone pool fire model in DNV PHAST Version 9.1 modelling software was used to model the consequences of pool fire involving diesel (modelled as m-xylene).

Consequence decay curves are provided in Appendix B.

Pool fire model outputs are summarised in Table 40.

Thermal radiation results are summarised in Table 41. The outdoor mortality consequence is based on the Eisenberg probit equation and an exposure duration of 60 s.

Table 40 Bulk Diesel Tank Rupture: Uncontained Pool Fire Model Outputs

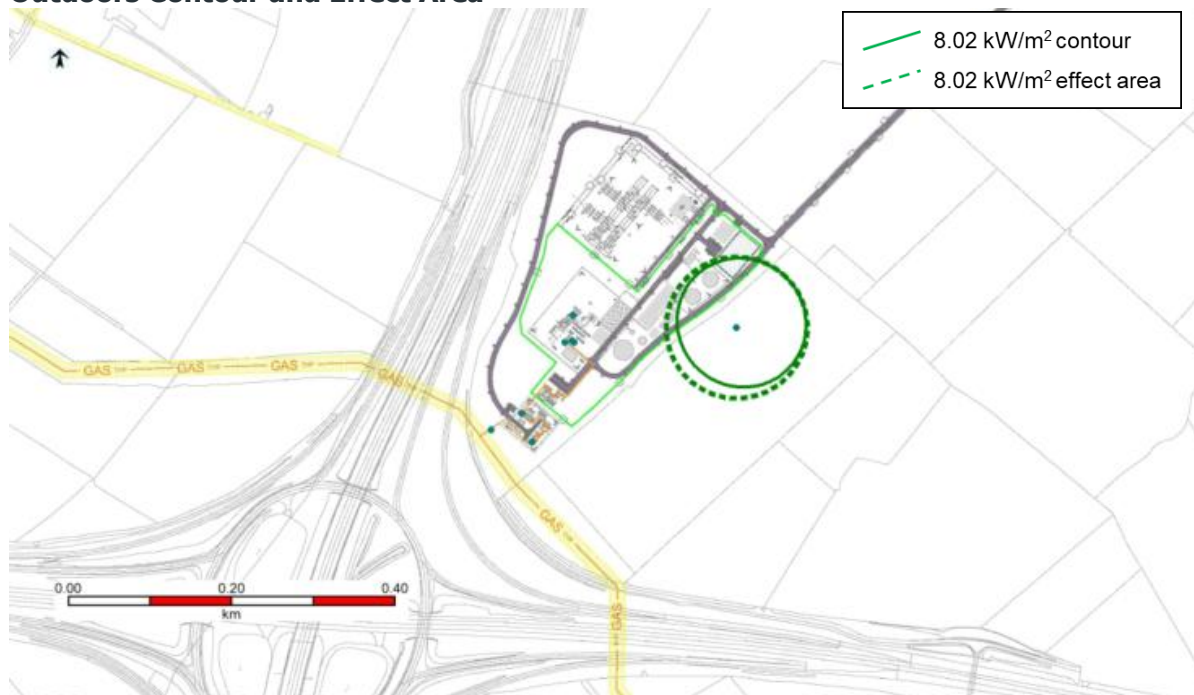
Parameter	Units	Catastrophic rupture	
		5 m/s	2 m/s
Pool fire diameter	m	100	100
Pool fire flame length	m	69	67
Total burn rate	kg/s	355	349
Radiative fraction	-	0.038	0.038

Table 41 Bulk Diesel Tank Rupture and Uncontained Pool Fire: Thermal Radiation Results

Thermal radiation level, kW/m ²	Consequences	Distance (m)	
		5 m/s	2 m/s
8.02	1% mortality outdoors	86	83
12.7	0% probability of fatality indoors	70	69
25.6	100% fatality indoors	60	58

Figure 24 illustrates the pool fire contour corresponding to 1% mortality outdoors for the worst case wind speed (5 m/s). The shape of the contour is shown for the prevailing wind direction (see wind rose on Figure 7) as well as the effect area which takes account of all possible wind directions.

Figure 24 Bulk Diesel Tank Rupture and Uncontained Pool Fire: Worst Case 1% Mortality Outdoors Contour and Effect Area



It is concluded that the thermal radiation level corresponding to the 1% mortality outdoors does not extend to any off site receptor.

6.5.3 Diesel Tank Release Frequencies

Table 54 of the HSA's TLUP guidelines (HSA, 2023) gives release and event frequencies for loss of containment scenarios from double containment atmospheric storage tanks. See Table 42 as follows.

Table 42 Secondary Fuel Diesel Tank Event Frequencies

LOC scenario	LOC frequency		Modifier 1	Modifier 2	LOC freq. /year	Consequence	Conditional probability	Event freq. (per year)
Instantaneous failure of primary and outer shell (with bund overtopping)	1.25E-08	/yr per tank	2 tanks	1 fraction overtop off site to east	1.25E-08	Uncontained Pool Fire	0.1 (probability of ignition)	1.25E-09

7. INDIVIDUAL RISK CONTOURS

Gexcon RiskCurves Version 12.5.1 modelling software was used to model the cumulative risk contours for the proposed Peaker Plant.

The site risk model inputs are as follows:

- ▶ The consequences arising from major accident scenarios (Appendix B)
- ▶ Event frequencies (Table 13, Table 22, Table 30, Table 38, and Table 42)
- ▶ Athenry met station wind speed and frequency data (see Section 4.5)
- ▶ Thermal radiation vulnerability relationships for persons outdoors and indoors described in Section 4.2
- ▶ Overpressure vulnerability relationships for persons outdoors (Hurst Nusey Pape Probit) and indoors (CIA Category 3 – see Section 4.3)
- ▶ Outdoor fatality levels of 100% are assumed inside the lower flammable limit (LFL) envelope, with 0% fatalities outside that envelope. Indoor fatality levels are conservatively assumed to be 10% within the flash fire envelope
- ▶ The HSA TLUP guidance document (HSA, 2023) specifies D5 conditions for 80% of the time, with F2 occurring for the remaining 20%.
- ▶ The HSA TLUP guidance document (HSA, 2023) states that persons are assumed to be indoors 90% of the time and outdoors 10% of the time.

Figure 25 illustrates individual risk of fatality contours corresponding to tolerability levels for new COMAH establishments based on a hypothetical residential population indoors in buildings of CIA Category 3 overpressure vulnerability (typical residential dwelling) for 90% of the time and outdoors for 10% of the time.

Figure 26 illustrates individual risk of fatality contours corresponding to the boundaries of COMAH land use planning zones as described in Section 3.

Figure 27 illustrates the proposed Consultation Distance for the proposed Peaker Plant development.

Figure 25 Individual Location-based Risk Contours for New Establishments

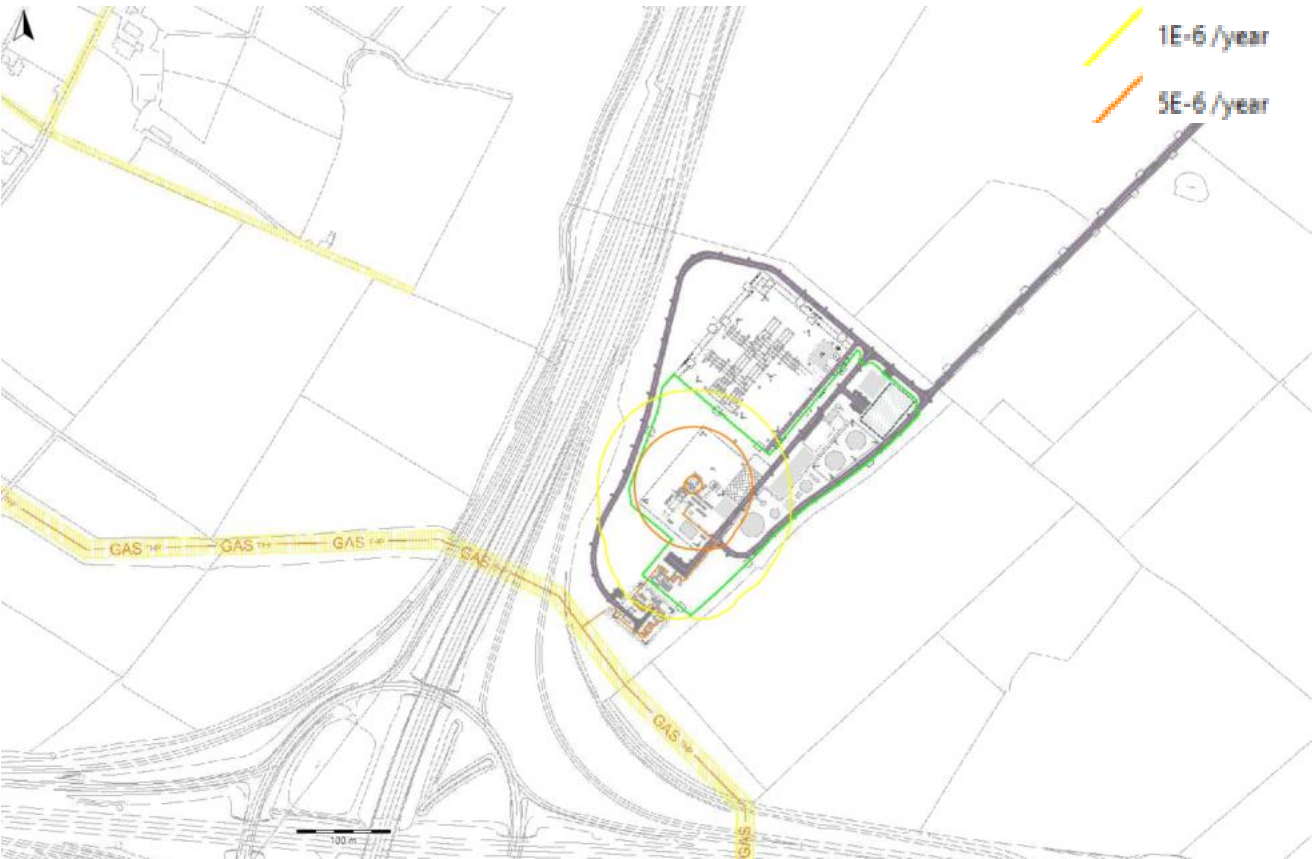


Figure 26 Individual Risk Based Land Use Planning Contours

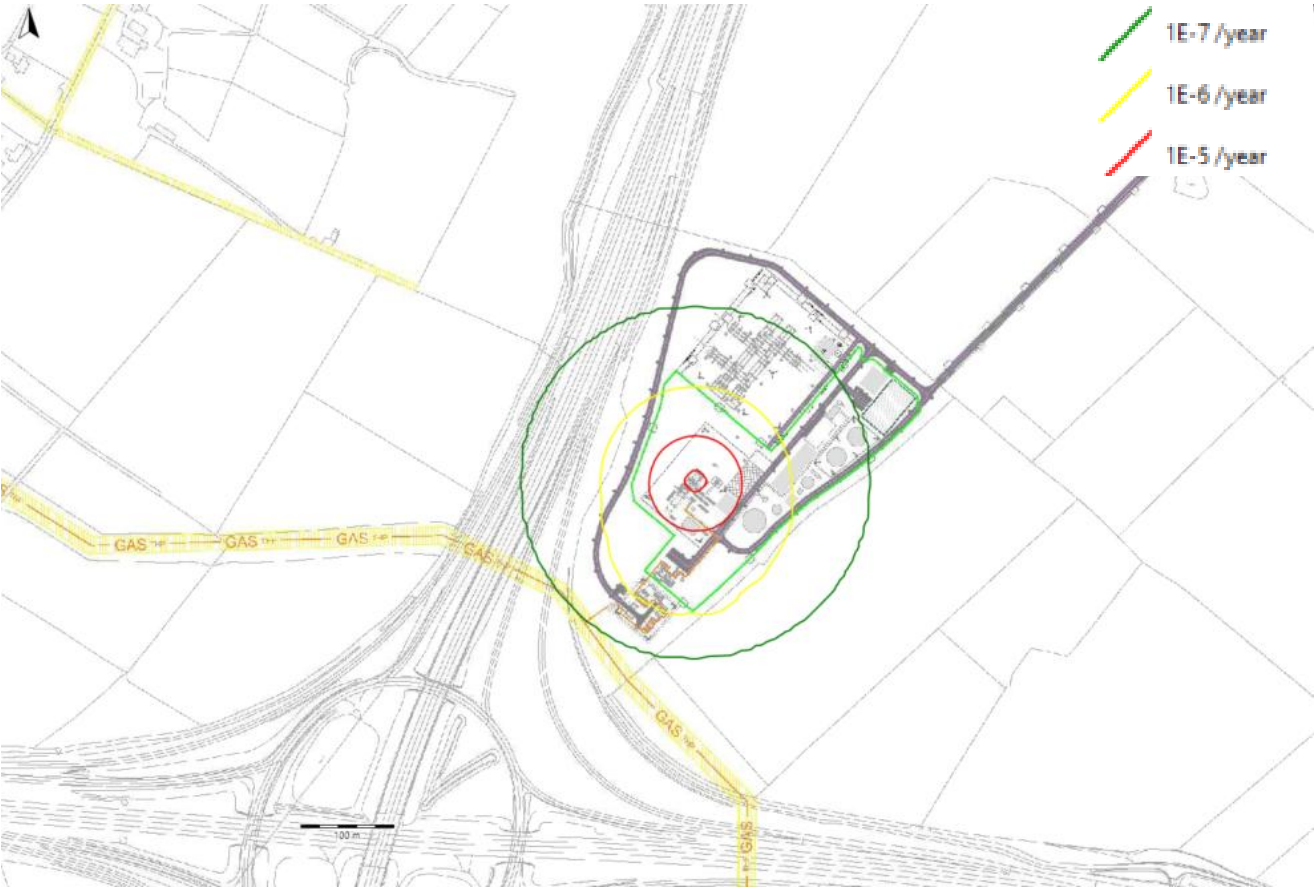
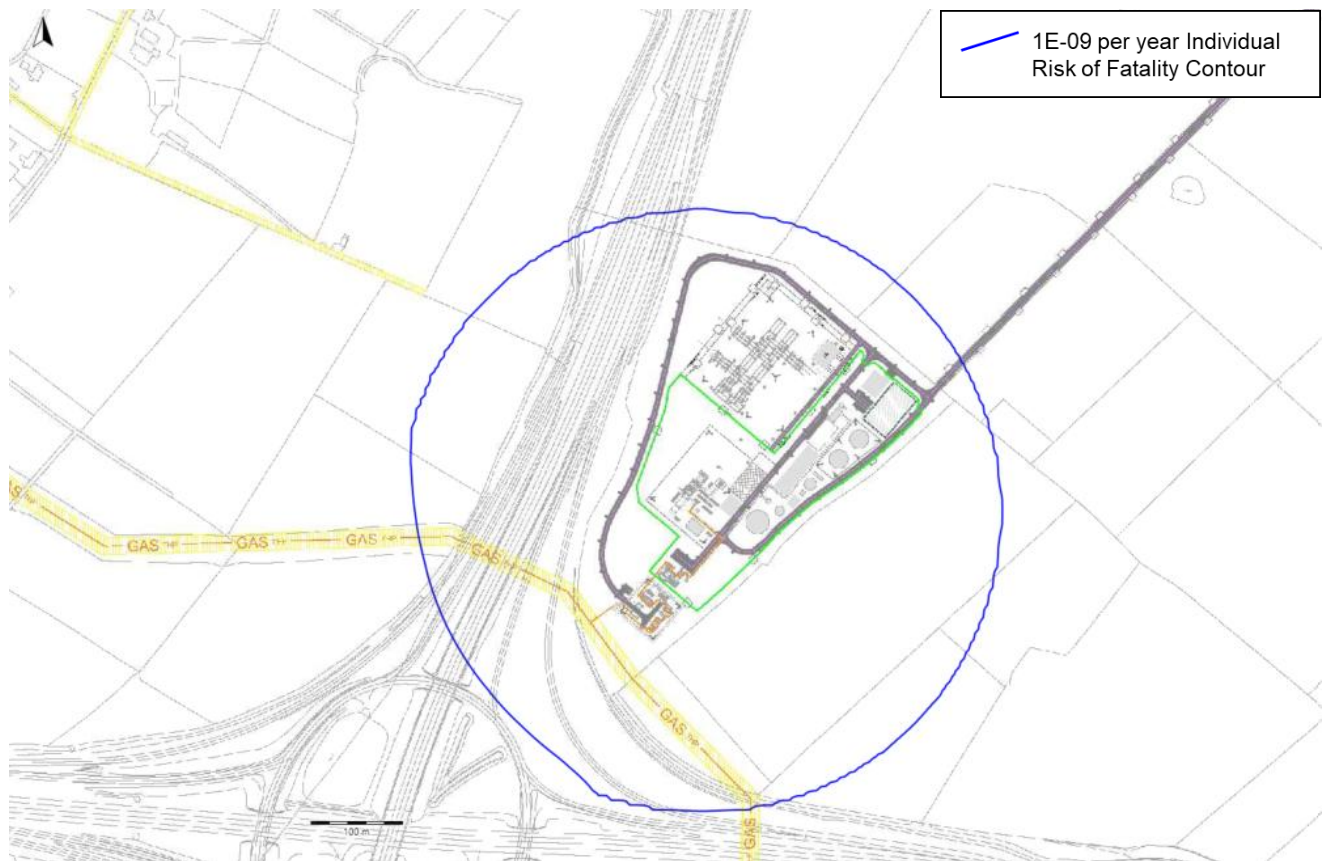


Figure 27 Proposed Consultation Distance (1×10^{-9} per year Individual Risk of Fatality Contour)



It is concluded that the individual location-based risk contours corresponding to tolerable levels for new COMAH establishments do not extend to an off-site work location or to an indoor area where the public are present. Therefore, it is concluded that the criteria in Table 1 of the *Guidance on Technical Land Use Planning advice (HSA, 2023)* are met, and level of off-site risk at the proposed development is acceptable.

8. SOCIETAL RISK ASSESSMENT

The purpose of this societal risk study is to generate advice on the types/nature and scale of development that is likely to be acceptable to the HSA.

A portion of the M18 to the east of the proposed development (i.e. the section 37E planning application) is within the consequence zone of a number of major accident scenarios at the proposed Peaker Plant.

The calculation of societal risk (Expectation Value) was based on the following inputs and assumptions:

- ▶ Annual daily traffic (all vehicles) 14778 from <https://trafficdata.tii.ie/>
- ▶ Traffic speed data supplied by the AtkinsRéalis project engineer indicates an average speed of 109.6 km/h at the M18
- ▶ No. of persons per vehicle assumed to be 2
- ▶ Overpressure vulnerability of vehicle occupants is assumed to be equivalent to CIA Category 3 (see Section 4.3)
- ▶ Thermal radiation vulnerability of vehicle occupants is conservatively assumed to be equivalent to that outdoors and based on the Eisenberg Probit equation (see Section 4.2)
- ▶ The vulnerability of vehicle occupants within a flash fire envelope is taken as 1.

Table 43 details the Societal Risk calculation for the proposed scheme. The Expectation Value (EV) at the proposed scheme is calculated to be **1.3**.

The total Expectation Value (EV) at the proposed scheme is **1.3**. This is <100; therefore, no further risk reduction is required.

Table 43 Societal Risk Calculation

Installation	LOC scenario and consequence	Consequence frequency		Consequence frequency, chances per million per year	Length of motorway in conseq. zone	Average daily traffic	Average speed	Time at risk in conseq. zone	Average No. of vehicles in conseq. zone	Persons per vehicle (assumed)	Number of Persons at risk	Distance to conseq.	Conseq.	Units	Vulnerability correlation	Vulnerability	Fatalities	Expectation Value
				F	metres		km/h	s				metres					N	EV=FN
Turbine	Release into turbine enclosure and VCE	2.00E-05	/yr	20	220	14778	109.6	7.23	1.24	2	2.47	155	61	mbar	CIA Cat. 3	0.016	0.040	0.791
Above ground 35 barg natural gas pipeline	Rupture (horizontal release direction) and VCE	3.01E-06	/yr	3.01	30	14778	109.6	0.99	0.17	2	0.34	118	50	mbar	CIA Cat. 3	0.01	0.003	0.010
LPG Road Tanker	Rupture and FB	7.99E-12	/yr	0.00000799	310	14778	109.6	10.18	1.74	2	3.48	157	1590	TDUs	Eisenberg Probit	0.15	0.522	4.175E-06
LPG Road Tanker	Rupture and VCE	1.37E-12	/yr	0.00000137	600	14778	109.6	19.71	3.37	2	6.74	125	141	mbar	CIA Cat. 3	0.098	0.661	9.052E-07
LPG Road Tanker	Loss of Entire Contents Through Largest Connection – Horizontal Release Direction and Jet Fire	4.00E-12	/yr	0.000004	415	14778	109.6	24.31	4.16	2	8.31	125	147993	TDUs	Eisenberg Probit	1	4.663	1.865E-05
LPG Road Tanker	Rupture of Unloading Arm – Horizontal Release Direction and Jet Fire	7.00E-08	/yr	0.07	415	14778	109.6	19.71	3.37	2	3.48	157	147993	TDUs	Eisenberg Probit	1	7.079	0.326
LPG Road Tanker	LPG Road Tanker rupture and FF	2.05E-12	/yr	0.00000205	630	14778	109.6	13.63	2.33	2	4.66	125	Within flash fire envelope			1	5.731	1.451E-05
LPG Road Tanker	Loss of Entire Contents Through Largest Connection – Horizontal Release Direction and FF	1.03E-12	/yr	0.00000103	740	14778	109.6	20.69	3.54	2	4.66	125	Within flash fire envelope			1	6.292	8.564E-06
LPG Road Tanker	Rupture of Unloading Arm – Horizontal Release Direction and FF	1.80E-08	/yr	0.018	740	14778	109.6	24.31	4.16	2	7.08	125	Within flash fire envelope			1	6.292	0.150
LPG Road Tanker	BLEVE (hot)	1.16E-10	/yr	0.000116	310	14778	109.6	24.31	4.16	2	8.31	125	1590	TDUs	Eisenberg Probit	0.25	4.663	6.061E-05
Total EV																		1.277

9. CONCLUSION

AWN Consulting, a Trinity Consultants Team, has been commissioned by AtkinsRealis to complete a COMAH land use planning assessment of a proposed 334 MW Open Cycle Gas Turbine Peaker Plant and associated infrastructure at Athenry, Co. Galway.

The proposed development (i.e. the section 37E planning application) will be classified as a "lower tier" COMAH establishment and as such will be subject to the provisions of the Chemicals Act (Control of Major Accident Hazards Involving Dangerous Substances) Regulations, S.I. No. 209 of 2015.

The Land Use Planning assessment was completed in accordance with guidance published by the HSA (HSA, 2023). The following major accident scenarios were assessed:

Table 44 Summary of Major Accident Scenarios

Installation	LOC scenario	Consequence/Event
Indoor equipment (release of natural gas in turbine enclosure)	Instantaneous failure	VCE
	Continuous leak over 10 minutes	VCE
	10 mm pipe leak over 30 minutes	VCE
Natural Gas Pipeline	Rupture of Pipeline	Fireball/Jet fire
		VCE
		Flash fire
	Pipeline Leak of 0.1D	Fireball/Jet fire
		VCE
		Flash fire
LPG Tank	Instantaneous release	Fireball
		VCE
		Flash fire
	Continuous leak over 10 minutes	Jet fire
		VCE
		Flash fire
	10 mm pipe leak over 30 minutes	Jet fire
		VCE
		Flash fire
LPG Road Tanker	Instantaneous failure	Fireball
		VCE
		Flash fire
	Loss of entire contents through largest connection	Jet fire
		VCE
		Flash fire
	Rupture of unloading hose	Jet fire
		VCE
		Flash fire
	Leak of unloading hose 10% of diameter	Jet fire
		VCE
		Flash fire
	BLEVE (hot)	BLEVE (hot)
Diesel	Instantaneous failure	Pool fire

Figure 28 illustrates individual risk of fatality contours corresponding to tolerability levels for new COMAH establishments based on a hypothetical residential population indoors in buildings of CIA Category 3 overpressure vulnerability (typical residential dwelling) for 90% of the time and outdoors for 10% of the time.

Figure 29 illustrates individual risk of fatality contours corresponding to the boundaries of COMAH land use planning zones.

Figure 30 illustrates the proposed Consultation Distance for the proposed Peaker Plant development.

Figure 28 Individual Location-based Risk Contours for New Establishments



Figure 29 Individual Risk Based Land Use Planning Contours

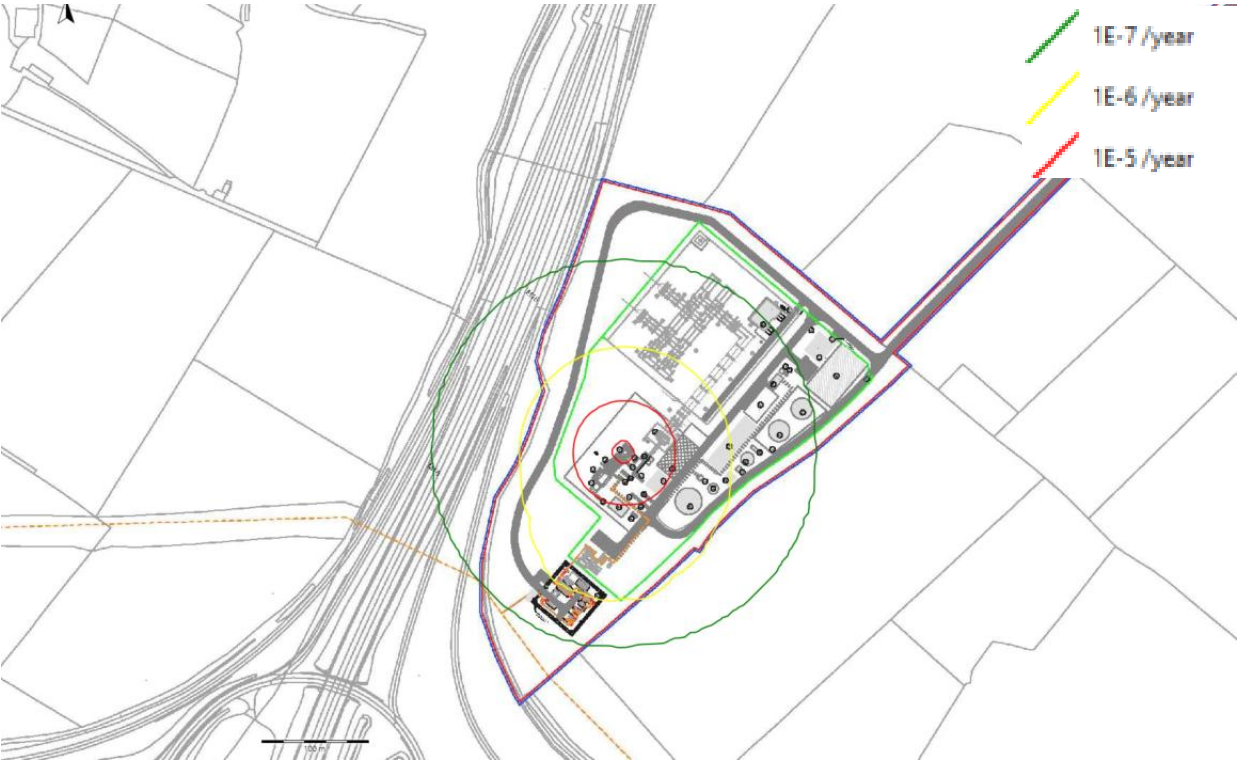


Figure 30 Proposed Consultation Distance (1×10^{-9} per year Individual Risk of Fatality Contour)



It is concluded that the individual location-based risk contours corresponding to tolerable levels for new COMAH establishments do not extend to an off-site work location or to an indoor area where the public are present. Therefore, it is concluded that the criteria in Table 1 of the *Guidance on Technical Land Use Planning advice (HSA, 2023)* are met, and level of off-site risk at the proposed development (i.e. the section 37E planning application) is acceptable.

A portion of the M18 to the east of the proposed development (i.e. the section 37E planning application) is within the consequence zone of a number of major accident scenarios at the proposed Peaker Plant. A Societal Risk calculation for the proposed development was completed and the Expectation Value (EV) was calculated to be **1.3**. This is <100; therefore, no further risk reduction is required.

10. REFERENCES

Centre for Chemical Process Safety (CCPS) (2000), Guidelines for Chemical Process Quantitative Risk Analysis, 2nd Edition, AIChE

Chemical Industries Association (CIA) (2020), Guidance for the location and design of occupied buildings on chemical manufacturing and similar major accident sites, 4th Edition

Committee for Prevention of Disasters (2005), Guidelines for Quantitative Risk Assessment, CPR 18E, Second Edition, The Hague ("Purple Book")

CONCAWE (1996), Gas Oils (diesel fuels/heating oils) Product Dossier 95/107, Brussels

DNV, PHAST Supporting Documentation, DNV Phast Version 9.1 Technical Documentation, 2024

Health and Safety Authority (HSA) (2017) Guidance to Inspectors on the Assessment of Safety Reports under the COMAH Regulations 2015

Health and Safety Authority (HSA) (2023) Guidance on Technical Land-Use Planning Advice, for planning authorities and COMAH establishment operators

APPENDIX A. NATURAL GAS VCE FLAMMABLE MASS CALCULATION

Complete combustion equation for Methane: $\text{CH}_4 + 2\text{O}_2 = \text{CO}_2 + \text{H}_2\text{O}$

Stoichiometric Mass Fraction Calculation:

Compound	Mol	Mol fraction	Molecular weight (kg/kmol)	Mass (kg)	Mass fraction
CH_4	1	0.096	16.040	1.54	0.056
O_2	2	0.192	31.999	6.13	0.222
N_2	7.44	0.713	28.014	19.96	0.723
Total	10.44	1		27.63	1.000

OCGT Enclosure

Volume of OCGT Turbine Enclosure excluding turbine: 1400 m³

Density of Natural Gas Mixture at 10°C (conservative temperature assumption) (calculated from DNV PHAST 9.1): 1.193 kg/m³

Mass of Flammable Mixture in OCGT: 1670.20 kg (1400 m³ x 1.193 kg/m³)

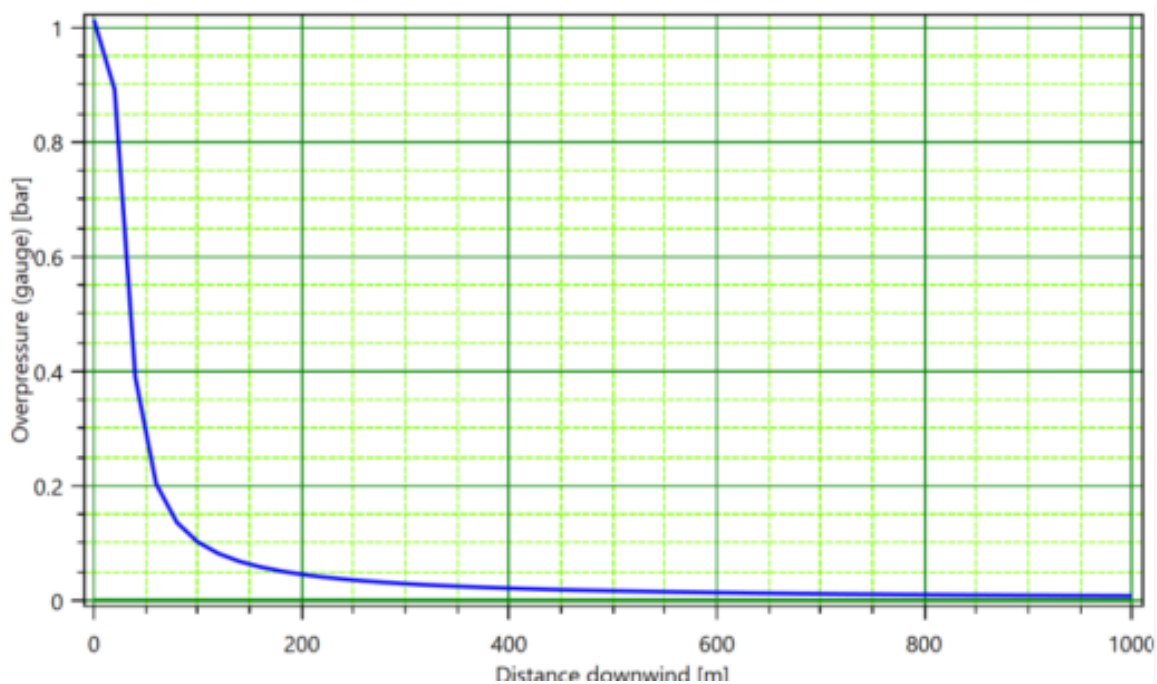
Compound	Mass (kg)
CH_4	92.87
O_2	370.55
N_2	1206.77

Flammable Mass of Methane in OCGT Turbine Enclosure: **92.87 kg**

APPENDIX B. CONSEQUENCE MODELLING CURVES

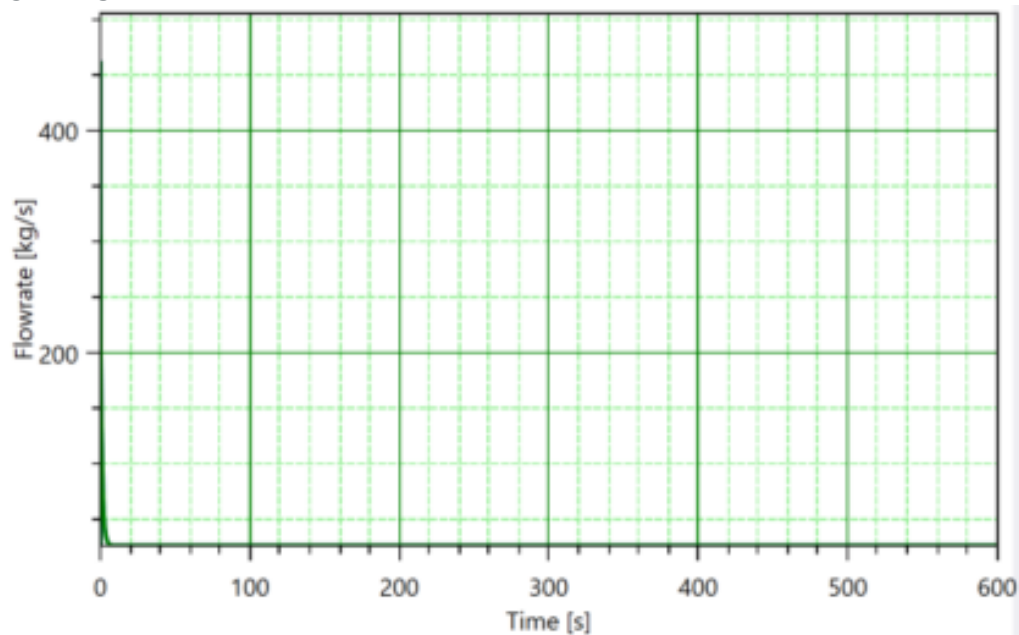
Installation	Gas Turbine
Scenario	Vapour Cloud Explosion within Gas Turbine Enclosure
Software/model	DNV PHAST Version 9.1 TNO Multi Energy Model
Source Term	92.87 kg flammable mass (natural gas) Explosion strength of 7 100% confinement

Appendix Figure B-1. Gas Turbine Enclosure VCE: Overpressure Decay Curve

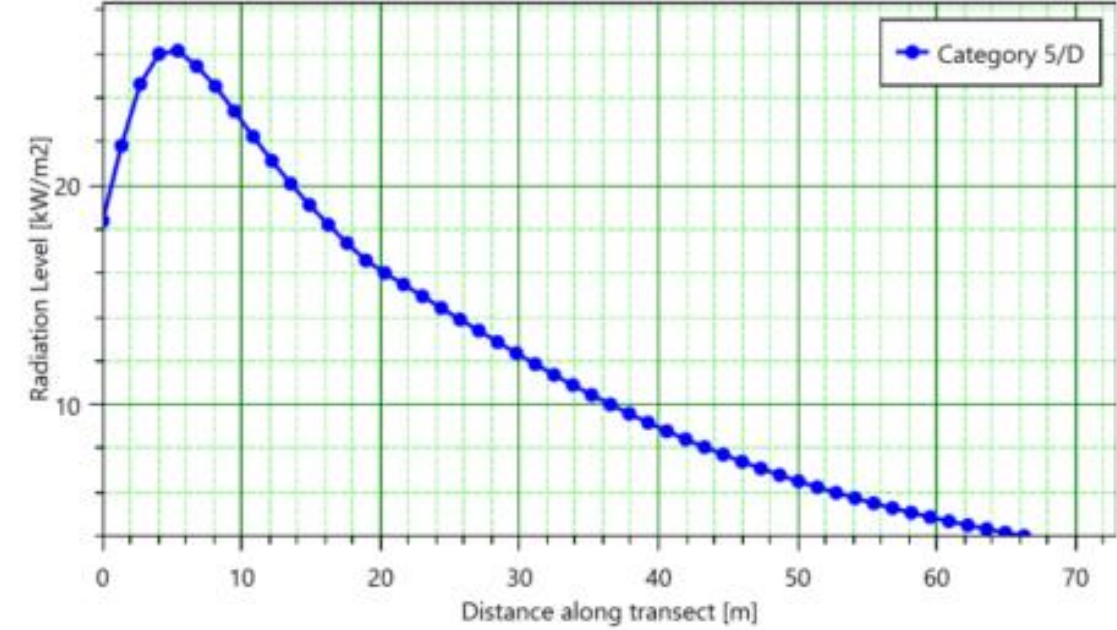


Installation	Natural Gas Pipeline 35 barg above ground pipeline from AGI regulator to turbine
Scenario	Above Ground Outdoor Pipeline rupture, Jet Fire/Fireball, Vapour Cloud Explosion or Flash Fire
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Fireball Static (HSE) Model Jet Fire Cone Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	26.2 kg/s (D5/F2) natural at 35 barg and ambient temperature, 250 mm diameter (D) pipeline, hole 250 mm size 29 metre fireball radius (D5/F2), 4.6 second duration
Jet Fire Model Source Term	39.5 / 39.7 kg/s (D5/F2) natural gas 644 / 638 m/s velocity D5 / F2
Vapour cloud explosion source term	Horizontal release: 21/23 kg flammable mass Vertical release: No vapour cloud explosion hazard is predicted for a vertical release

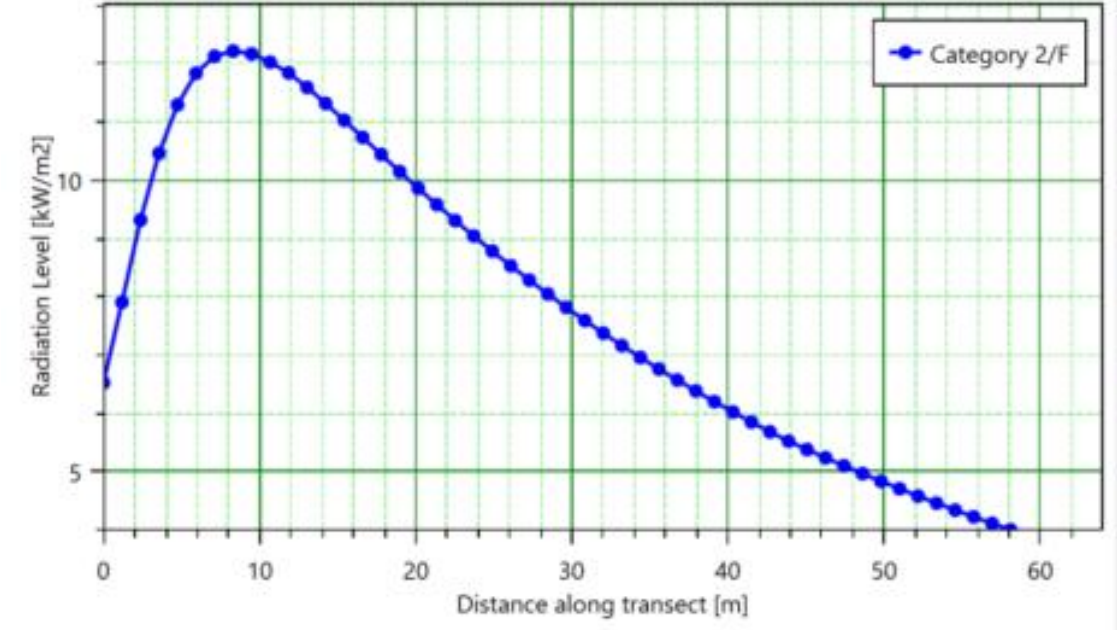
Appendix Figure B-2. Above Ground 35 barg Natural Gas Pipeline Rupture: Mass Flow Rate vs. Time



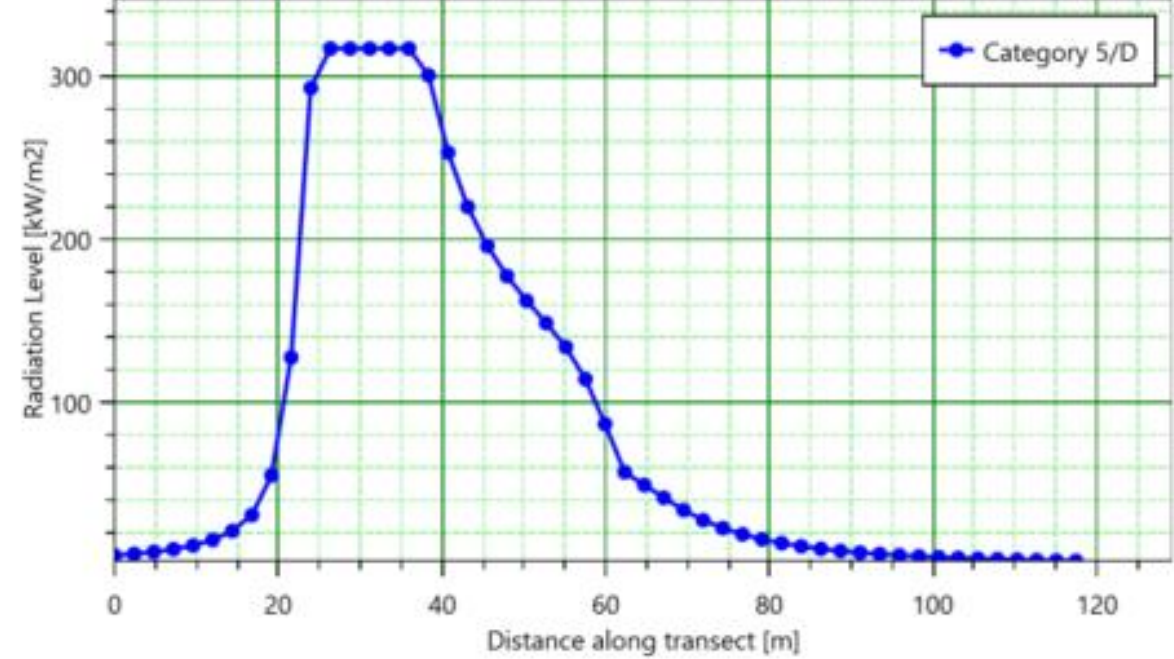
Appendix Figure B-3. Above Ground 35 barg Natural Gas Pipeline Rupture and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



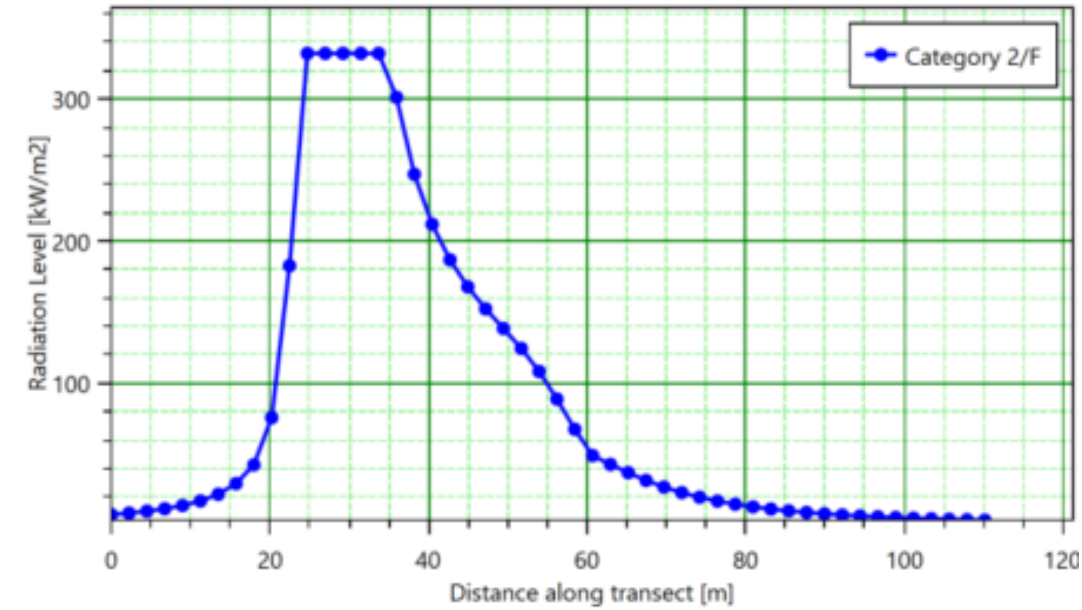
Appendix Figure B-4. Above Ground 35 barg Natural Gas Pipeline Rupture and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



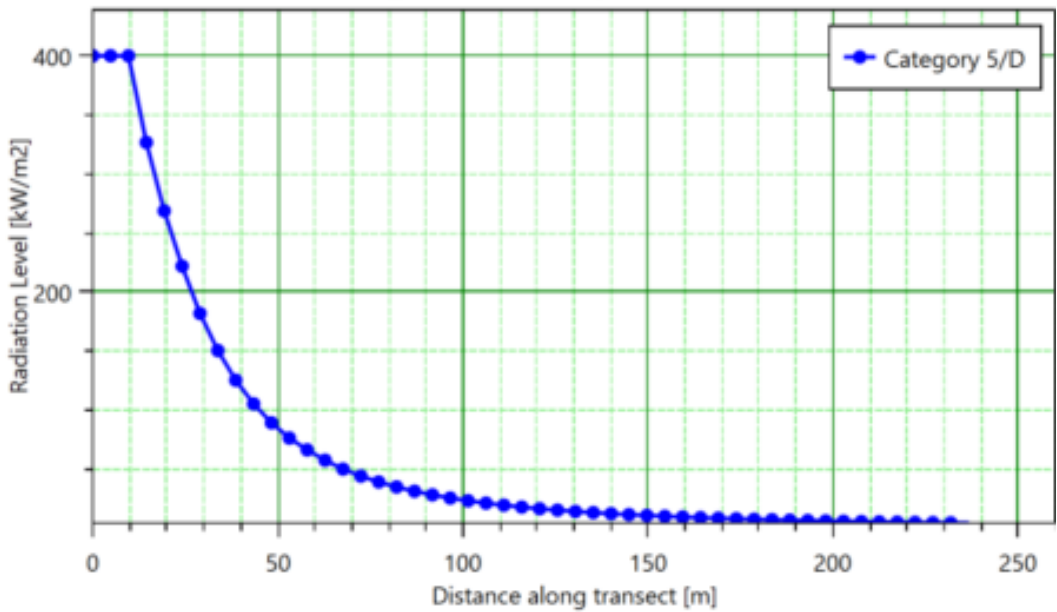
Appendix Figure B-5. Above Ground 35 barg Natural Gas Pipeline Rupture and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



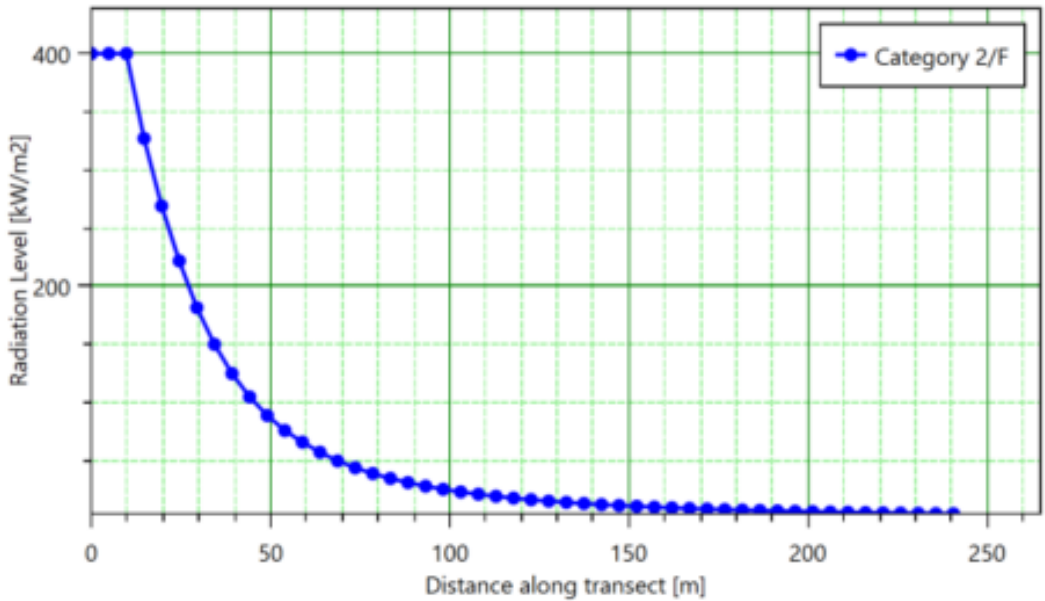
Appendix Figure B-6. Above Ground 35 barg Natural Gas Pipeline Rupture and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



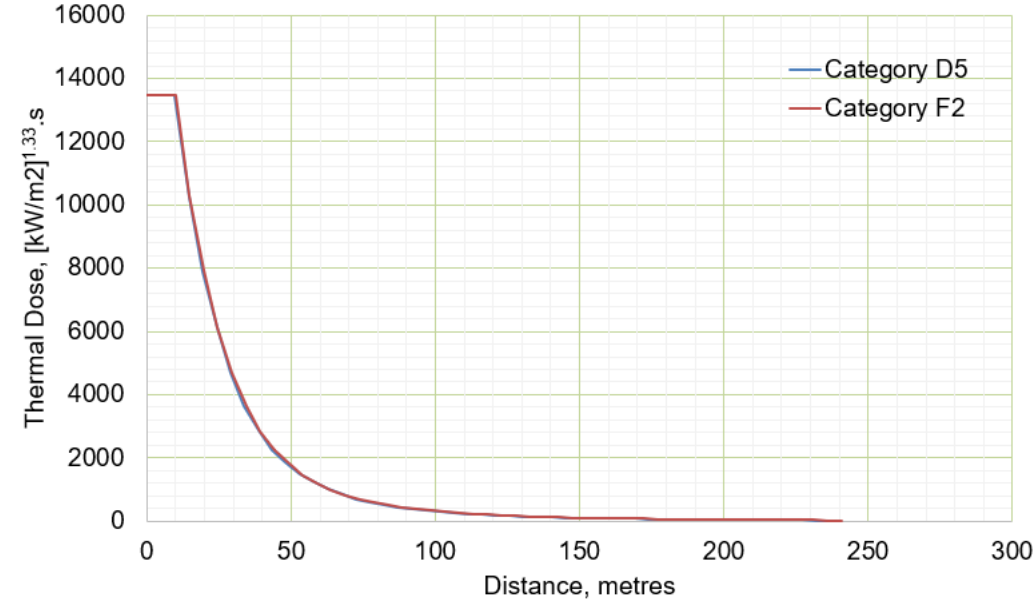
Appendix Figure B-7. Above Ground 35 barg Natural Gas Pipeline Rupture and Fireball: Thermal Radiation vs. Distance Downwind, Category D5



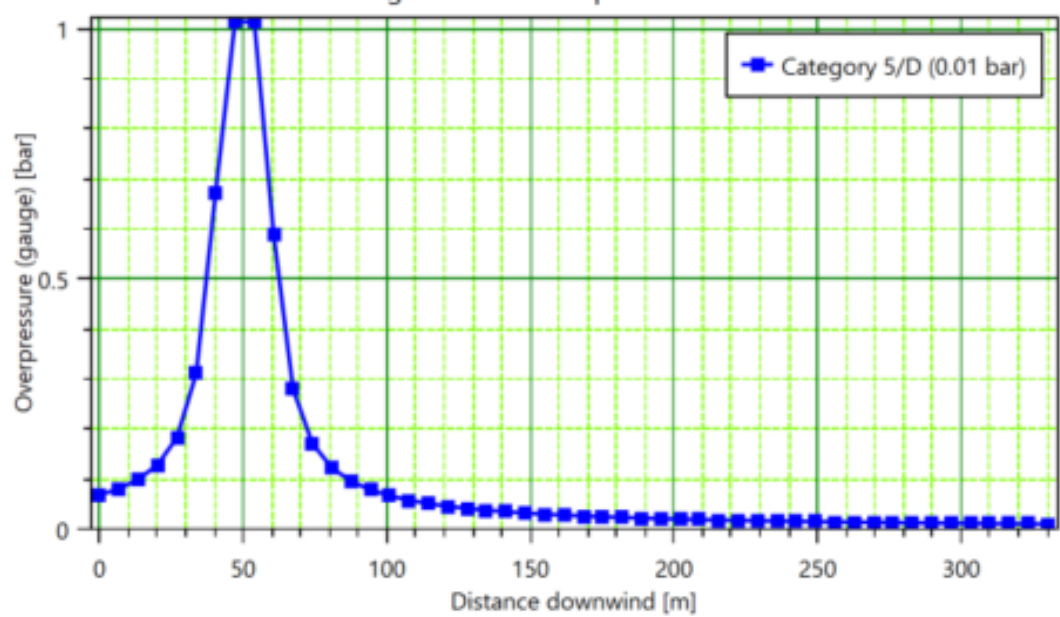
Appendix Figure B-8. Above Ground 35 barg Natural Gas Pipeline Rupture and Fireball: Thermal Radiation vs. Distance Downwind, Category F2



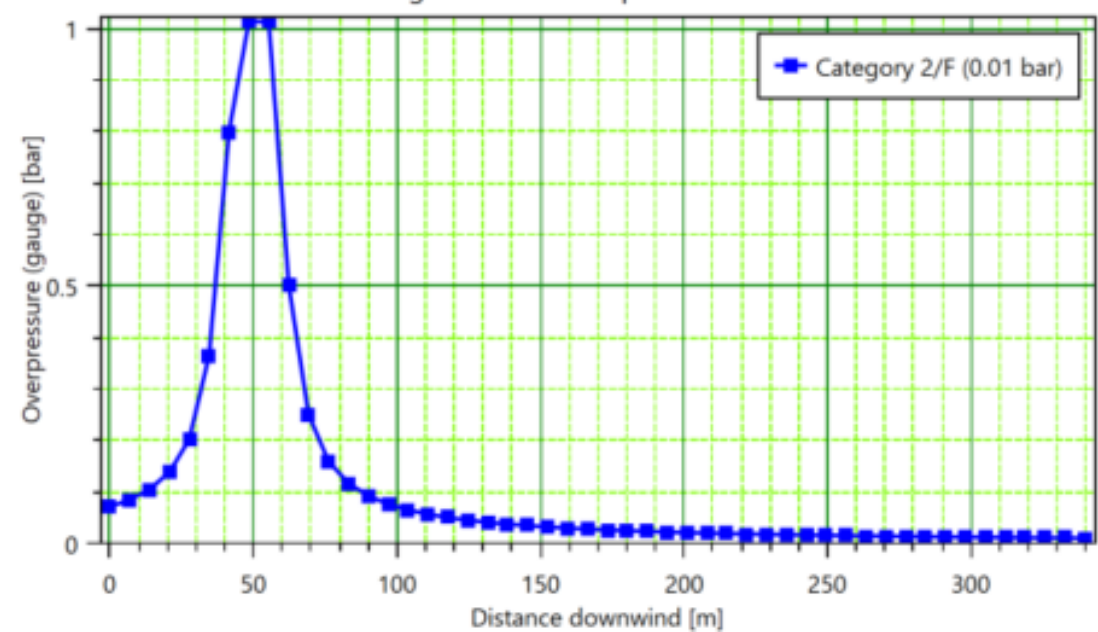
Appendix Figure B-9. Above Ground 35 barg Natural Gas Pipeline Rupture and Fireball: Thermal Dose vs. Distance Downwind



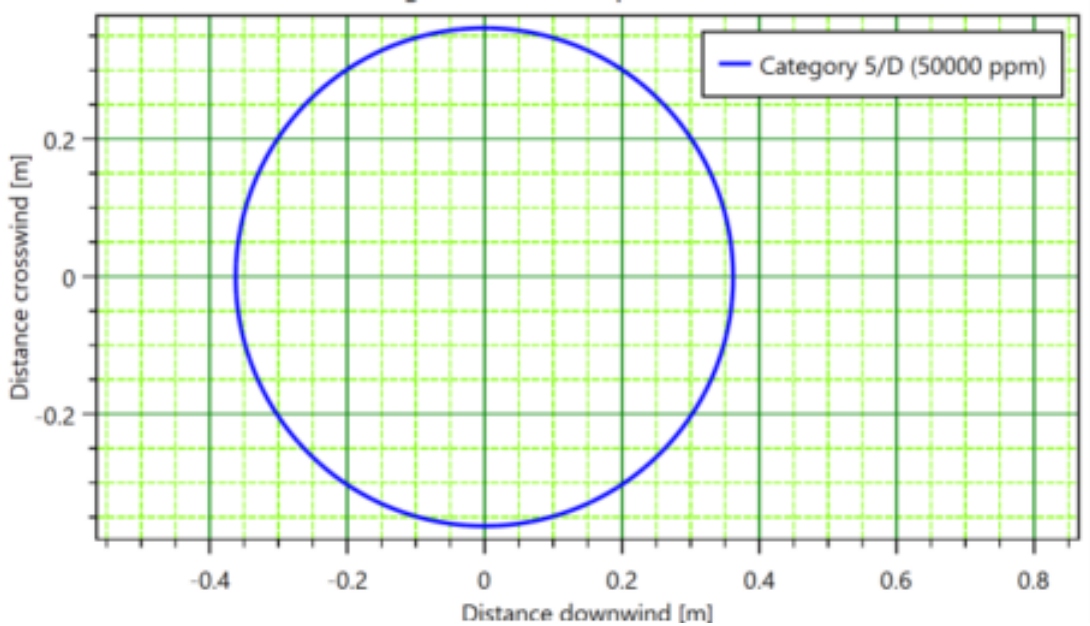
Appendix Figure B-10. Above Ground 35 barg Natural Gas Pipeline Rupture, Horizontal Release and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



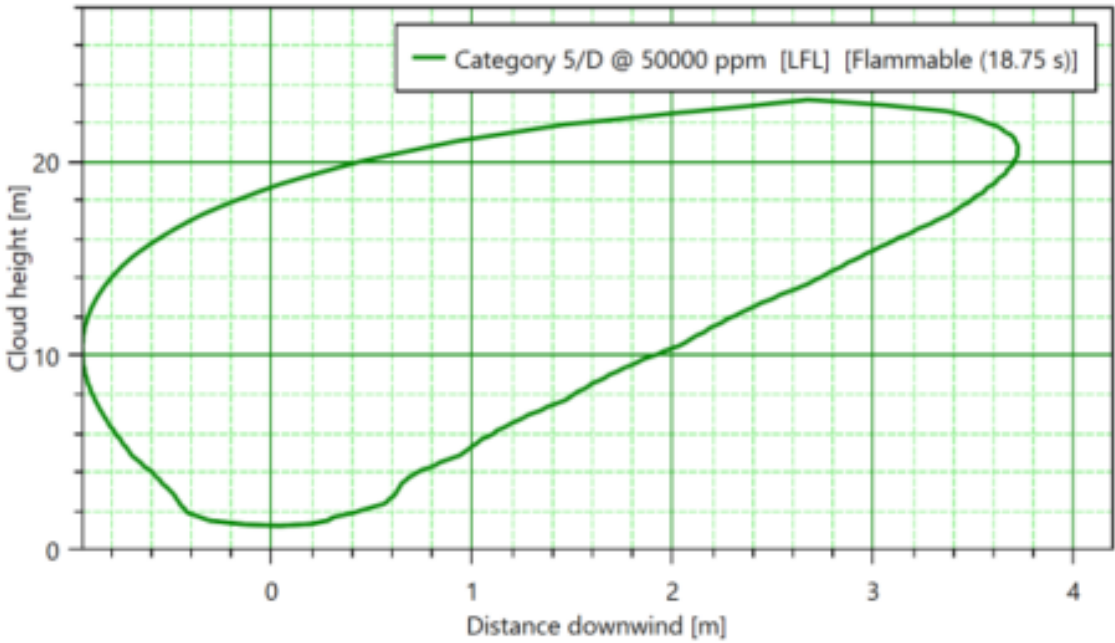
Appendix Figure B-11. Above Ground 35 barg Natural Gas Pipeline Rupture, Horizontal Release and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



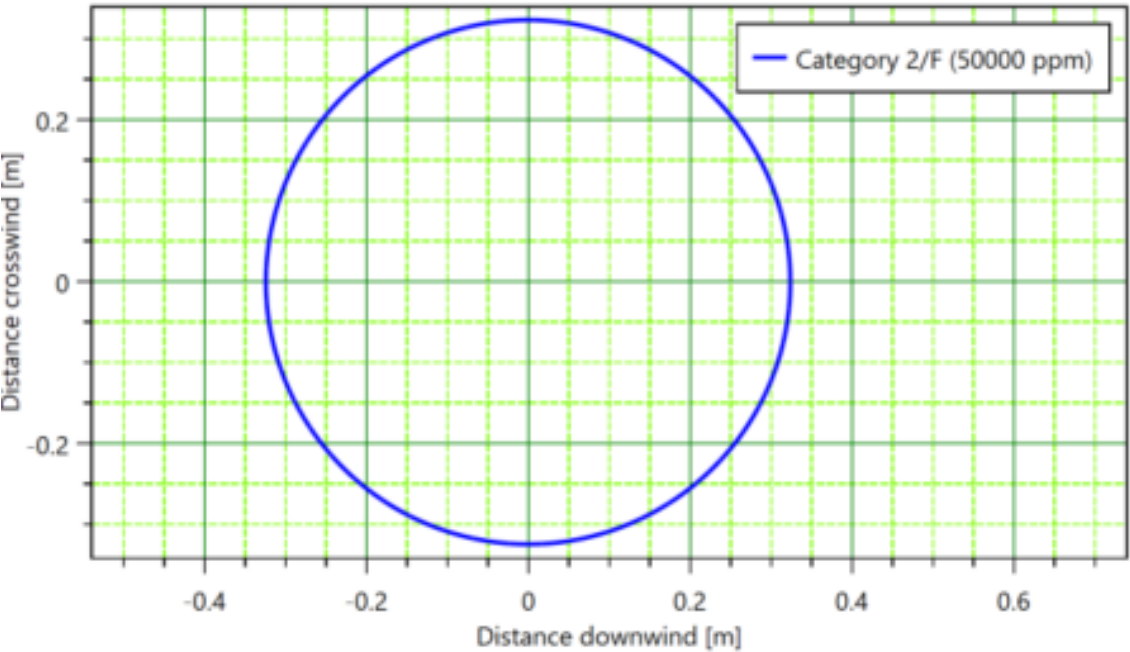
Appendix Figure B-12. Above Ground 35 barg Natural Gas Pipeline Rupture, Vertical Release and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category D5



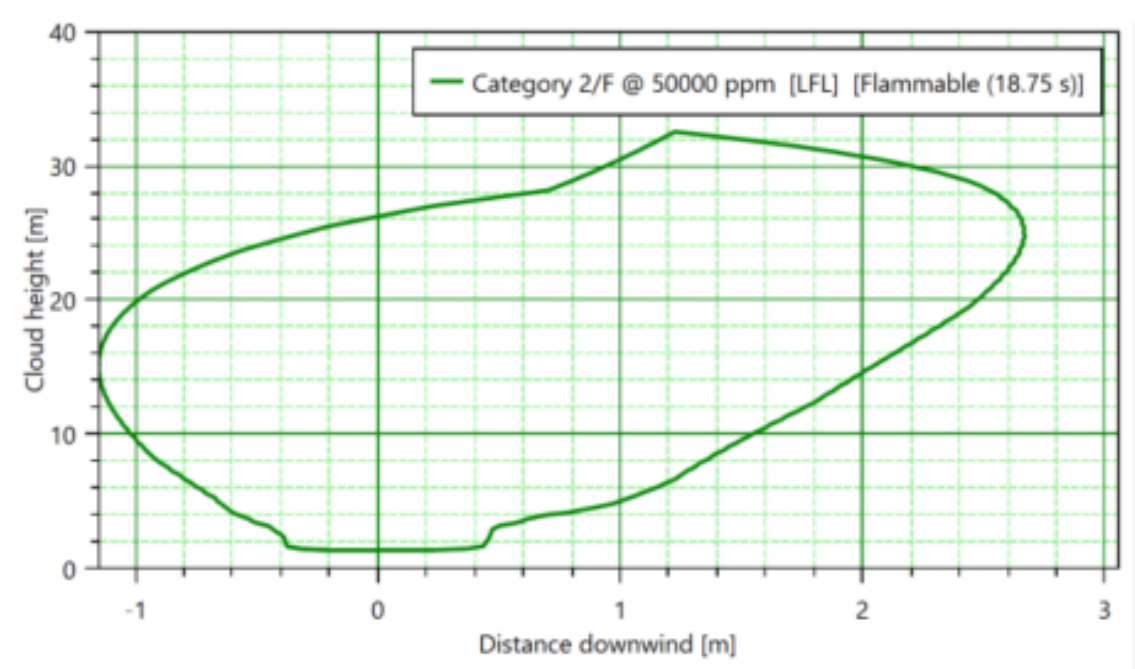
Appendix Figure B-13. Above Ground 35 barg Natural Gas Pipeline Rupture Vertical Release and Flash Fire: Dispersion Side View, Category D5



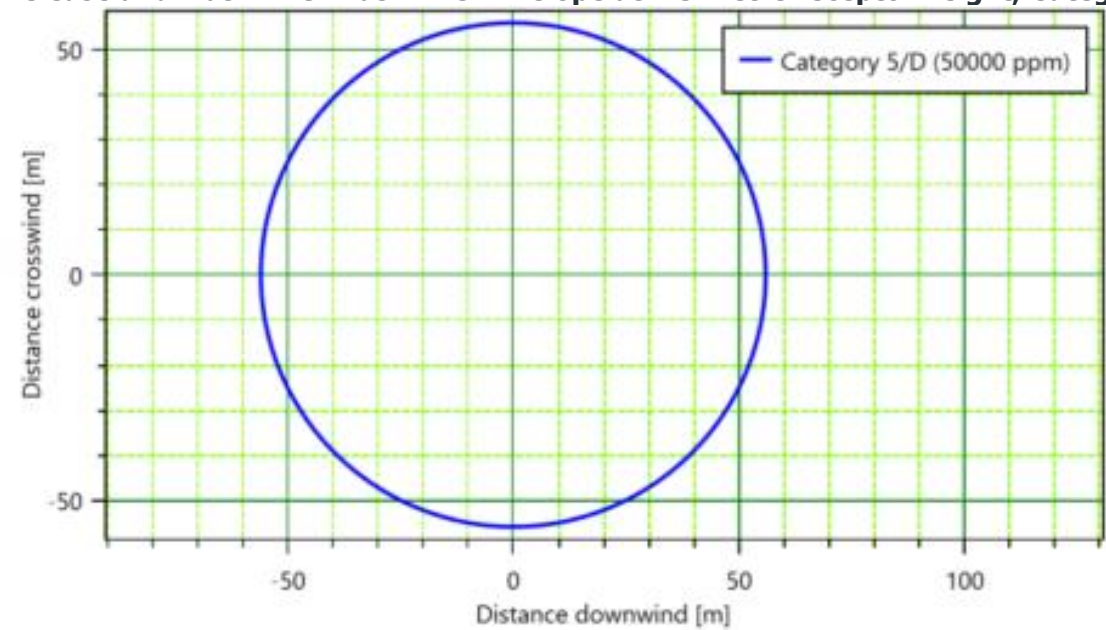
Appendix Figure B-14. Above Ground 35 barg Natural Gas Pipeline Rupture, Vertical Release and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category F2



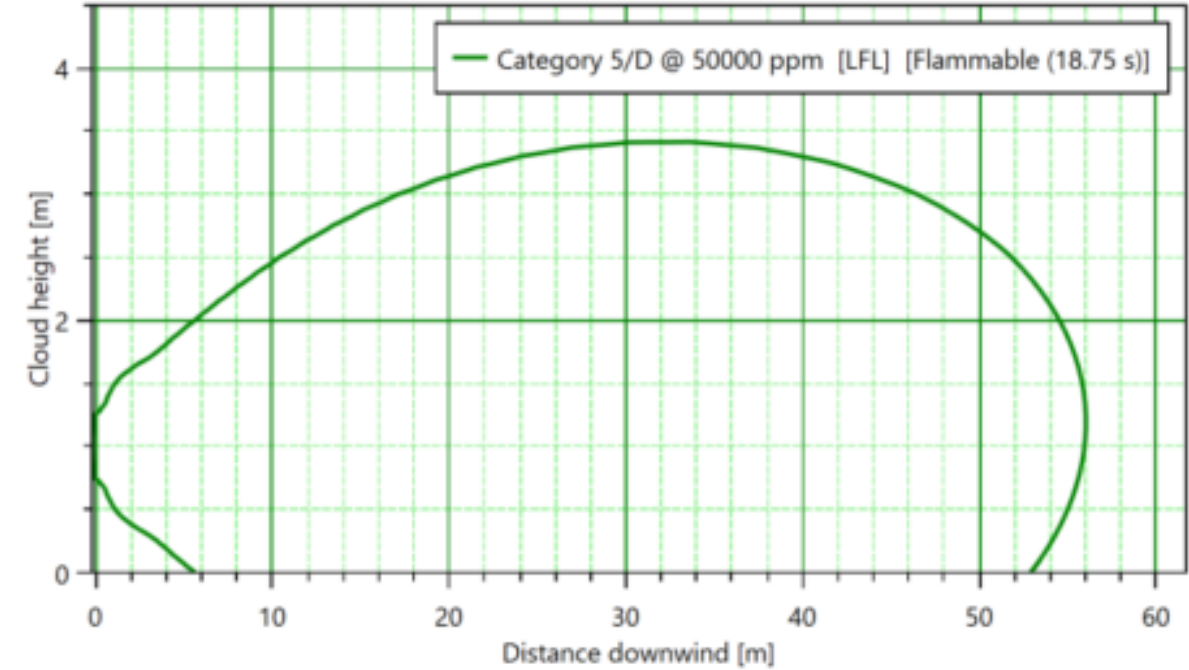
Appendix Figure B-15. Above Ground 35 barg Natural Gas Pipeline Rupture, Vertical Release and Flash Fire: Dispersion Side View, Category F2



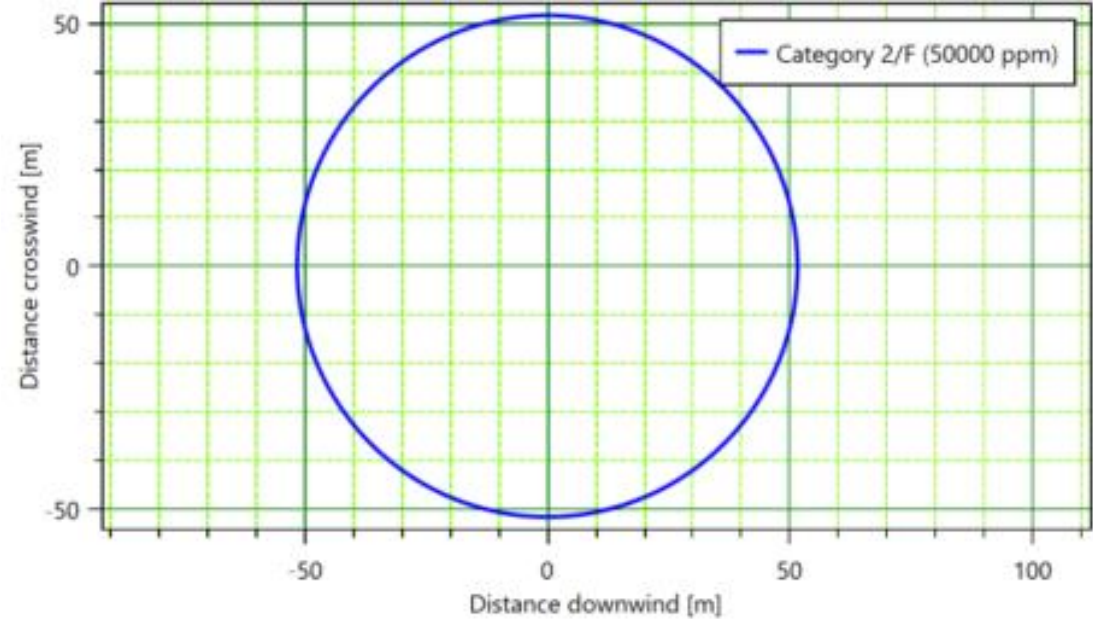
Appendix Figure B-16. Above Ground 35 barg Natural Gas Pipeline Rupture, Horizontal Release and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category D5



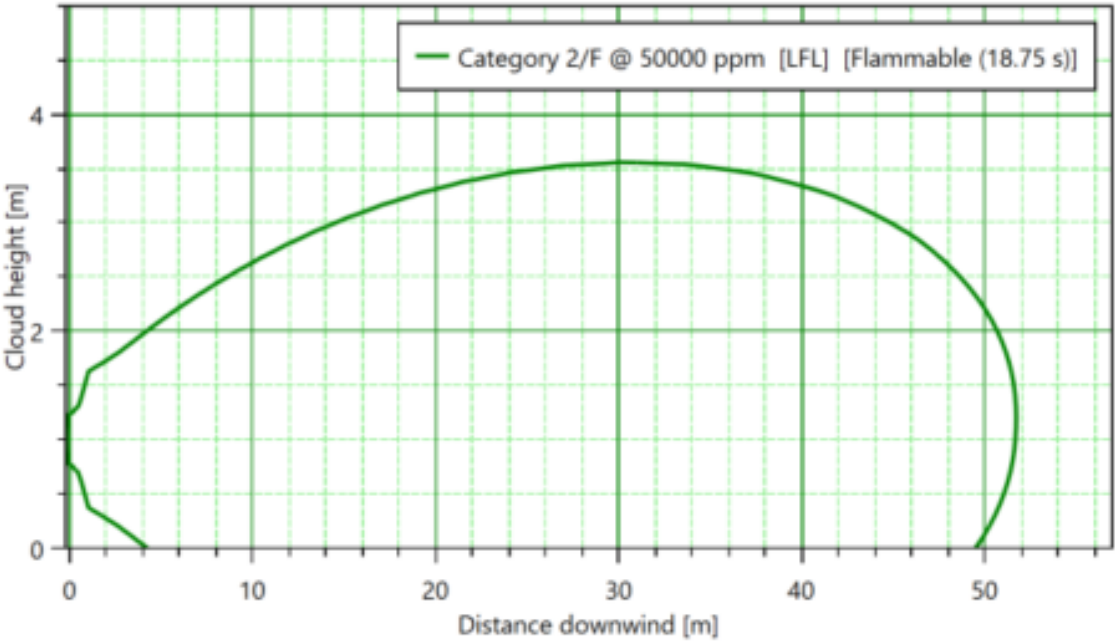
Appendix Figure B-17. Above Ground 35 barg Natural Gas Pipeline Rupture Horizontal Release and Flash Fire: Dispersion Side View, Category D5



Appendix Figure B-18. Above Ground 35 barg Natural Gas Pipeline Rupture, Horizontal Release and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category F2

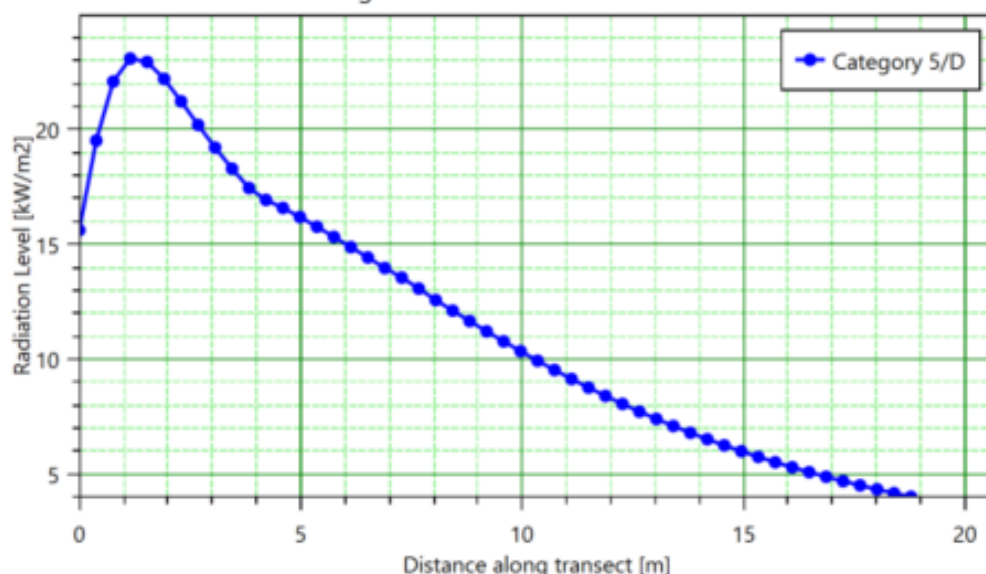


Appendix Figure B-19. Above Ground 35 barg Natural Gas Pipeline Rupture, Horizontal Release and Flash Fire: Dispersion Side View, Category F2

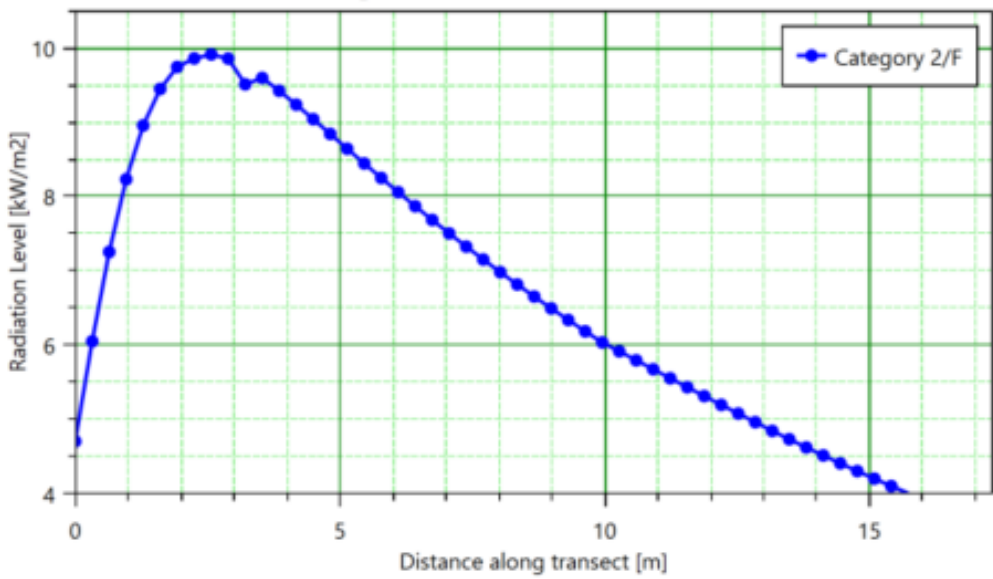


Installation	Natural Gas Pipeline 35 barg above ground pipeline from AGI regulator to turbines
Scenario	Above Ground Outdoor Pipeline leak (10% of diameter), Jet Fire/Fireball, Vapour Cloud Explosion or Flash Fire
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Fireball Static (HSE) Model Jet Fire Cone Model TNO Multi Energy Model Unified Dispersion Model
Discharge/Fireball/ Dispersion Model Source Term	26.2 kg/s (D5/F2) natural at 35 bar and ambient temperature, 250 mm diameter (D) pipeline, hole 250 mm size 12.7 metre fireball radius (D5/F2), 2.0 second duration
Jet Fire Model Source Term	2.8 kg/s (D5/F2) natural gas 682 / 674 m/s velocity D5 / F2
Vapour cloud explosion source term	Horizontal release: 0.25 kg flammable mass Category F2, no VCE hazard for Category D5 Vertical release: No vapour cloud explosion hazard is predicted for a vertical release

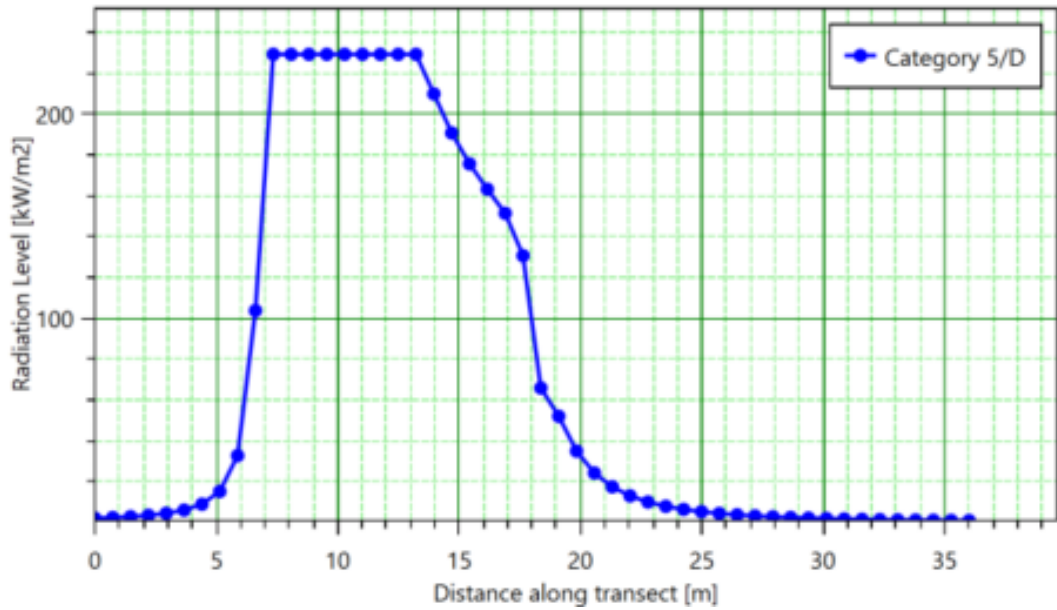
Appendix Figure B-20. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter) and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



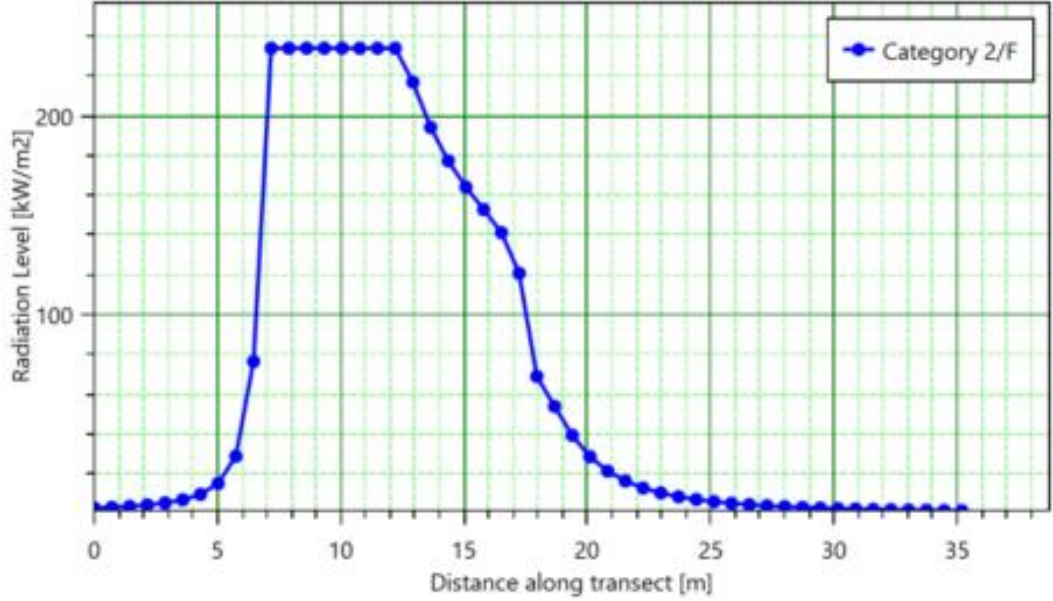
Appendix Figure B-21. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter) and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



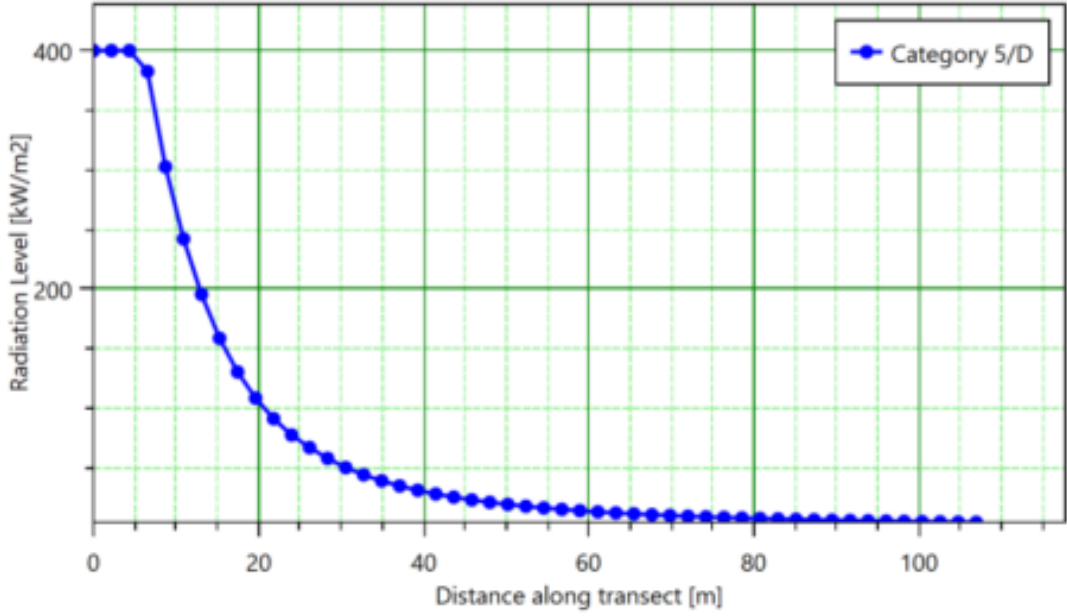
Appendix Figure B-22. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter) and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



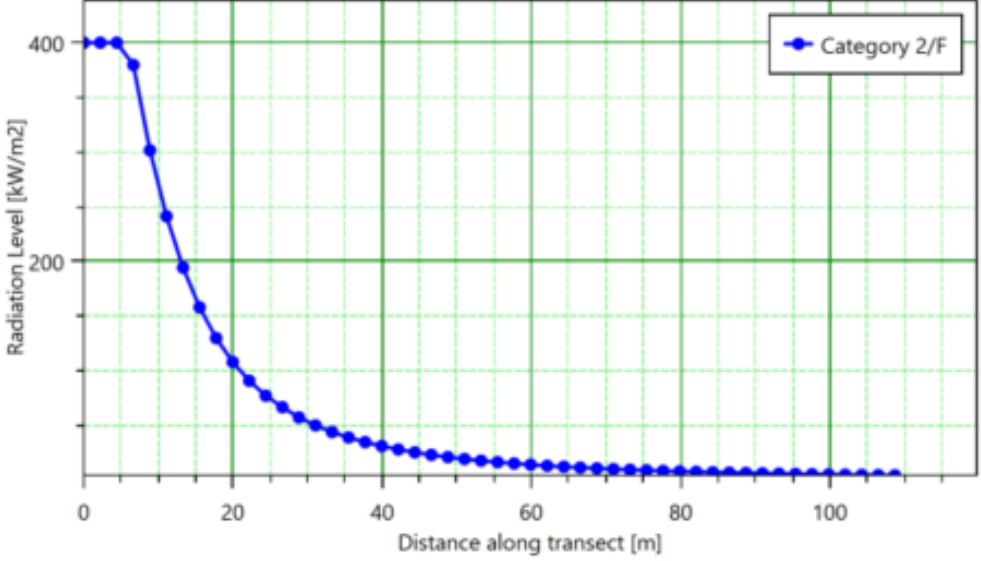
Appendix Figure B-23. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter) and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



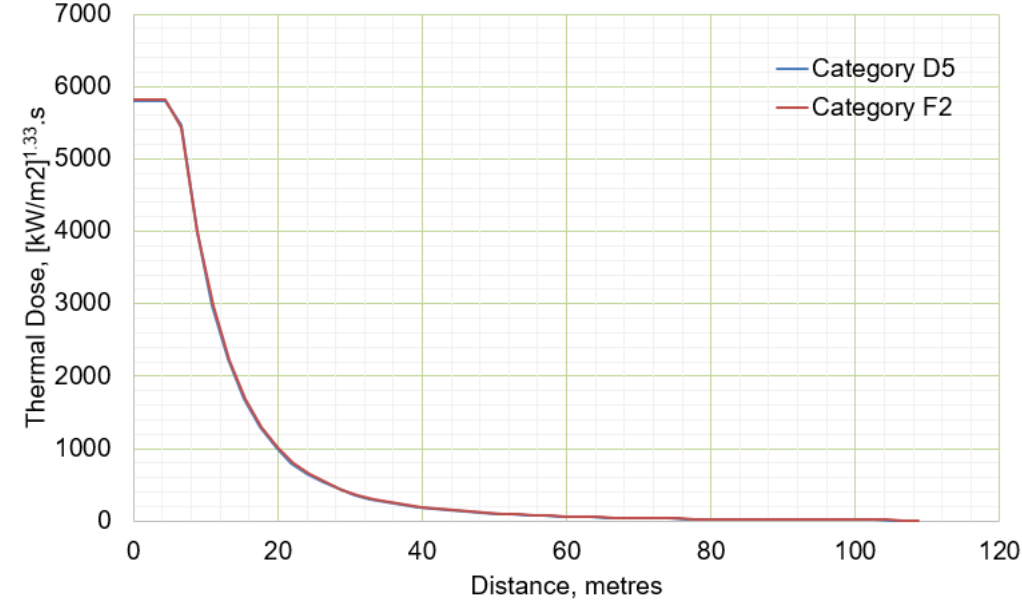
Appendix Figure B-24. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter) and Fireball: Thermal Radiation vs. Distance Downwind, Category D5



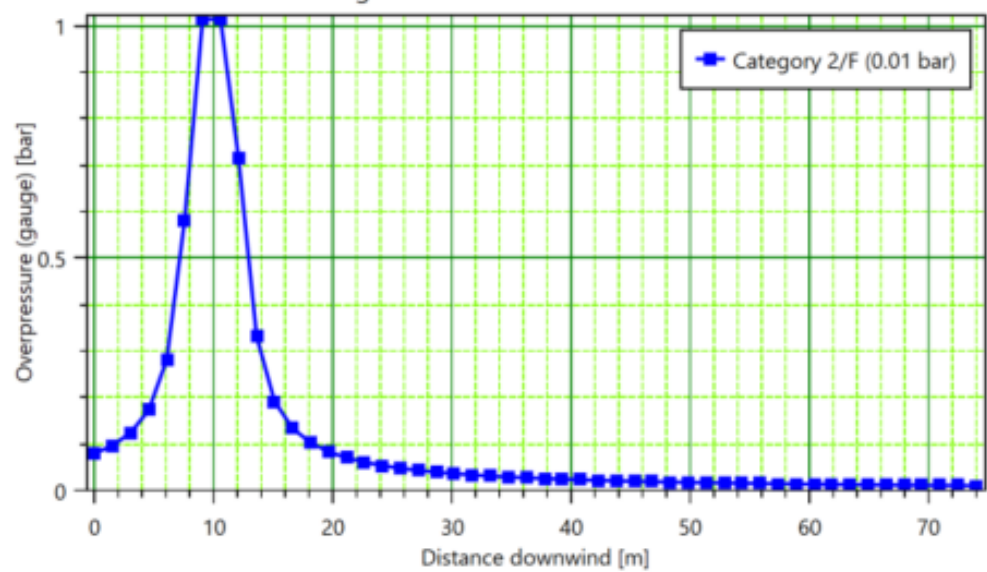
Appendix Figure B-25. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter) and Fireball: Thermal Radiation vs. Distance Downwind, Category F2



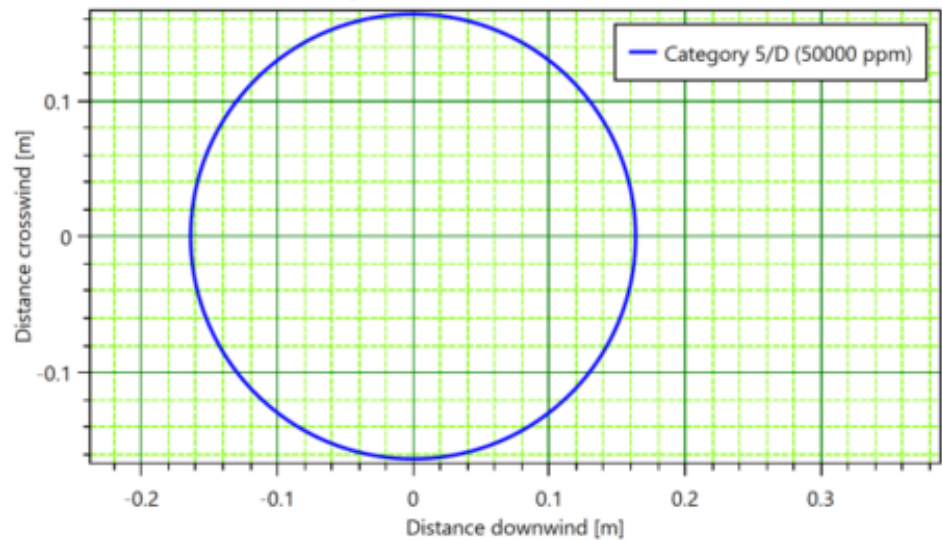
Appendix Figure B-26. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter) and Fireball: Thermal Dose vs. Distance Downwind



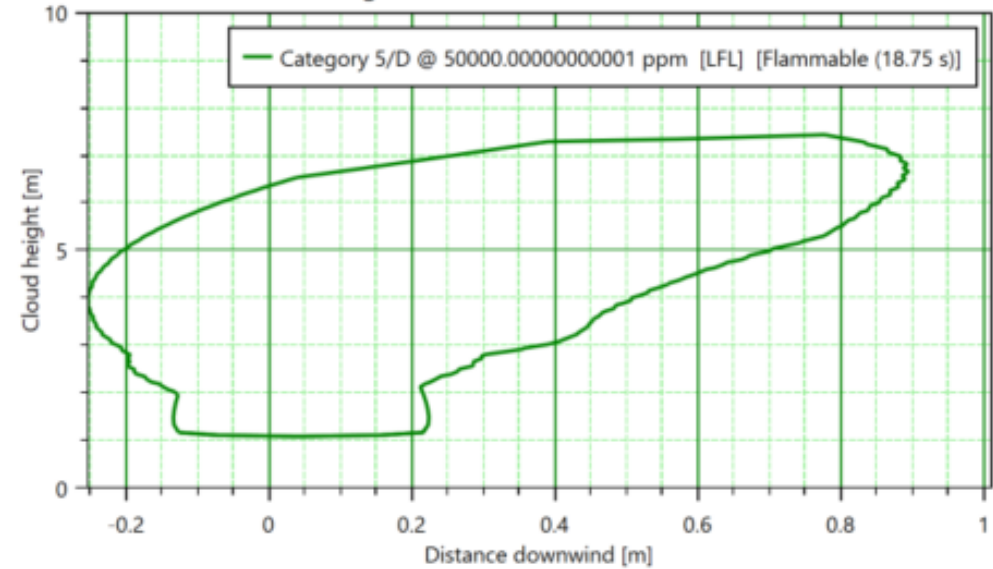
Appendix Figure B-27. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter), Horizontal Release and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



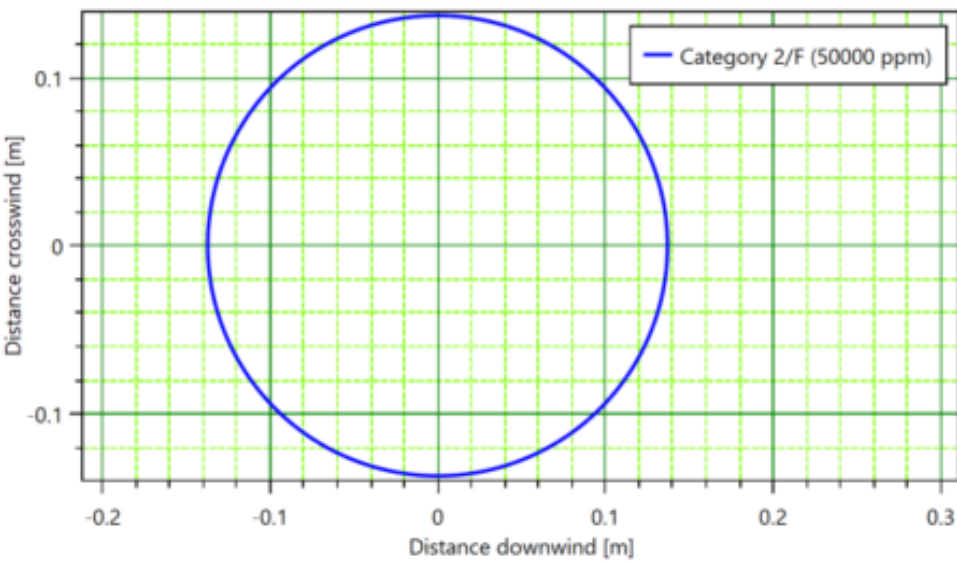
Appendix Figure B-28. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter), Vertical Release and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category D5



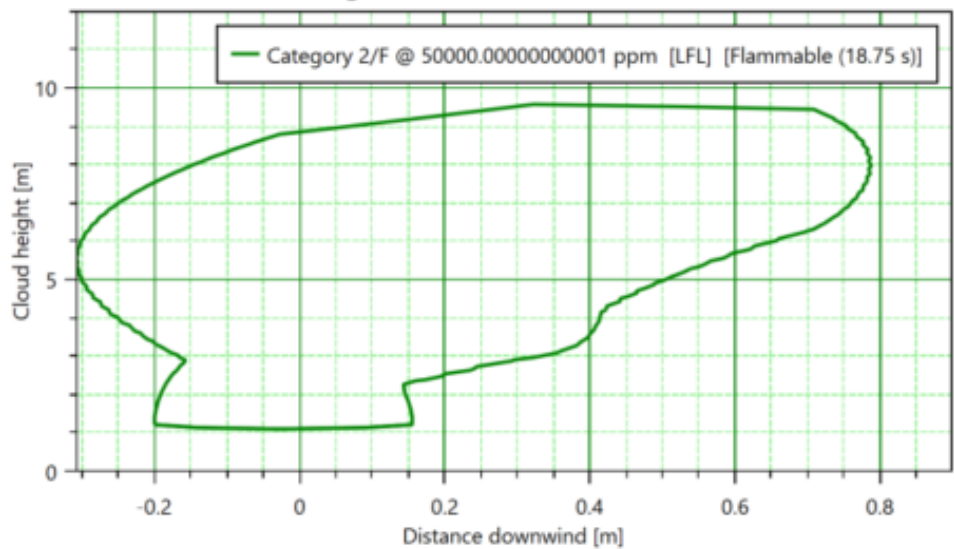
Appendix Figure B-29. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter), Vertical Release and Flash Fire: Dispersion Side View, Category D5



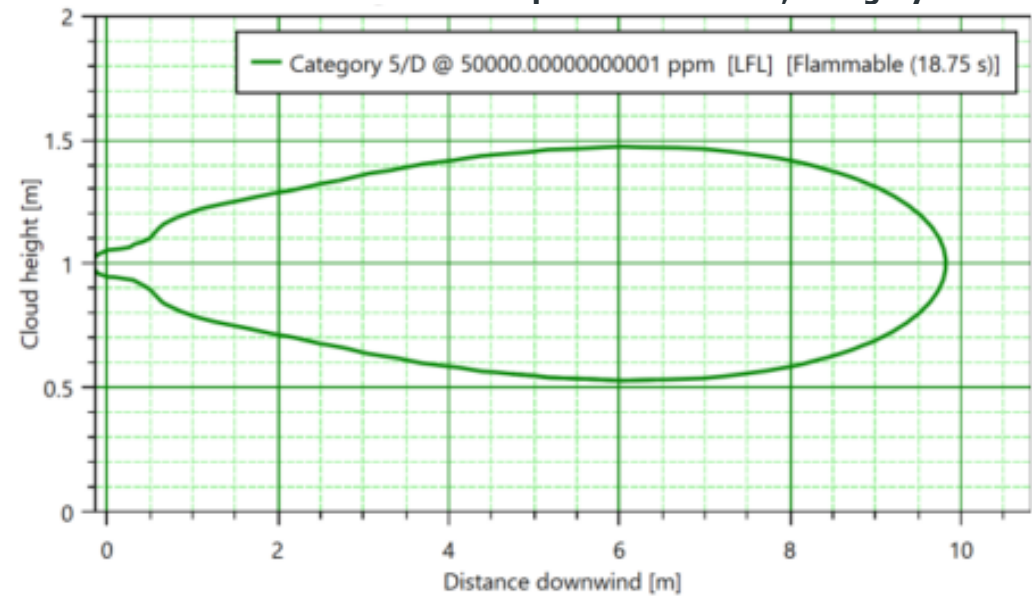
Appendix Figure B-30. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter), Vertical Release and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category F2



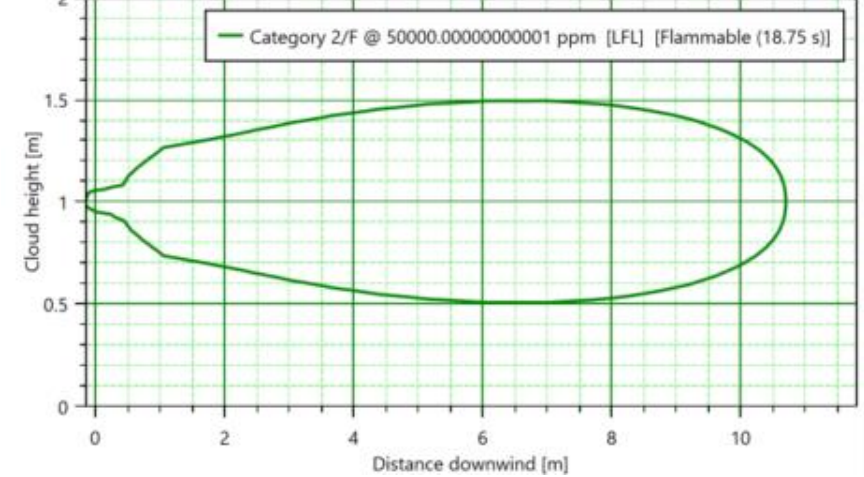
Appendix Figure B-31. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter), Vertical Release and Flash Fire: Dispersion Side View, Category F2



Appendix Figure B-32. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter), Horizontal Release and Flash Fire: Dispersion Side View, Category D5

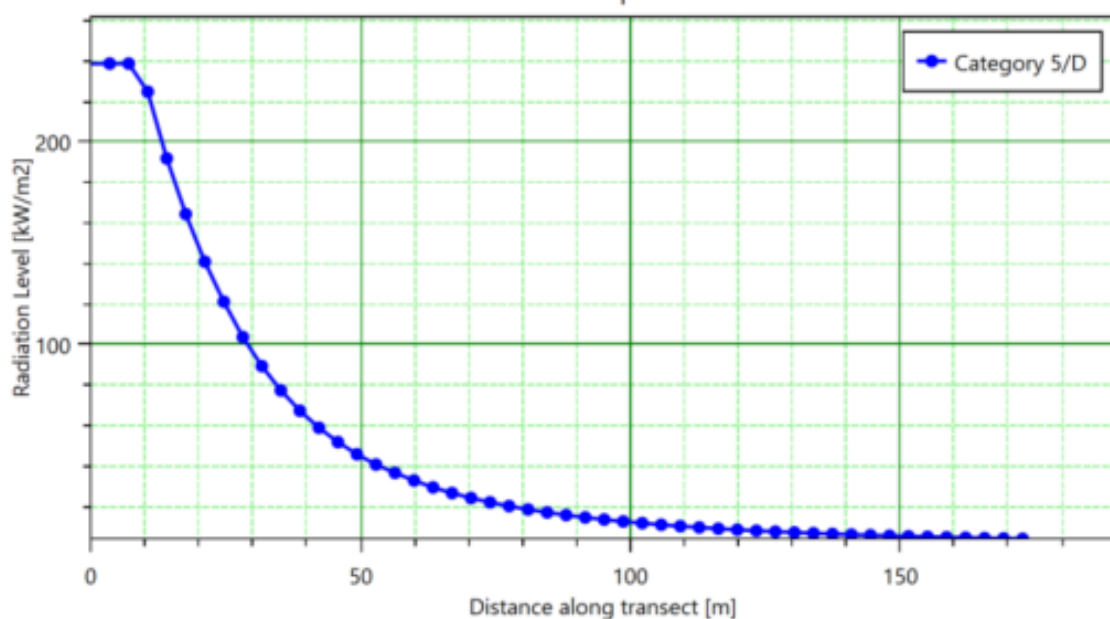


Appendix Figure B-33. Above Ground 35 barg Natural Gas Pipeline Leak (10% of Diameter), Horizontal Release and Flash Fire: Dispersion Side View, Category F2

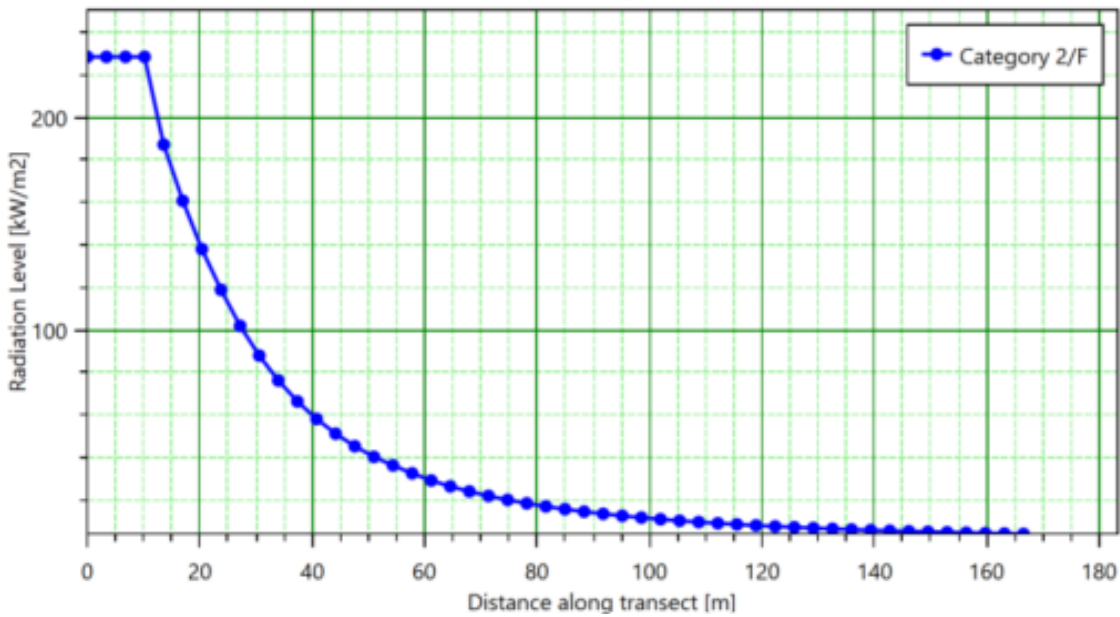


Installation	LPG Tank (Propane)
Scenario	LPG Tank Instantaneous Release
Software/model	DNV PHAST Version 9.1 Catastrophic rupture and Unified Dispersion Models Fireball Static (HSE) Model CCPS (1 st Ed.) BLEVE Model TNO Multi Energy Model Unified Dispersion Model
Discharge/BLEVE/Fireball/ Dispersion Model Source Term	1008 kg of propane at 27.5 barg and ambient temperature 27.4/26.5 metre fireball radius (D5/F2), 4.2/4.1 second duration (D5/F2)
Vapour cloud explosion source term	Flammable mass 80 kg at source of release (confined region), Category D5/F2

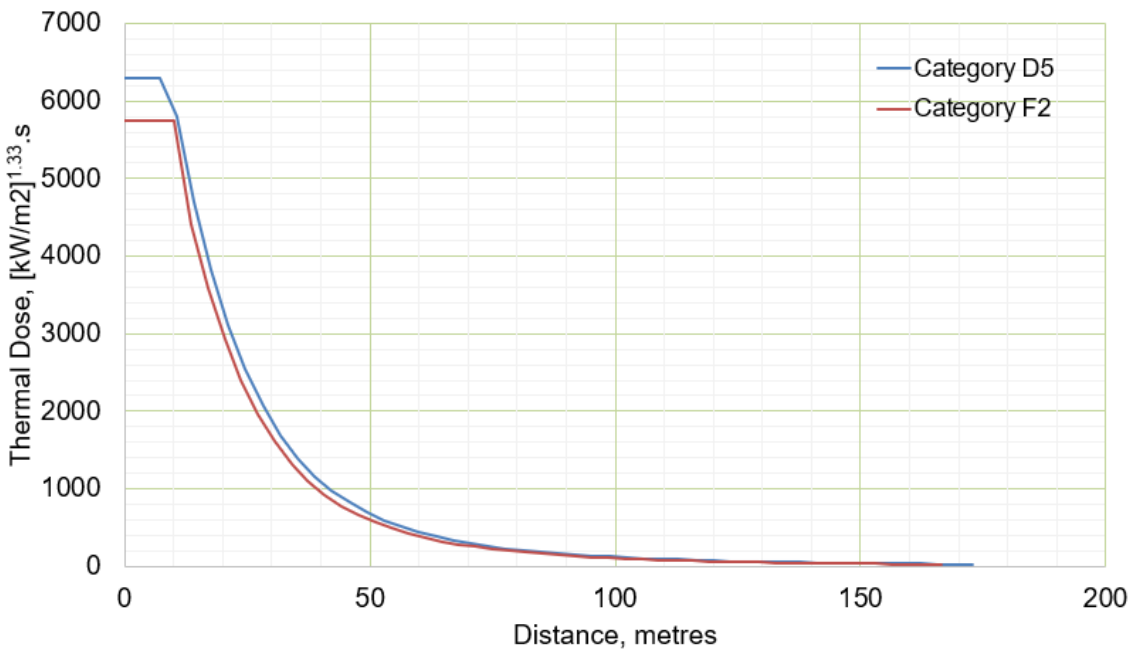
Appendix Figure B-34. LPG Tank Rupture and Fireball: Thermal Radiation vs. Distance Downwind, Category D5



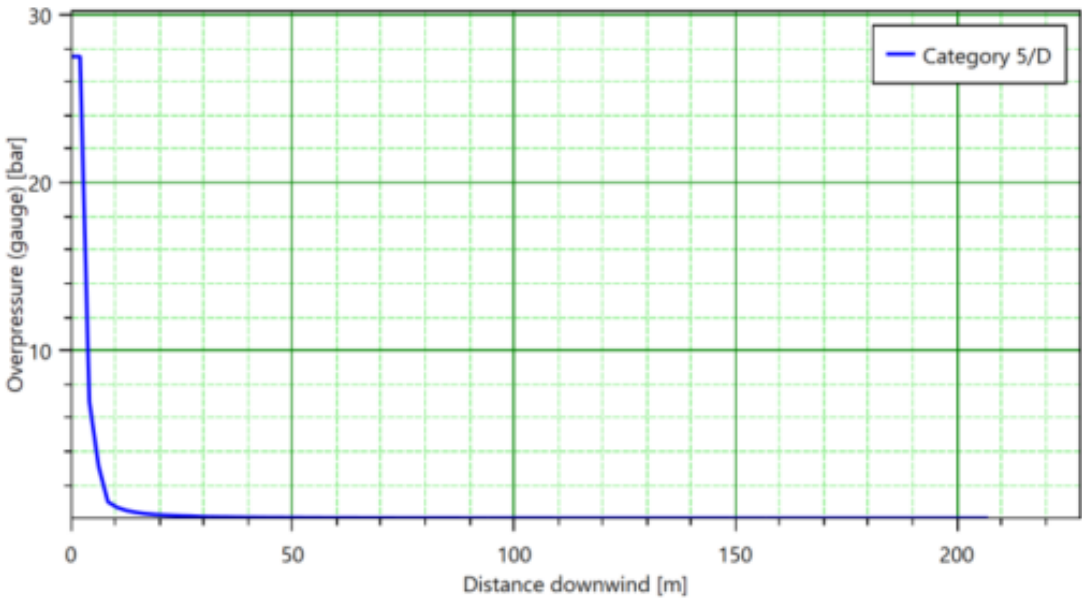
Appendix Figure B-35. LPG Tank Rupture and Fireball: Thermal Radiation vs. Distance Downwind, Category F2



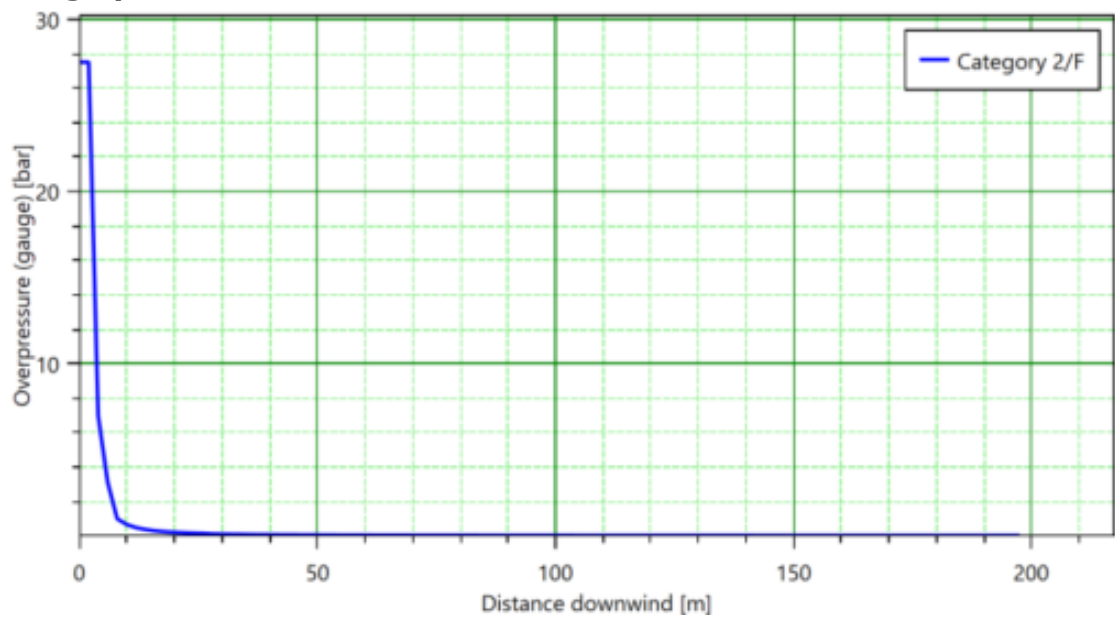
Appendix Figure B-36. LPG Tank Rupture and Fireball: Thermal Dose vs. Distance Downwind



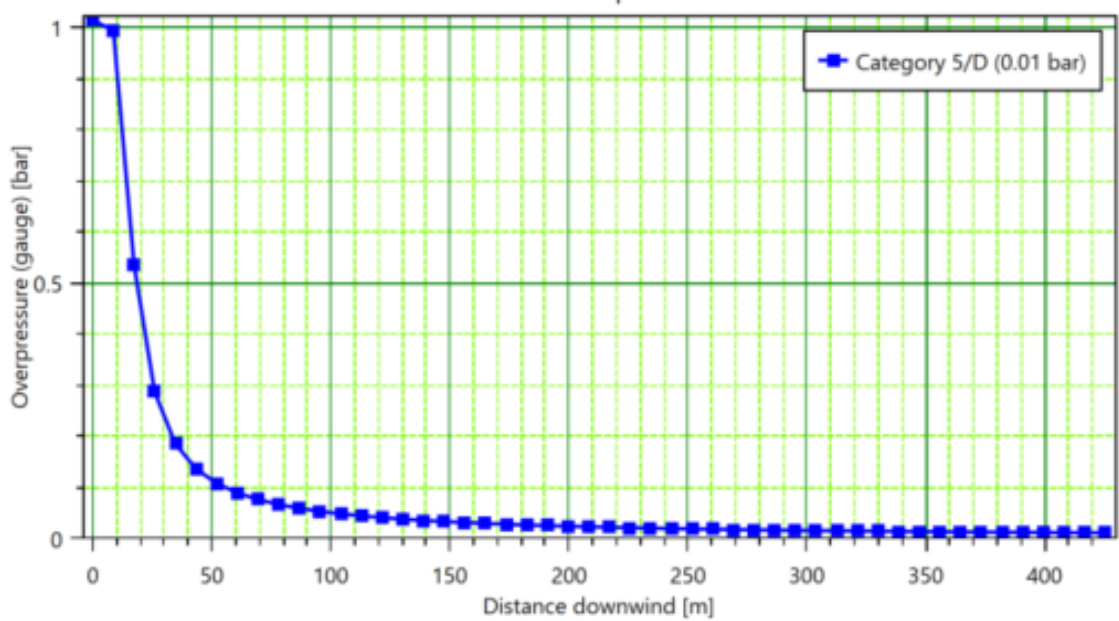
Appendix Figure B-37. LPG Tank Rupture and BLEVE: Overpressure vs. Distance Downwind, Category D5



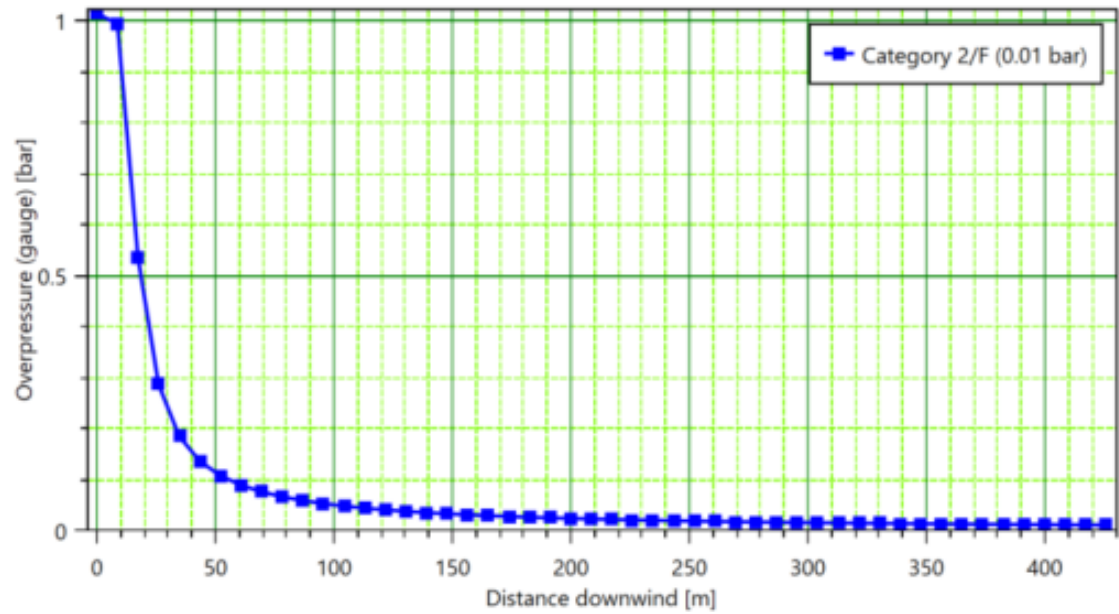
Appendix Figure B-38. LPG Tank Rupture and BLEVE: Overpressure vs. Distance Downwind, Category F2



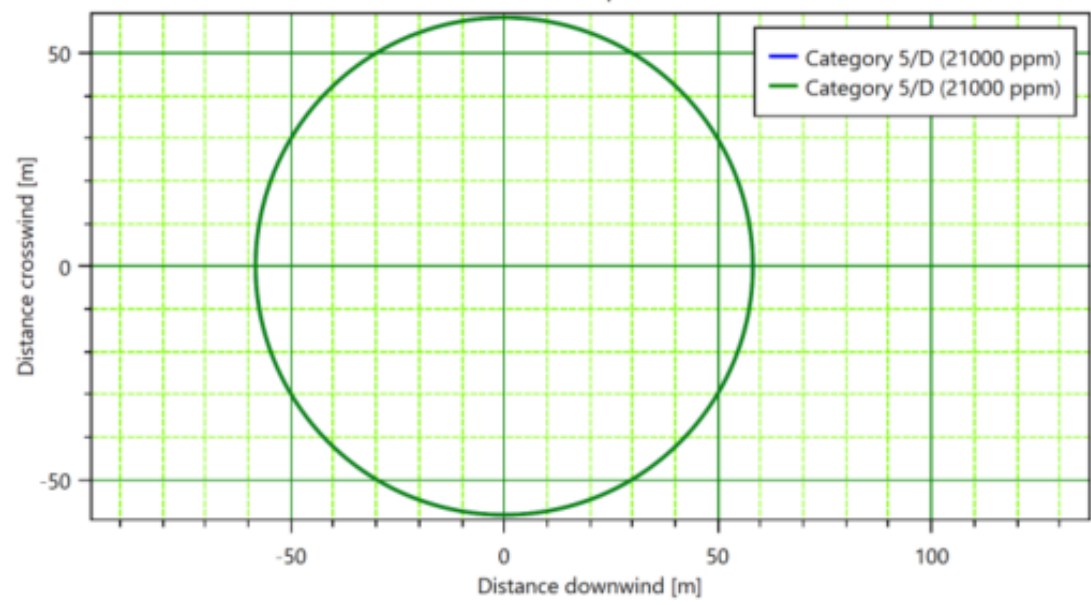
Appendix Figure B-39. LPG Tank Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



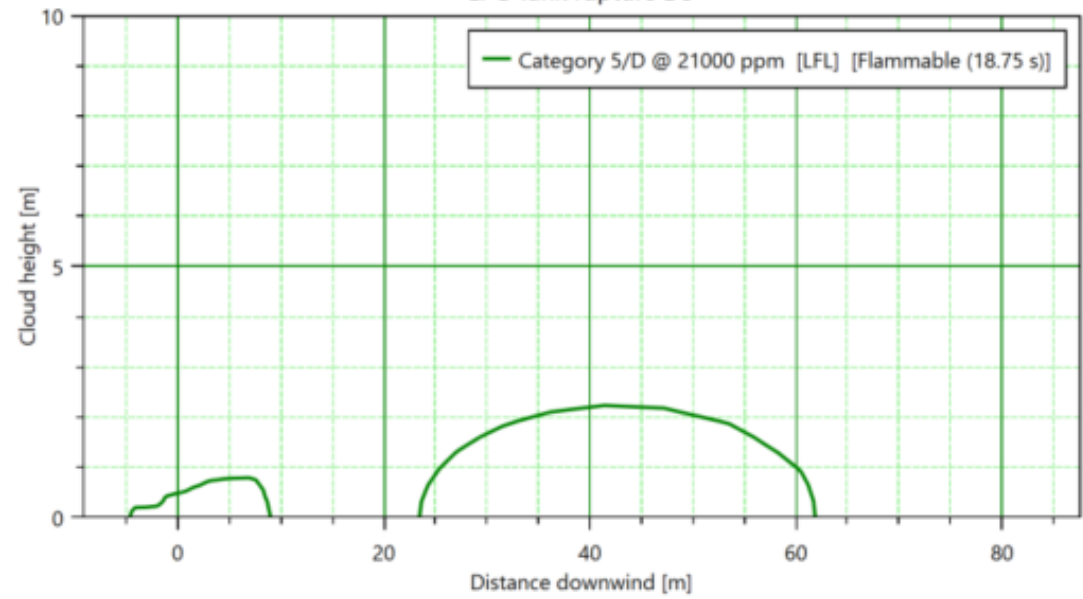
Appendix Figure B-40. LPG Tank Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



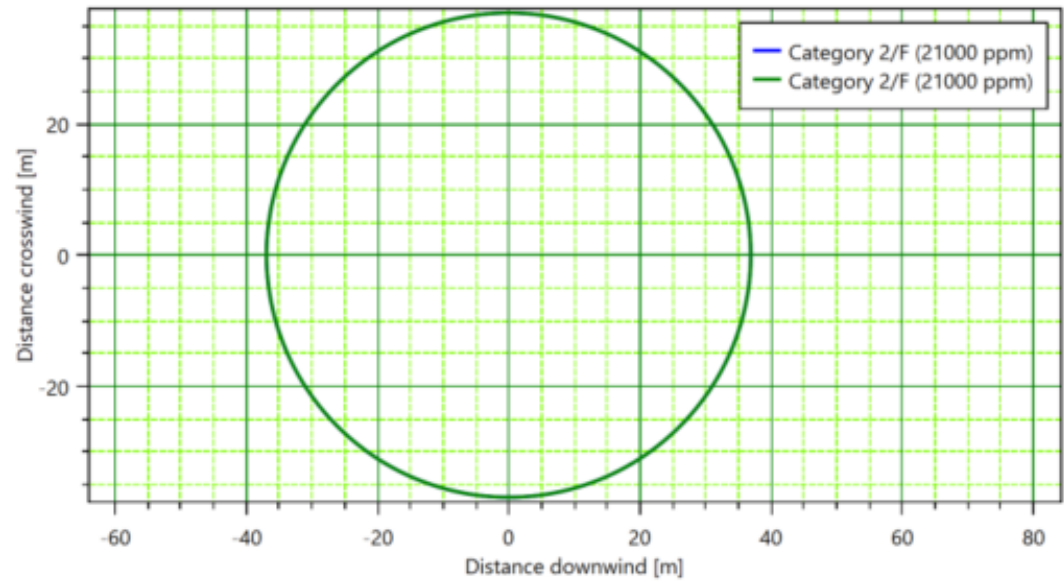
Appendix Figure B-41. LPG Tank Rupture and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category D5



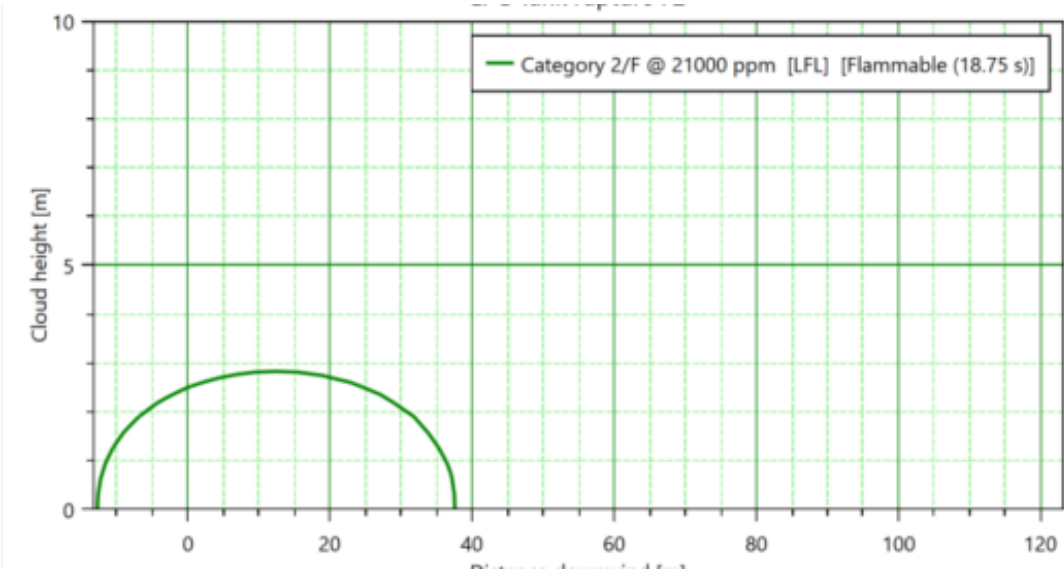
Appendix Figure B-42. LPG Tank Rupture and Flash Fire: Dispersion Side View, Category D5



Appendix Figure B-43. LPG Tank Rupture and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category F2

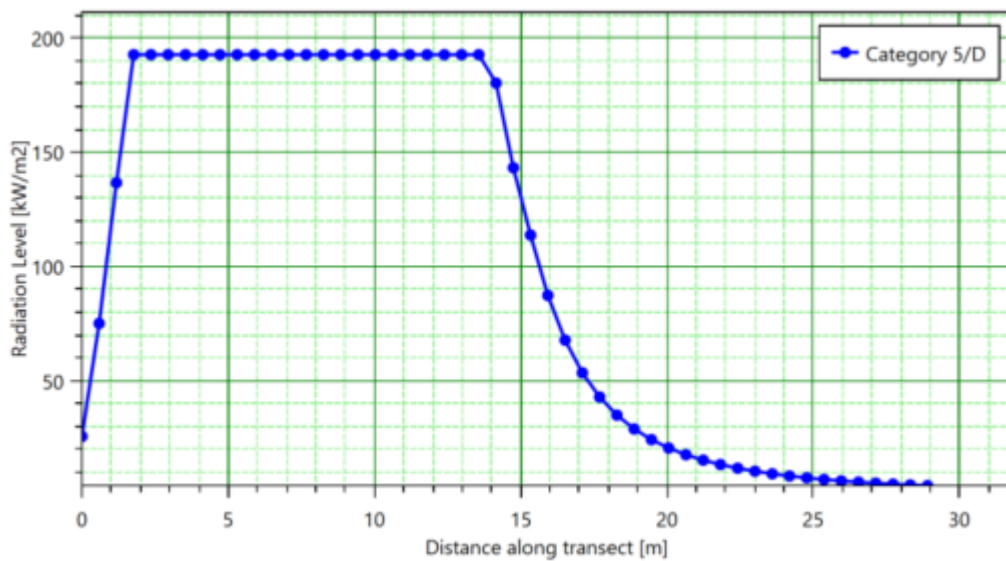


Appendix Figure B-44. LPG Tank Rupture and Flash Fire: Dispersion Side View, Category F2

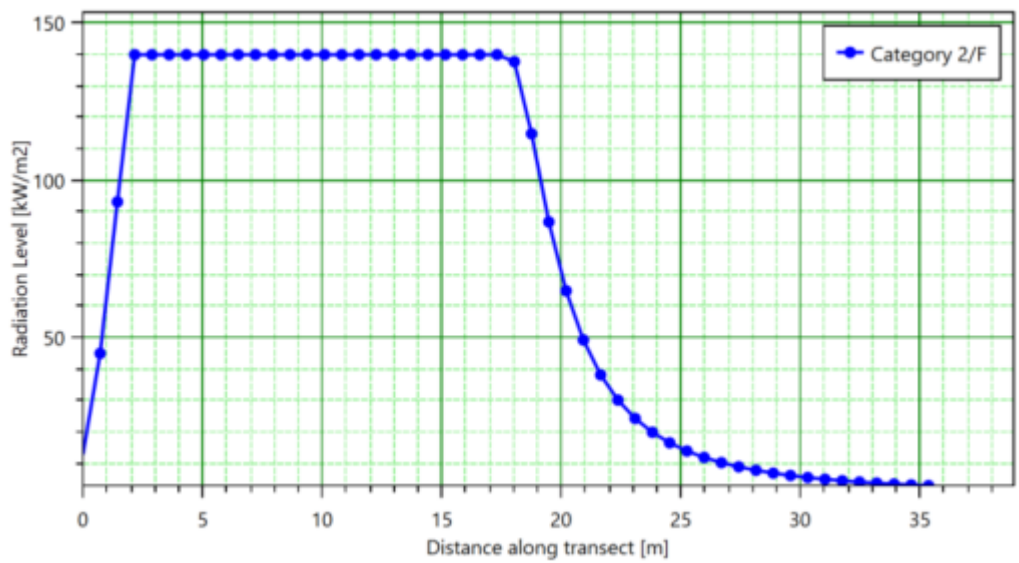


Installation	LPG Tank (Propane)
Scenario	LPG Tank Continuous Release (Entire Contents) Over 10 Minutes
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Jet Fire Cone Model TNO Multi Energy Model
Discharge/ Jet Fire /Dispersion Model Source Term	1008 kg of propane at 25 barg and ambient temperature
Vapour cloud explosion source term	Flammable mass 0.39/0.54 kg at source of horizontal release (confined region), Category D5/F2 Flammable mass 0.20/0.38 kg at source of vertical release (confined region), Category D5/F2

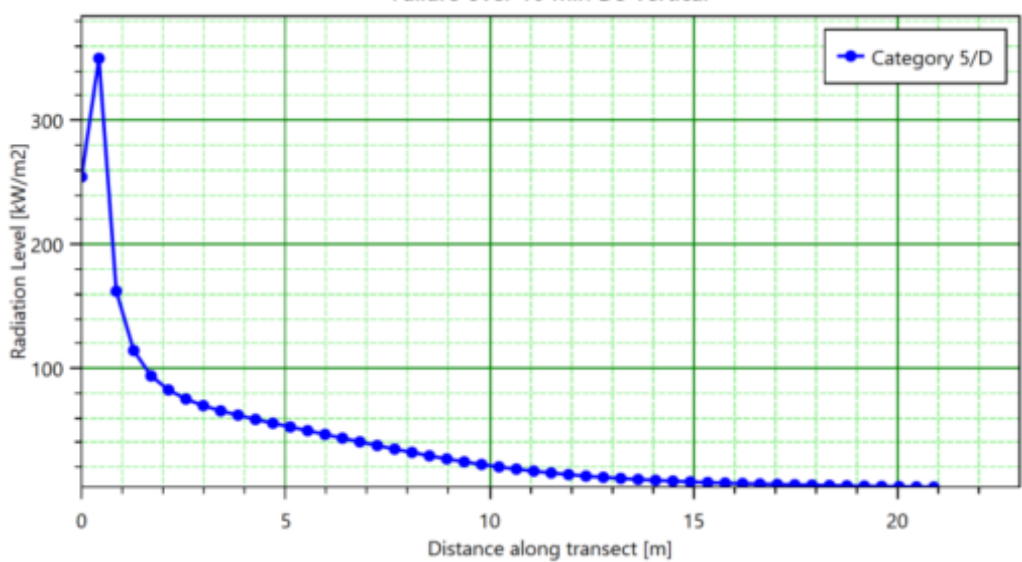
Appendix Figure B-45. LPG Tank Continuous Release Over 10 Minutes and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



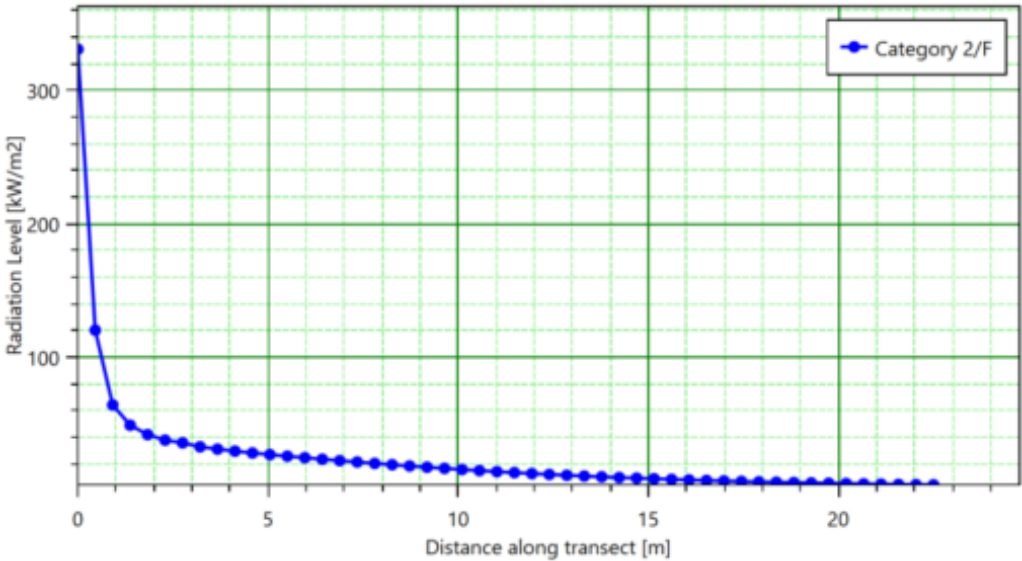
Appendix Figure B-46. LPG Tank Continuous Release Over 10 Minutes and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



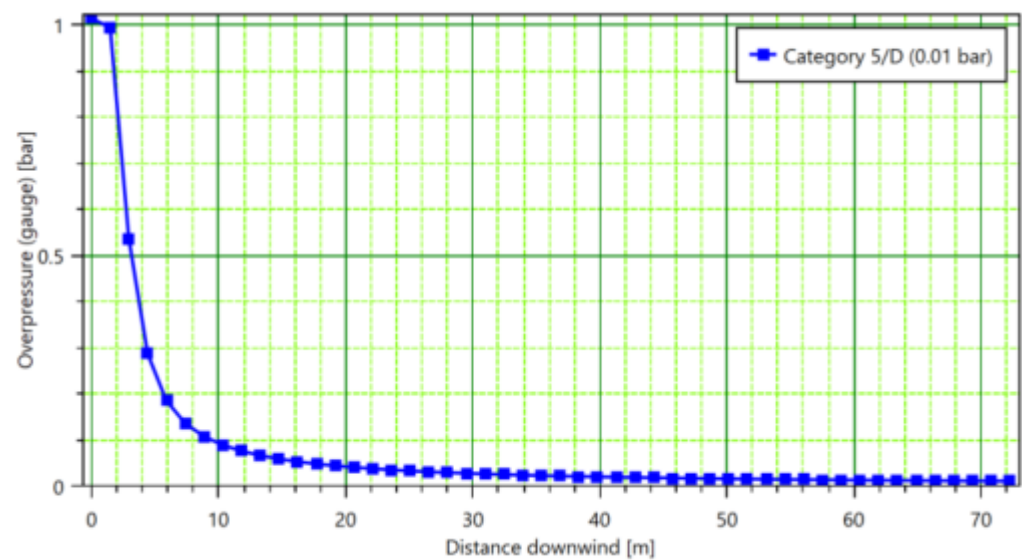
Appendix Figure B-47. LPG Tank Continuous Release Over 10 Minutes and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



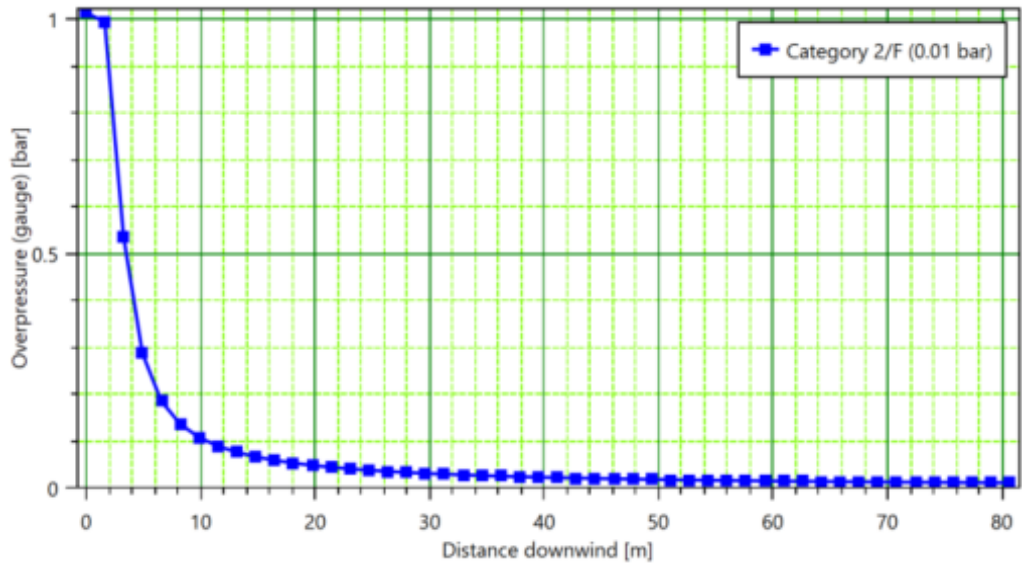
Appendix Figure B-48. LPG Tank Continuous Release Over 10 Minutes and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



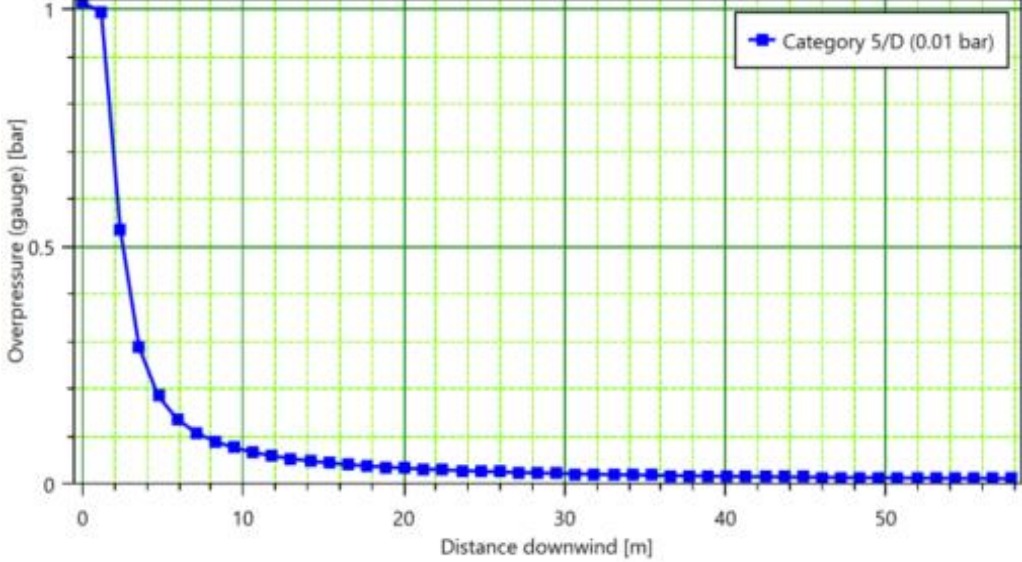
Appendix Figure B-49. LPG Tank Continuous Release Over 10 Minutes (Horizontal) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



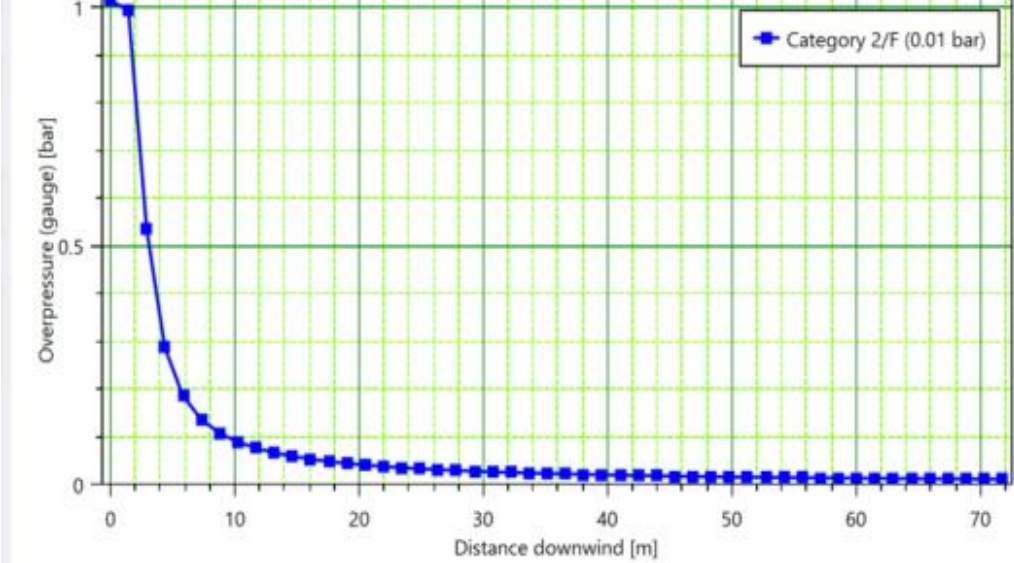
Appendix Figure B-50. LPG Tank Continuous Release Over 10 Minutes (Horizontal) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



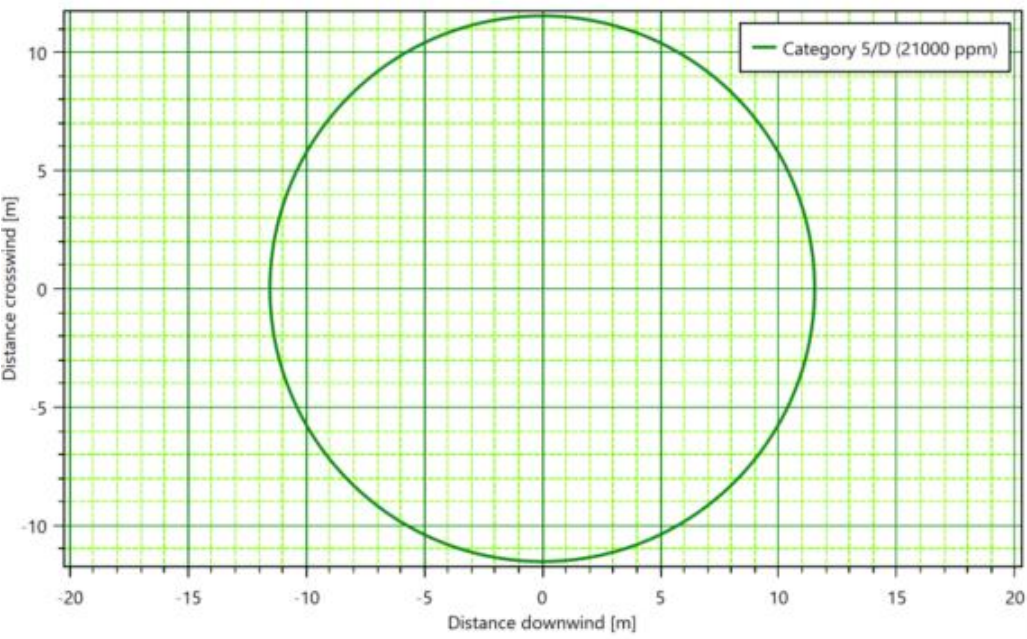
Appendix Figure B-51. LPG Tank Continuous Release Over 10 Minutes (Vertical) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



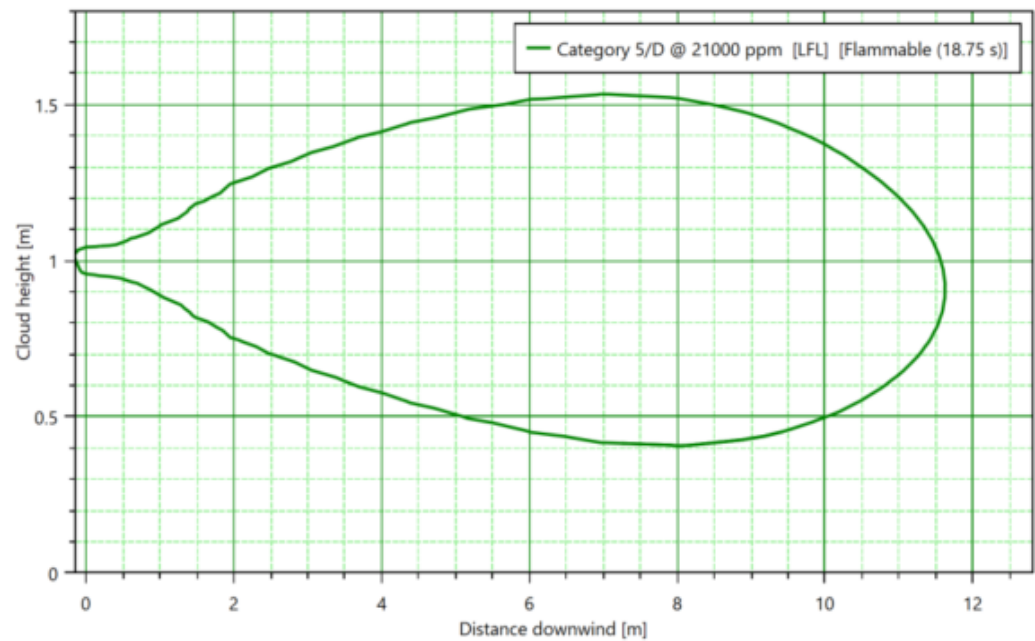
Appendix Figure B-52. LPG Tank Continuous Release Over 10 Minutes (Vertical) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



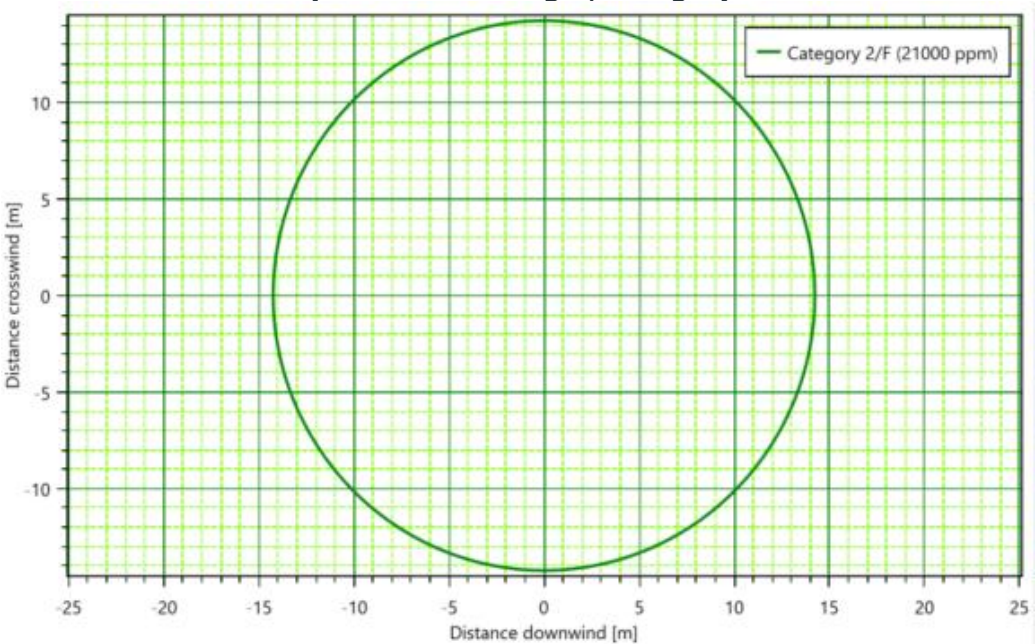
Appendix Figure B-53. LPG Tank Continuous Release Over 10 Minutes (Horizontal) and Flash Fire: Flash Fire Envelope, at release height Category D5



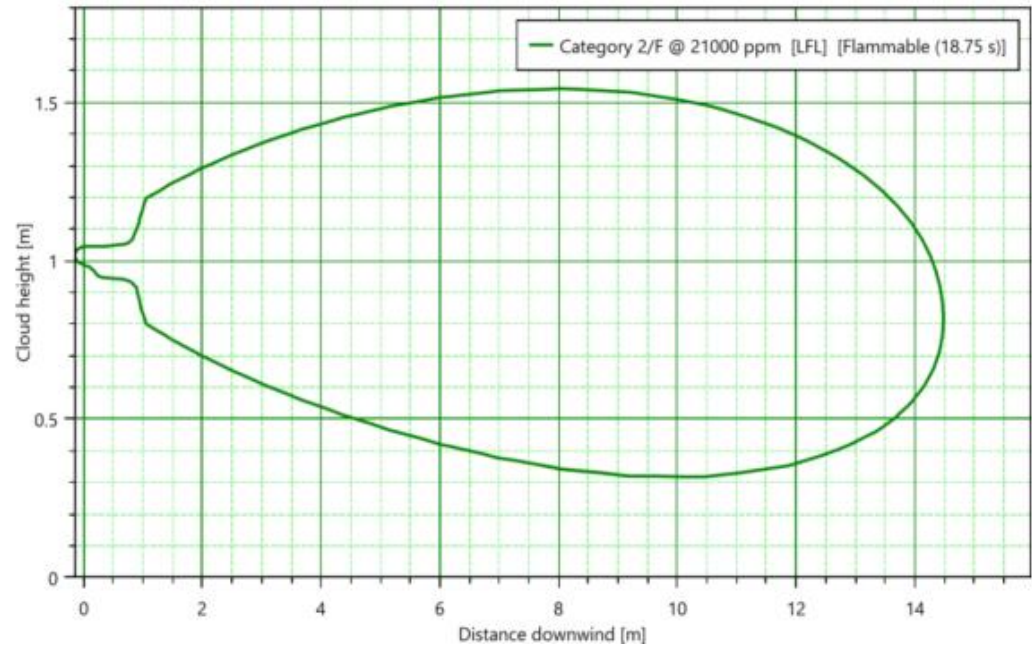
Appendix Figure B-54. LPG Tank Continuous Release Over 10 Minutes (Horizontal) and Flash Fire: Dispersion Side View, Category D5



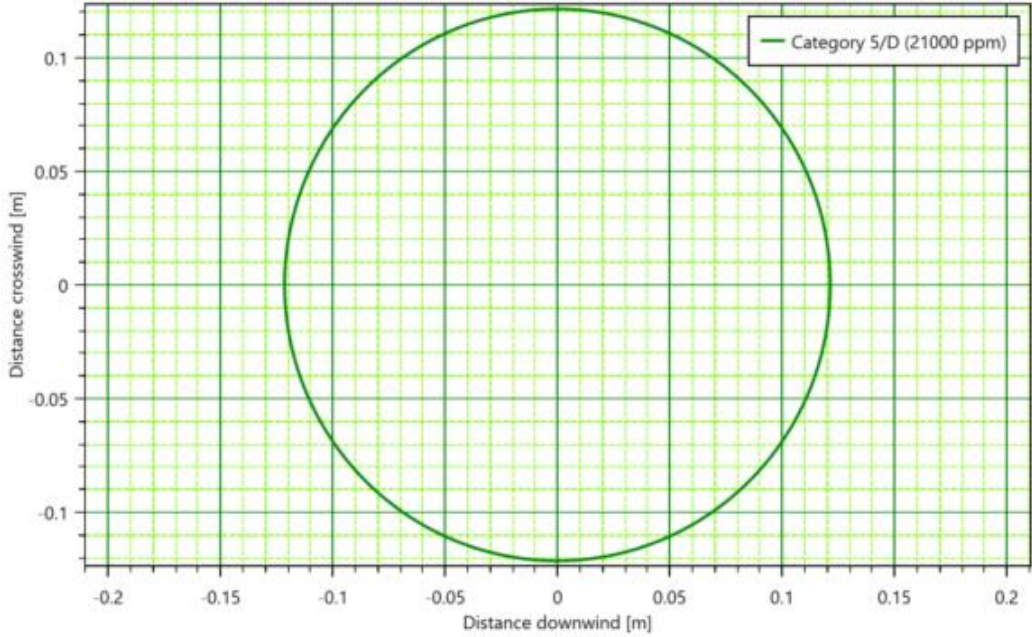
Appendix Figure B-55. LPG Tank Continuous Release Over 10 Minutes (Horizontal) and Flash Fire: Flash Fire Envelope at release height, Category F2



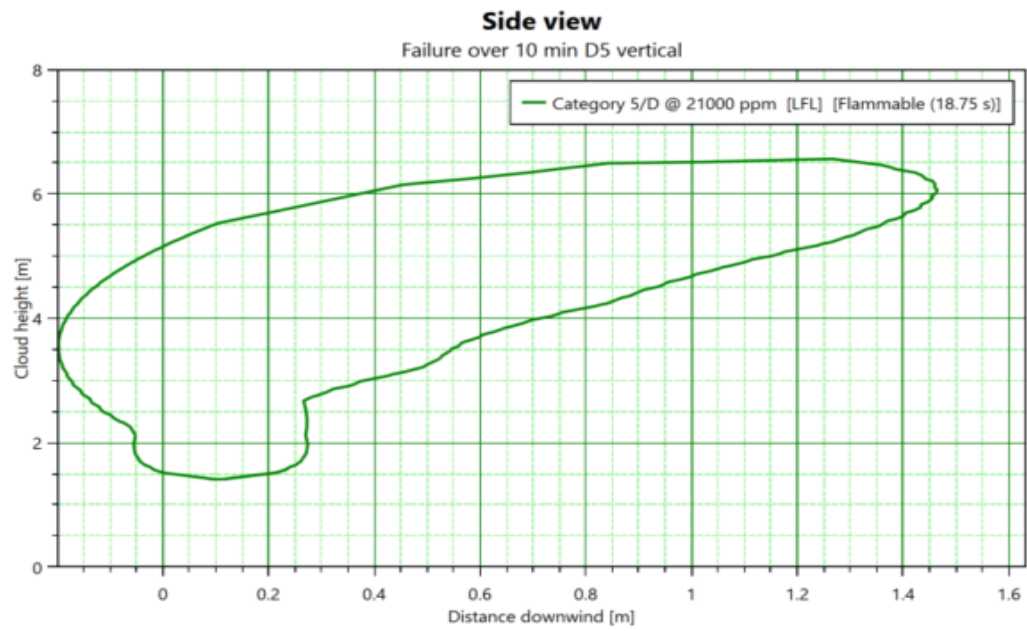
Appendix Figure B-56. LPG Tank Continuous Release Over 10 Minutes (Horizontal) and Flash Fire: Dispersion Side View, Category F2



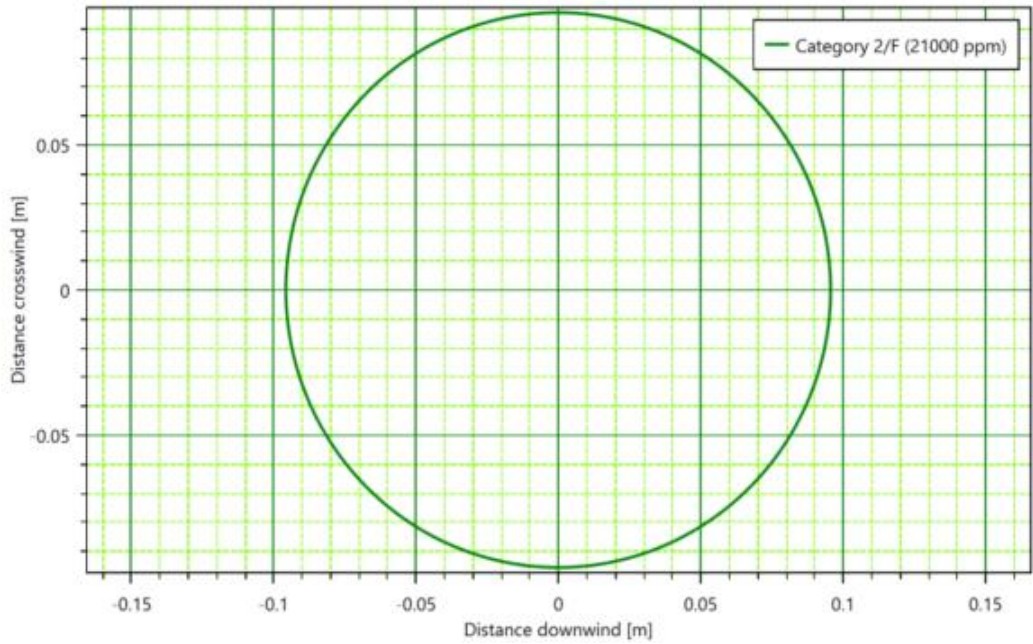
Appendix Figure B-57. LPG Tank Continuous Release Over 10 Minutes (Vertical) and Flash Fire: Flash Fire Envelope at release height, Category D5



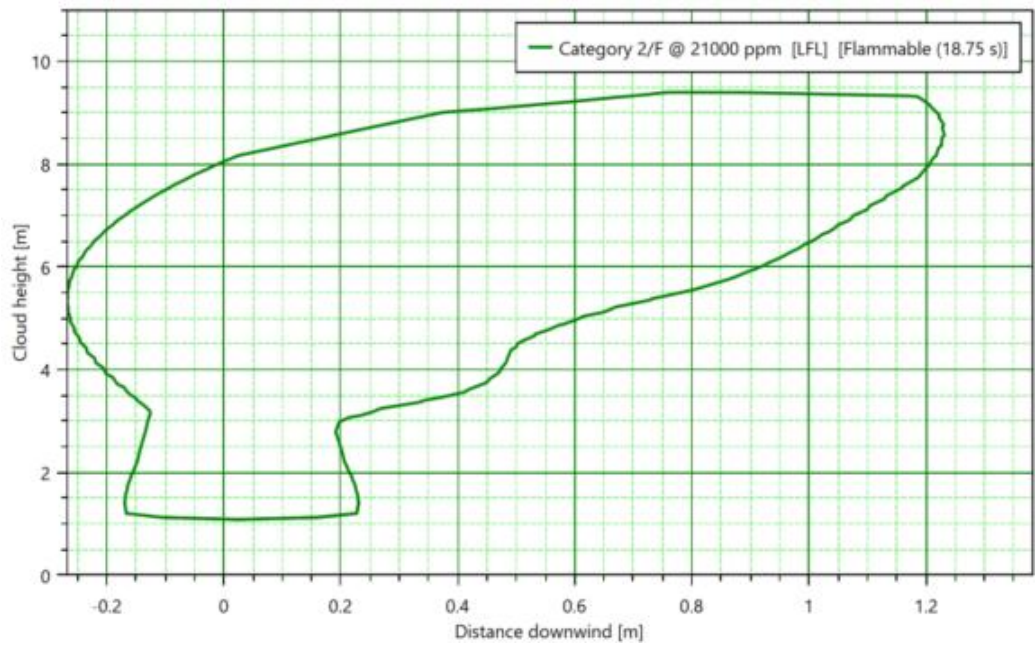
Appendix Figure B-58. LPG Tank Continuous Release Over 10 Minutes (Vertical) and Flash Fire: Dispersion Side View, Category D5



Appendix Figure B-59. LPG Tank Continuous Release Over 10 Minutes (Vertical) and Flash Fire: Flash Fire Envelope at release height, Category F2

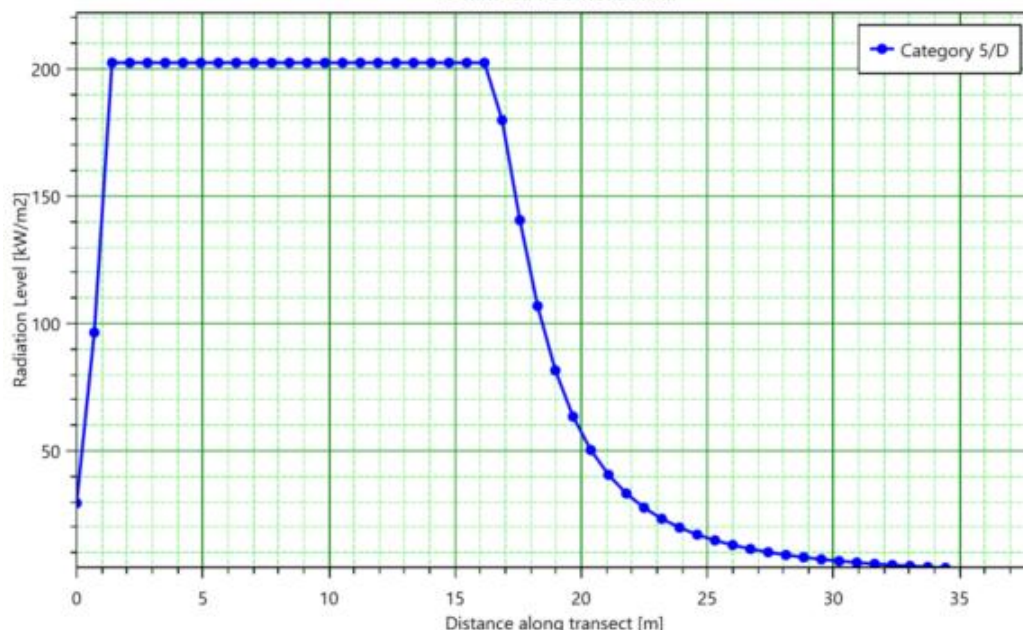


Appendix Figure B-60. LPG Tank Continuous Release Over 10 Minutes (Vertical) and Flash Fire: Dispersion Side View, Category F2

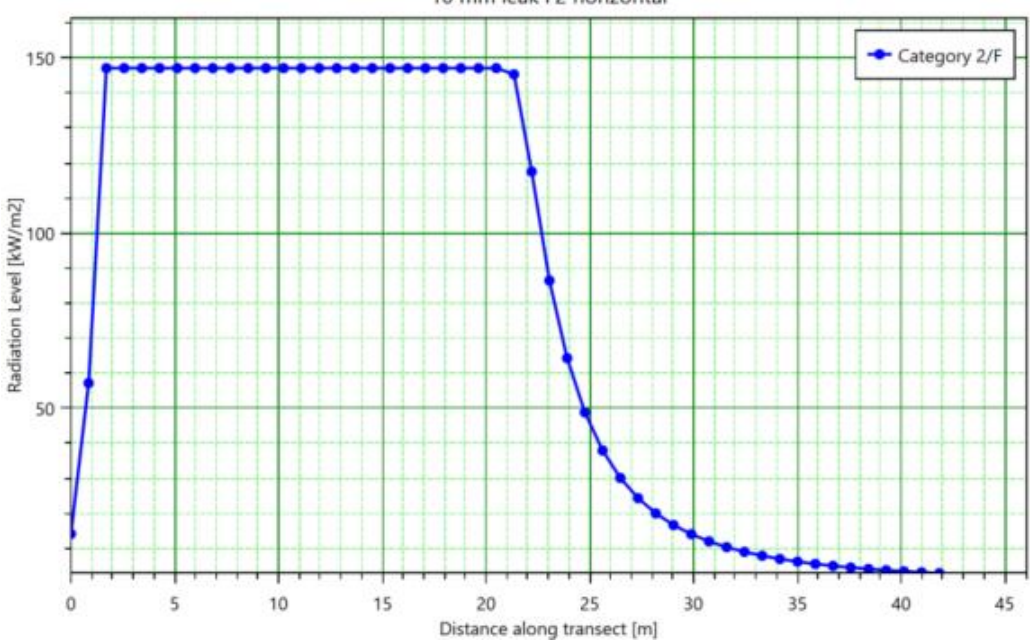


Installation	LPG Tank (Propane)
Scenario	LPG Tank 10 mm Leak Over 30 Minutes
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Jet Fire Cone Model TNO Multi Energy Model
Discharge/ Jet Fire /Dispersion Model Source Term	1008 kg of propane at 25 barg and ambient temperature
Vapour cloud explosion source term	Flammable mass 0.75/0.93 kg at source of horizontal release (confined region), Category D5/F2 Flammable mass 0.35/0.67 kg at source of vertical release (confined region), Category D5/F2

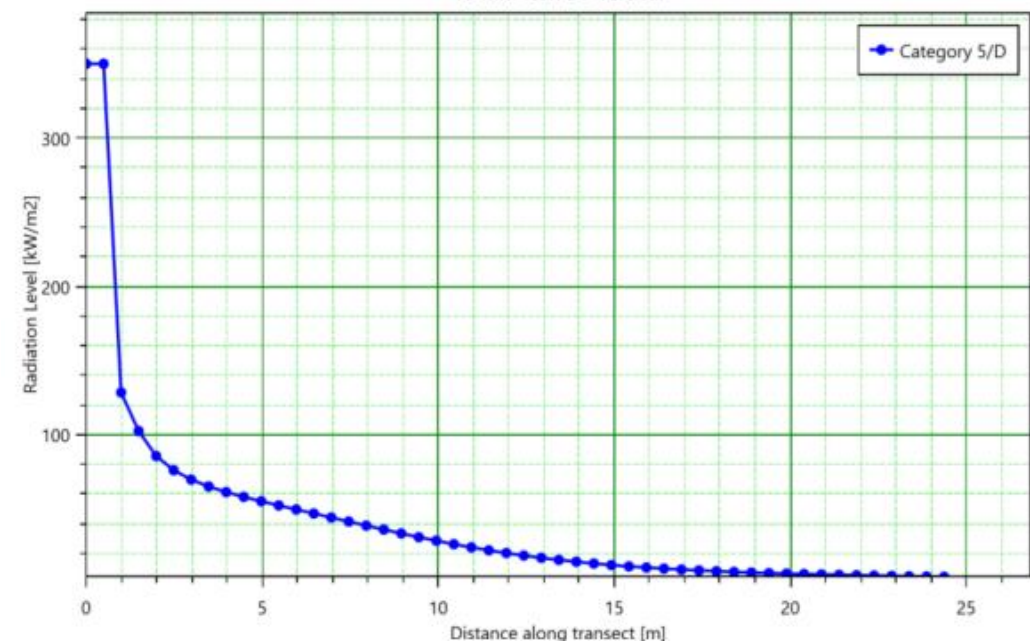
Appendix Figure B-61. LPG Tank 10 mm Leak and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



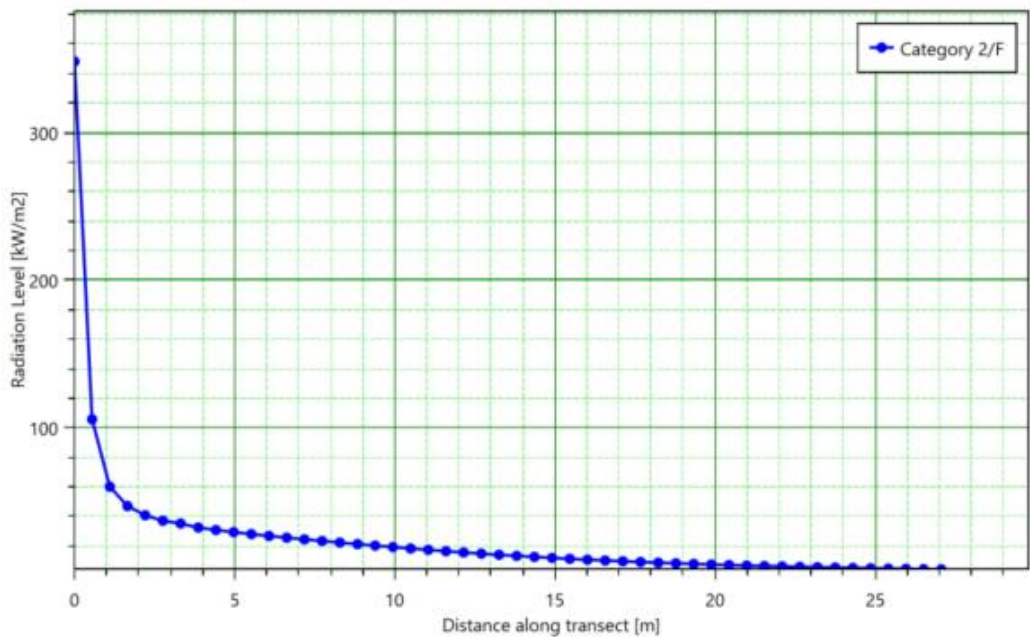
Appendix Figure B-62. LPG Tank 10 mm Leak and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



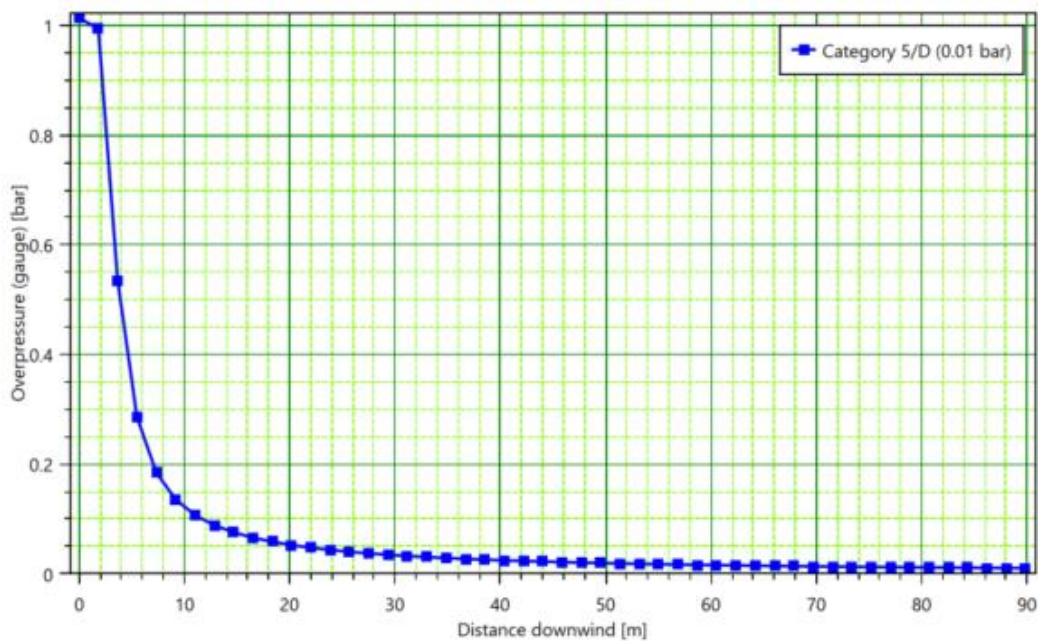
Appendix Figure B-63. LPG Tank 10 mm Leak and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



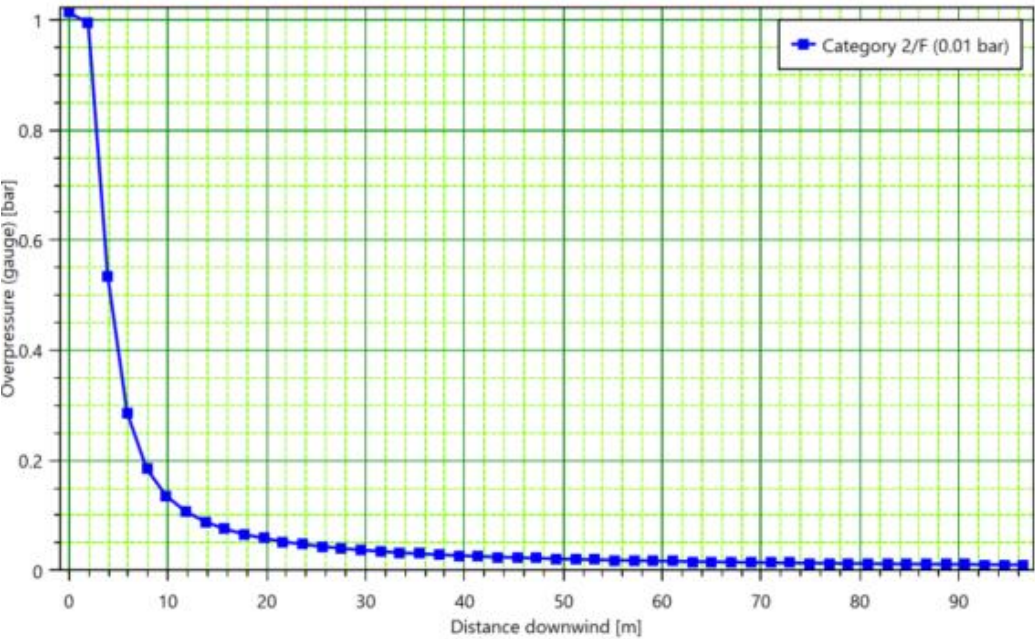
Appendix Figure B-64. LPG Tank 10 mm Leak and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



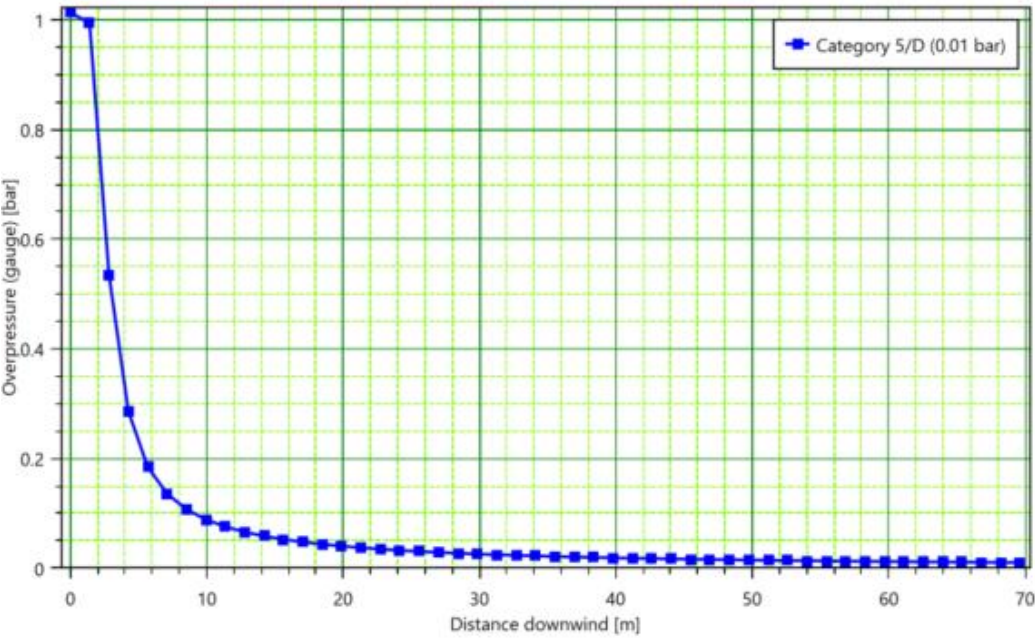
Appendix Figure B-65. LPG Tank 10 mm Leak (Horizontal) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



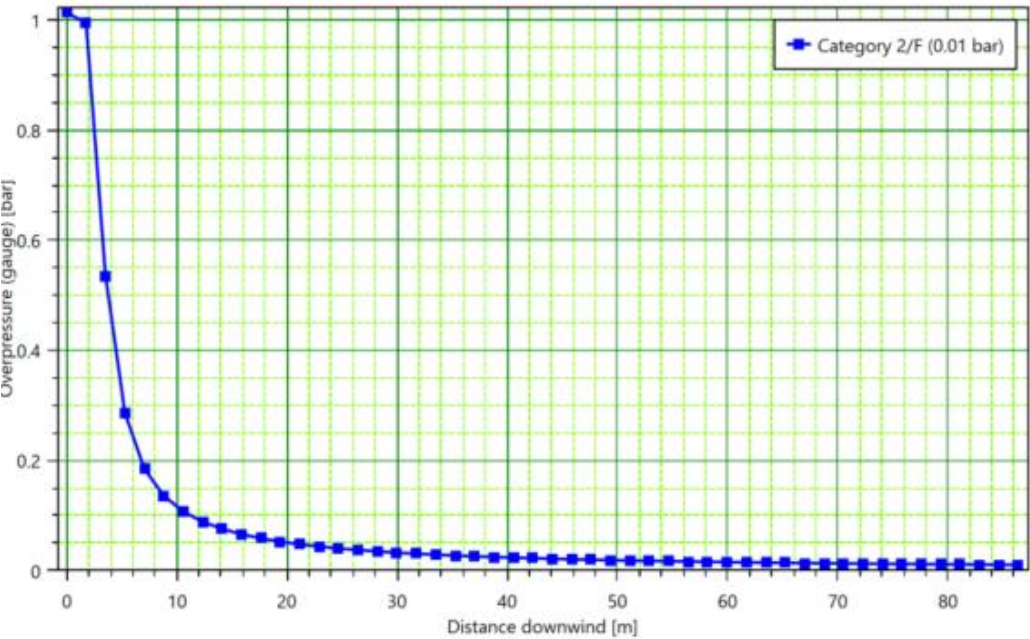
Appendix Figure B-66. LPG Tank 10 mm Leak (Horizontal) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



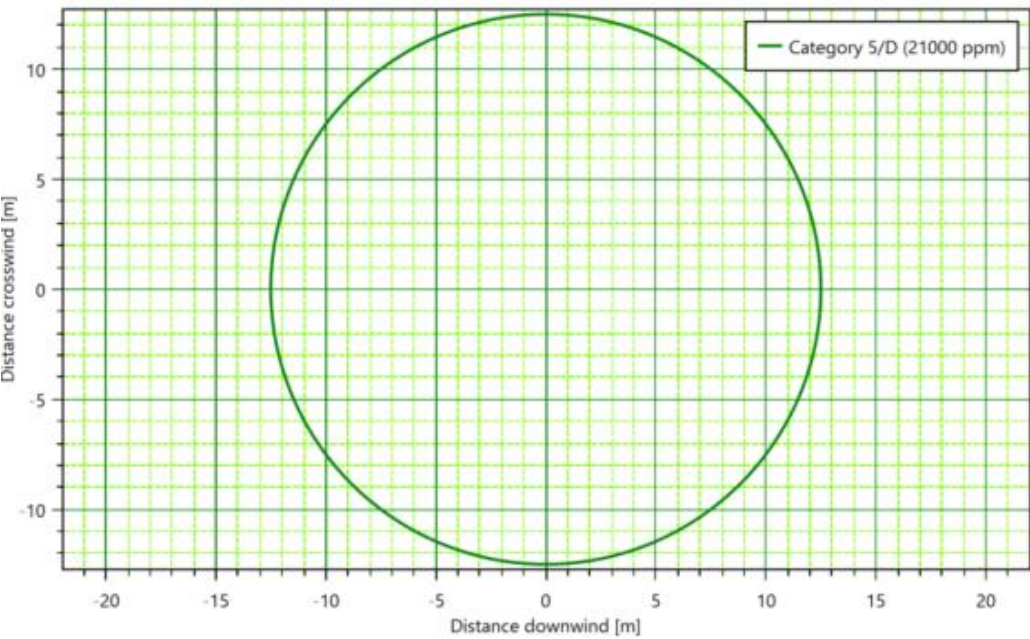
Appendix Figure B-67. LPG Tank 10 mm Leak (Vertical) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



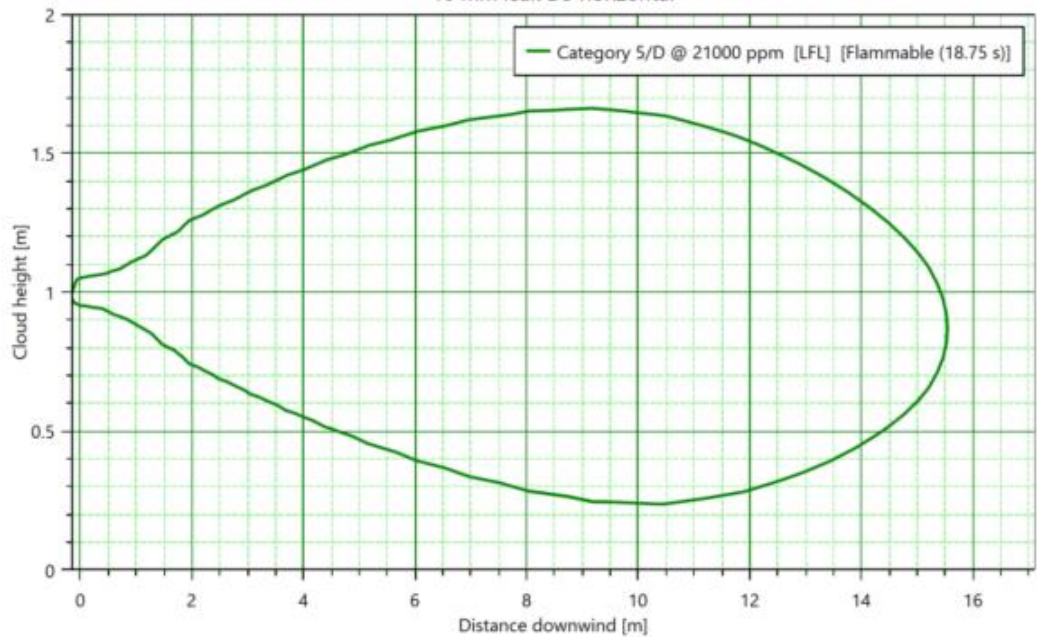
Appendix Figure B-68. LPG Tank 10 mm Leak (Vertical) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



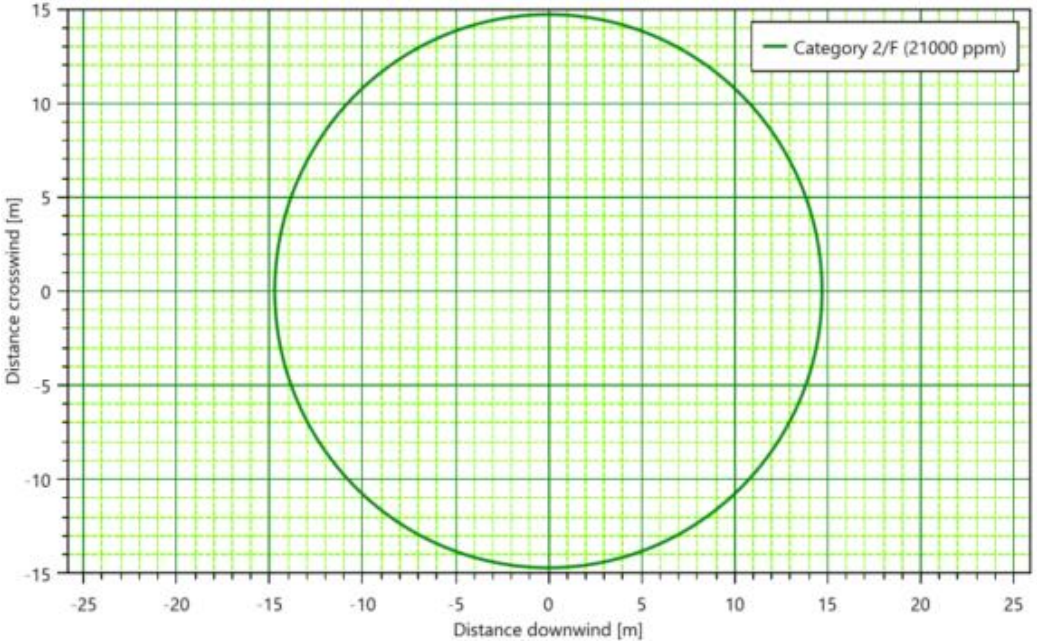
Appendix Figure B-69. LPG Tank 10 mm Leak (Horizontal) and Flash Fire: Flash Fire Envelope, at release height Category D5



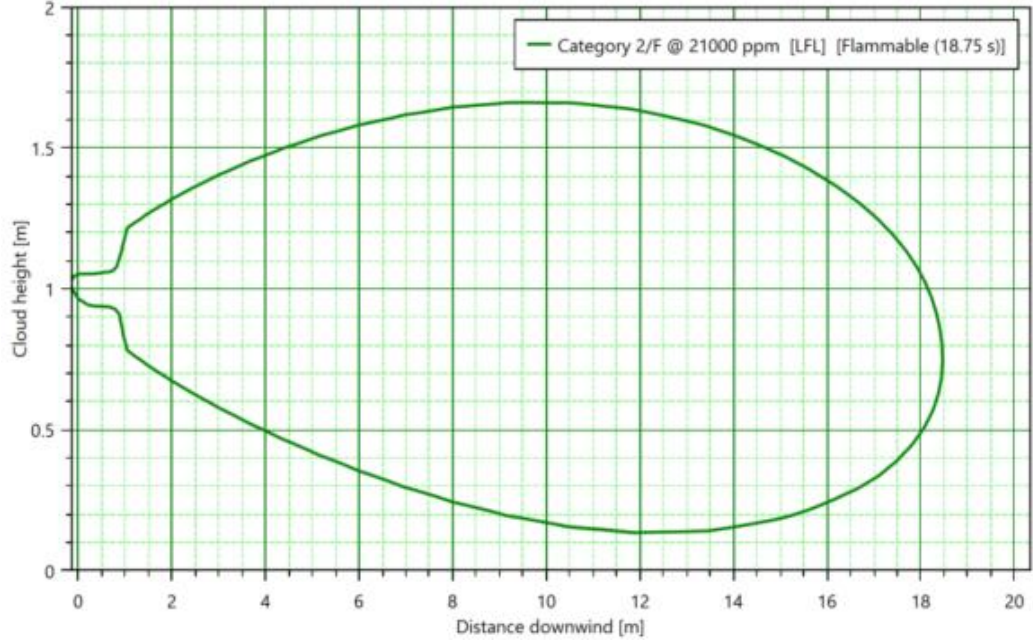
Appendix Figure B-70. LPG Tank 10 mm Leak (Horizontal) and Flash Fire: Dispersion Side View, Category D5



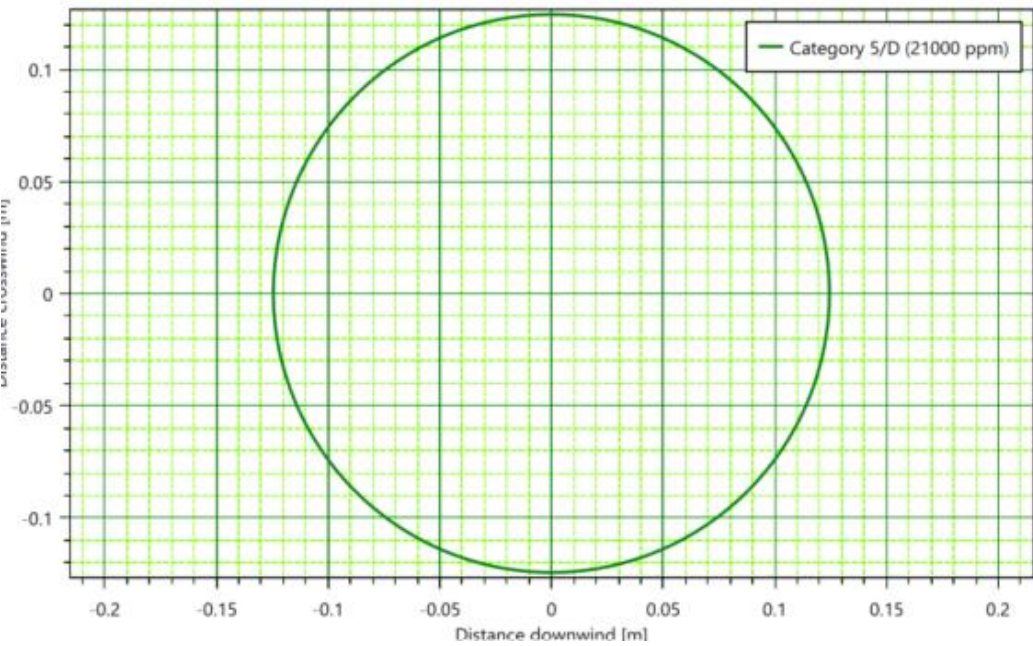
Appendix Figure B-71. LPG Tank 10 mm Leak (Horizontal) and Flash Fire: Flash Fire Envelope at release height, Category F2



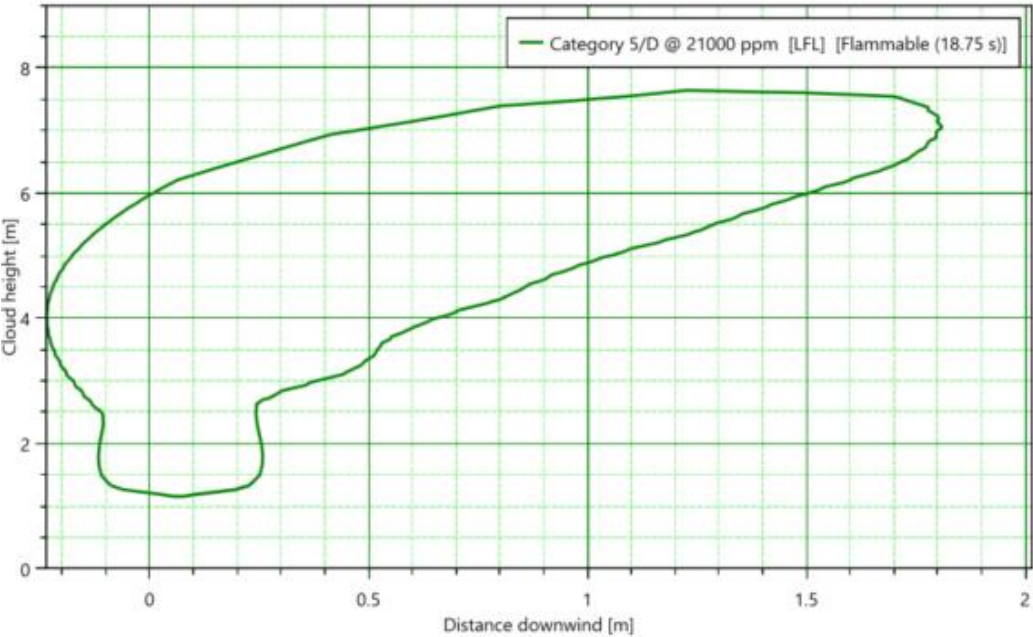
Appendix Figure B-72. LPG Tank 10 mm Leak (Horizontal) and Flash Fire: Dispersion Side View, Category F2



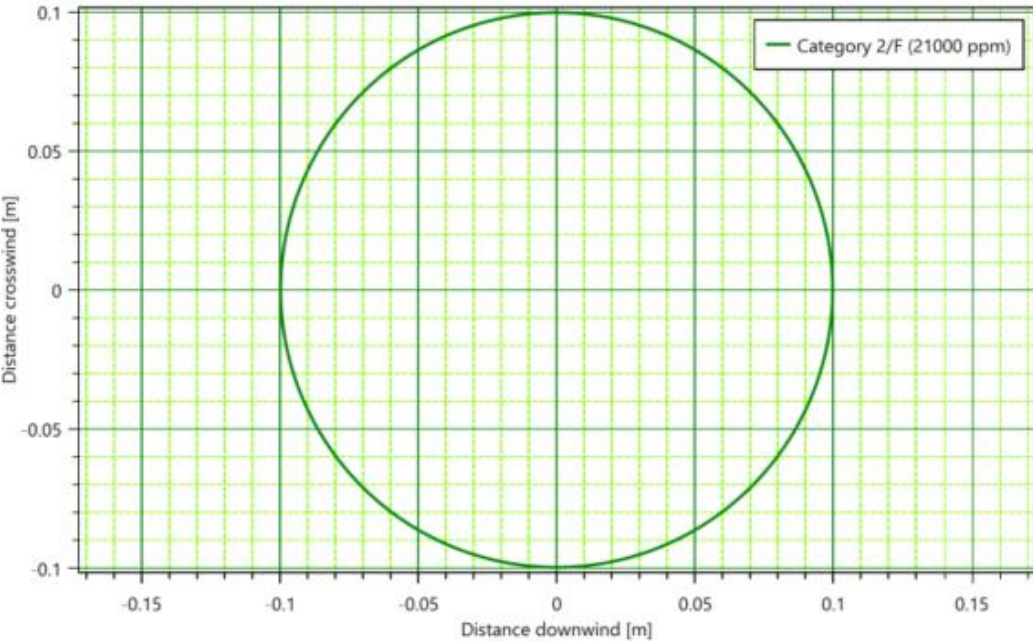
Appendix Figure B-73. LPG Tank 10 mm Leak (Vertical) and Flash Fire: Flash Fire Envelope at release height, Category D5



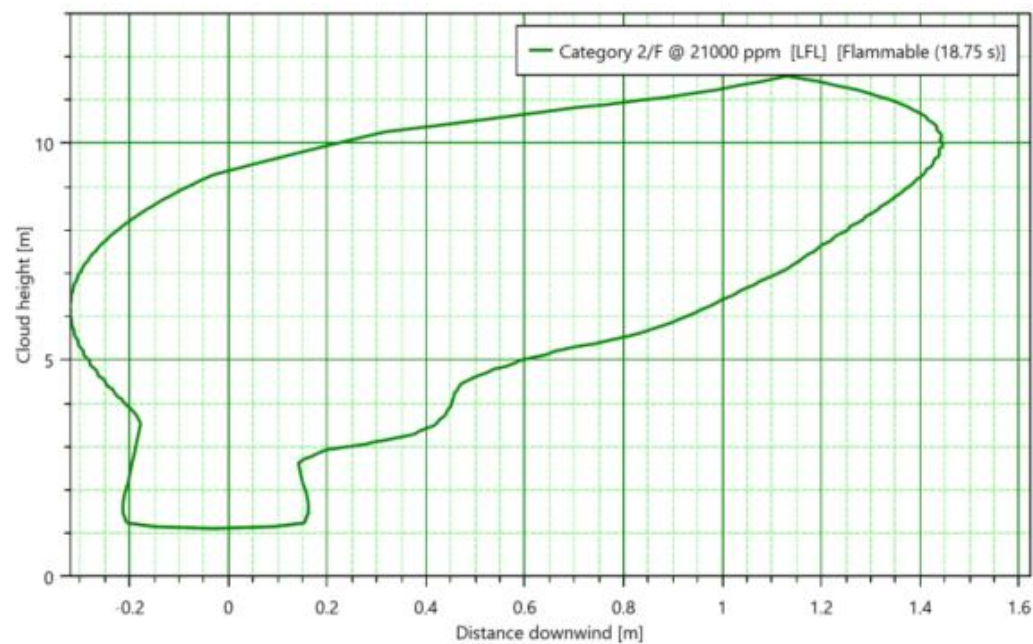
Appendix Figure B-74. LPG Tank 10 mm Leak (Vertical) and Flash Fire: Dispersion Side View, Category D5



Appendix Figure B-75. LPG Tank 10 mm Leak (Vertical) and Flash Fire: Flash Fire Envelope at release height, Category F2

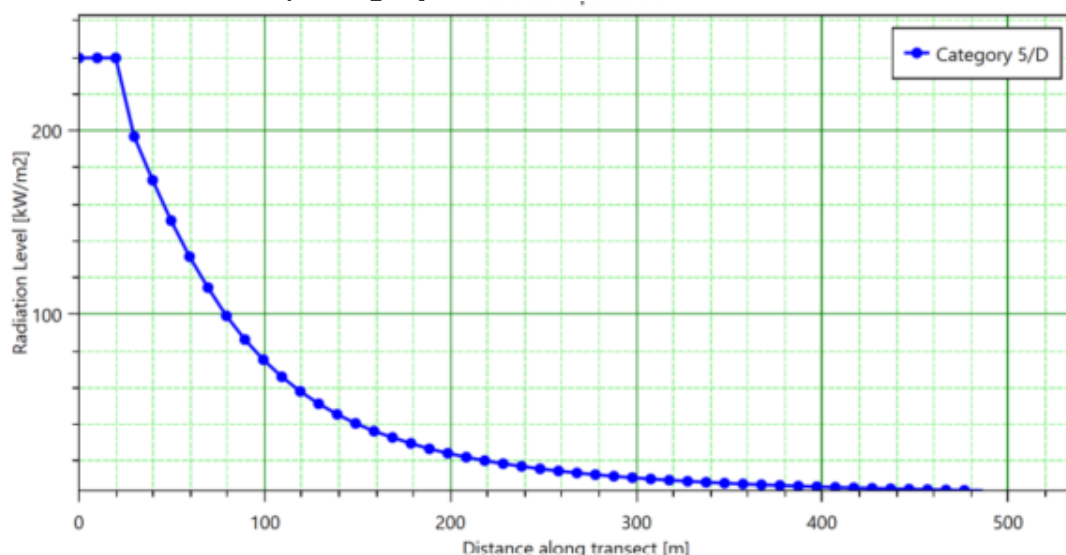


Appendix Figure B-76. LPG Tank 10 mm Leak (Vertical) and Flash Fire: Dispersion Side View, Category F2

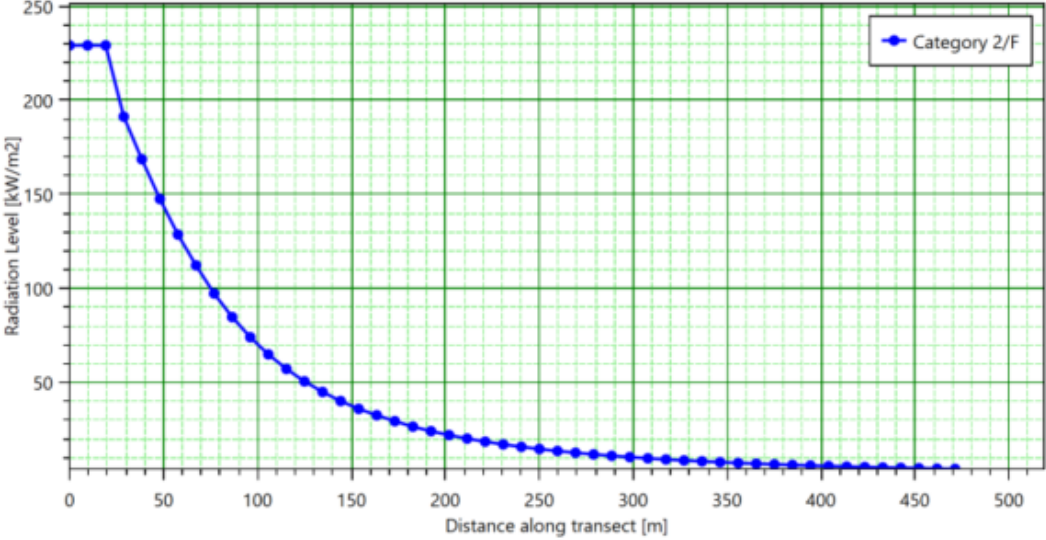


Installation	LPG Road Tanker (Propane)
Scenario	LPG Road Tanker Instantaneous Release (Rupture)
Software/model	DNV PHAST Version 9.1 Catastrophic rupture and Unified Dispersion Models Fireball Static (HSE) Model CCPS (1 st Ed.) BLEVE Model TNO Multi Energy Model Unified Dispersion Model
Discharge/ Jet Fire /Dispersion Model Source Term	28000 kg of propane at 33 barg and ambient temperature 83/80 metre fireball radius (D5/F2), 12.8/12.4 second duration (D5/F2)
Vapour cloud explosion source term	Flammable mass 2036/2032 kg at source of release (confined region), Category D5/F2

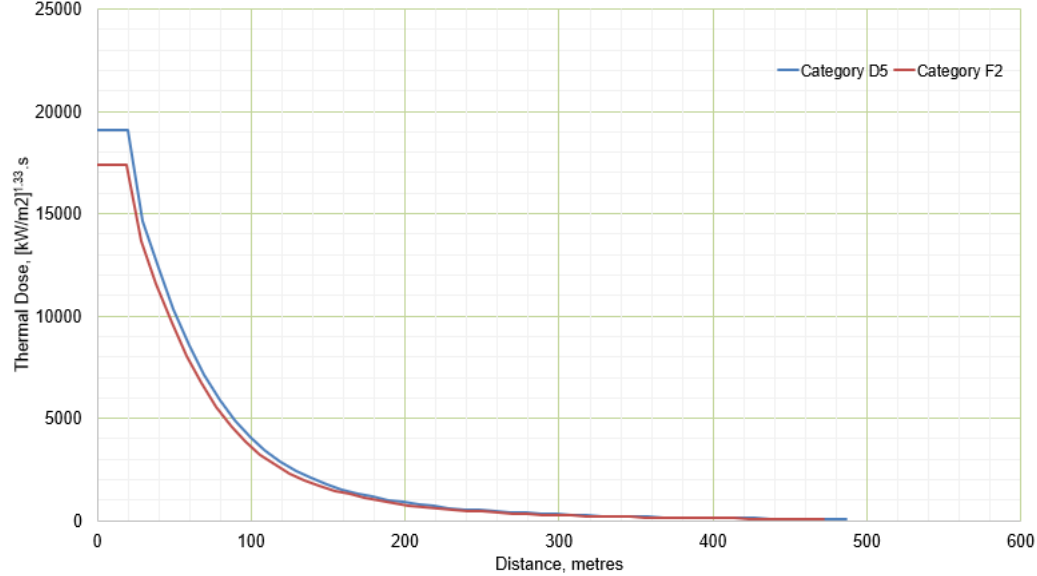
Appendix Figure B-77. LPG Road Tanker Rupture and Fireball: Thermal Radiation vs. Distance Downwind, Category D5



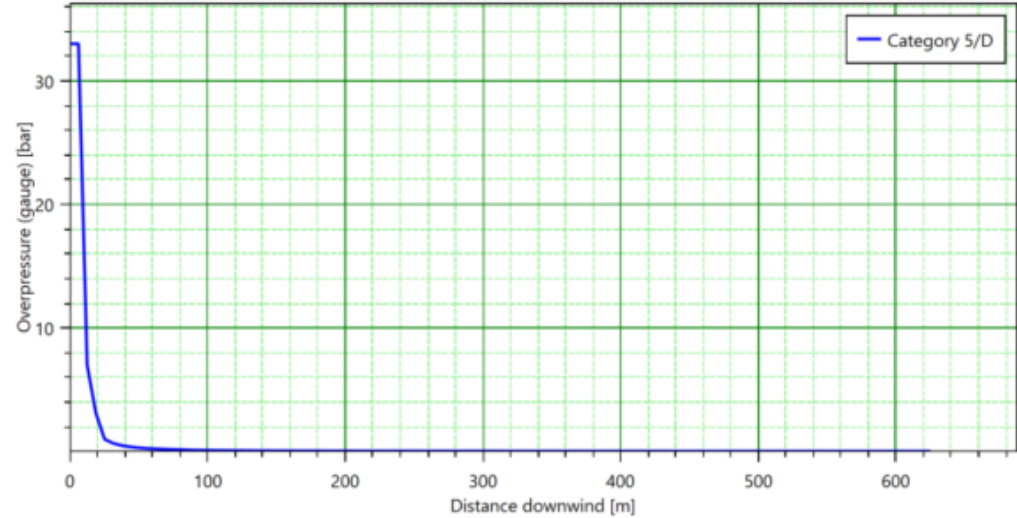
Appendix Figure B-78. LPG Road Tanker Rupture and Fireball: Thermal Radiation vs. Distance Downwind, Category F2



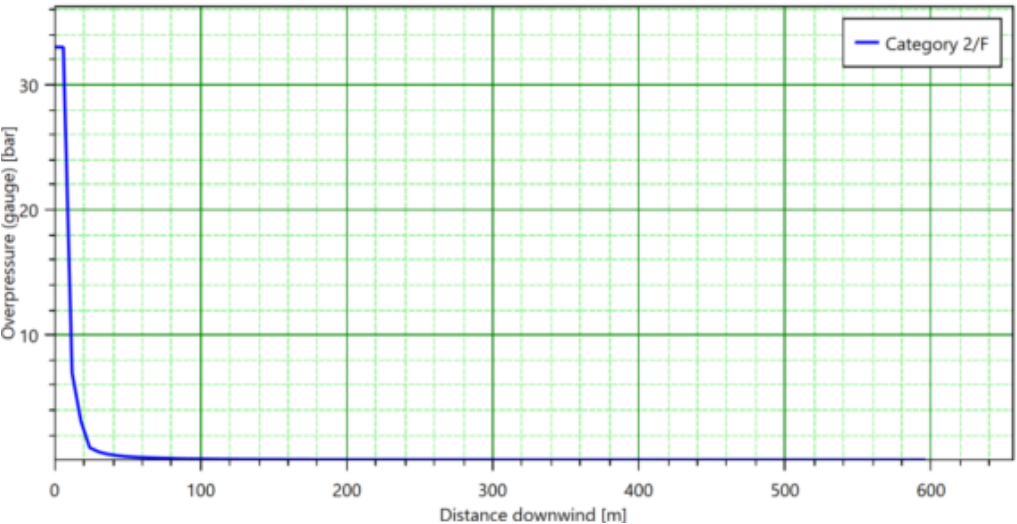
Appendix Figure B-79. LPG Road Tanker Rupture and Fireball: Thermal Dose vs. Distance Downwind



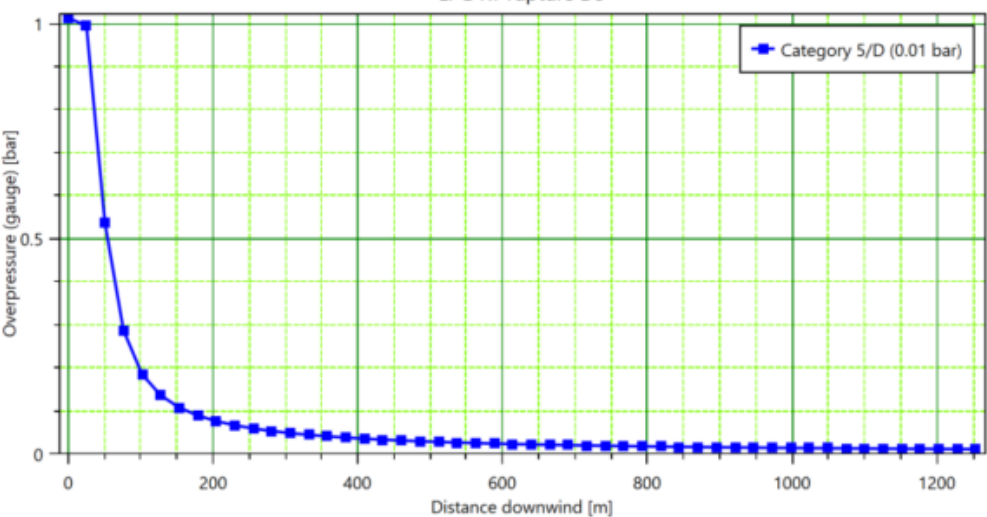
Appendix Figure B-80. LPG Road Tanker Rupture and BLEVE: Overpressure vs. Distance Downwind, Category D5



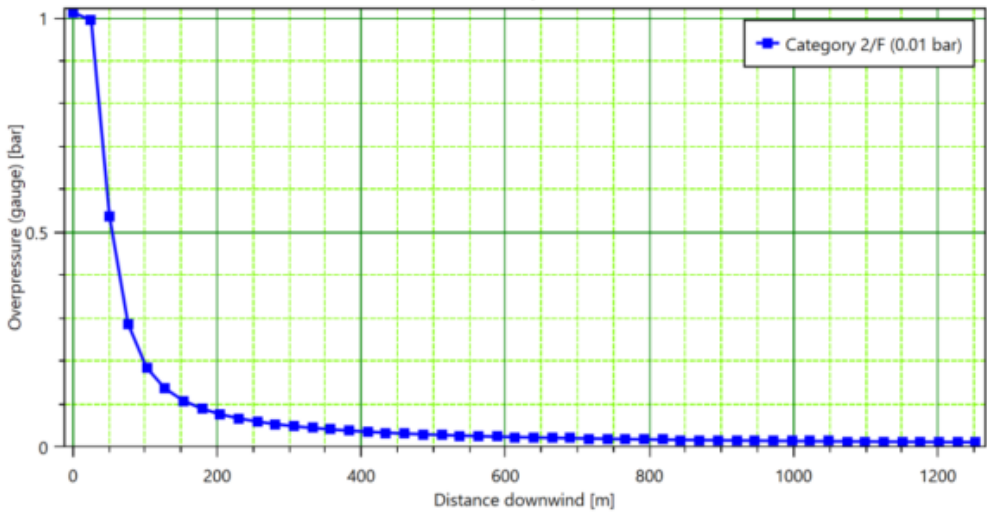
Appendix Figure B-81. LPG Road Tanker Rupture and BLEVE: Overpressure vs. Distance Downwind, Category F2



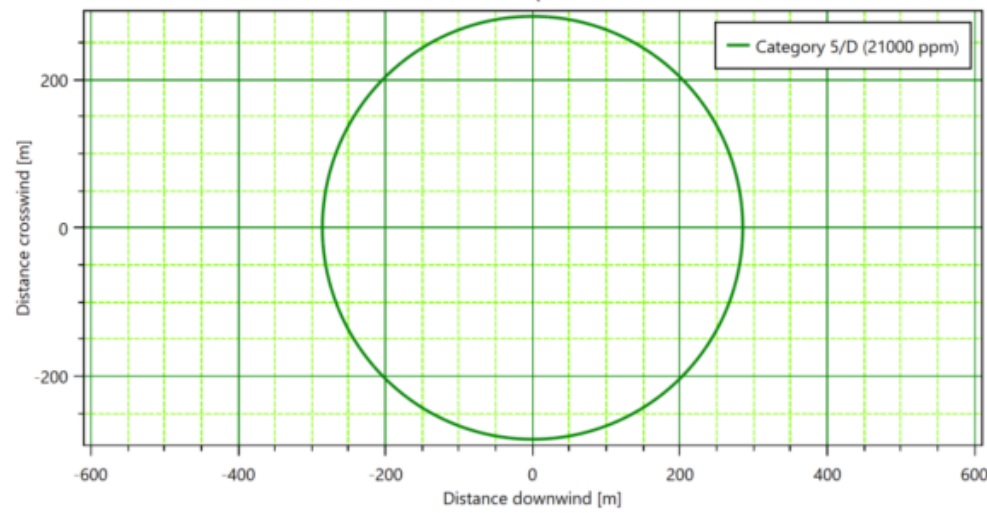
Appendix Figure B-82. LPG Road Tanker Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



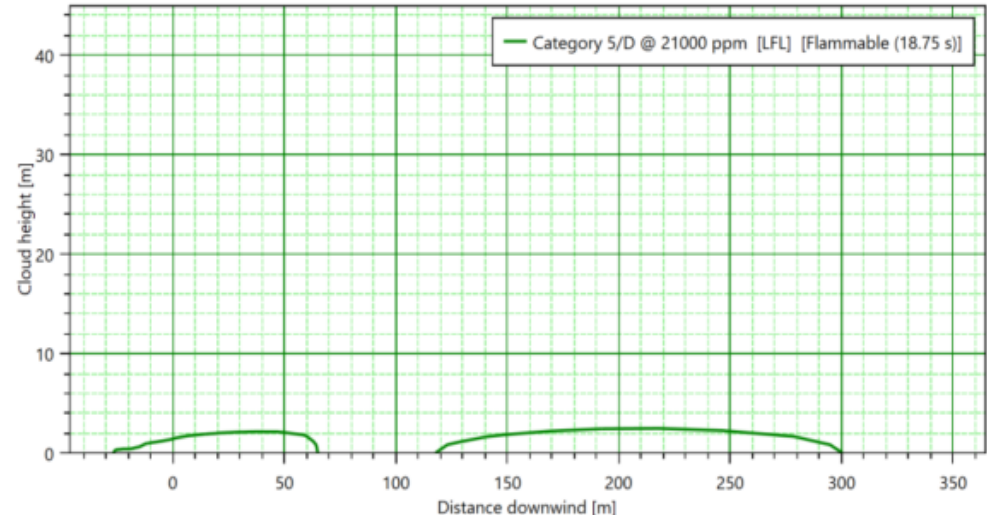
Appendix Figure B-83. LPG Road Tanker Rupture and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



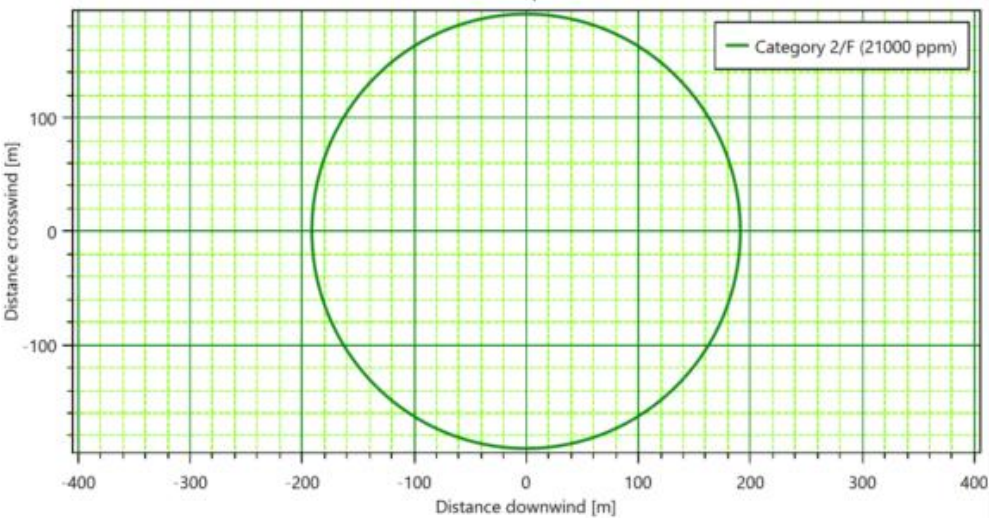
Appendix Figure B-84. LPG Road Tanker Rupture and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category D5



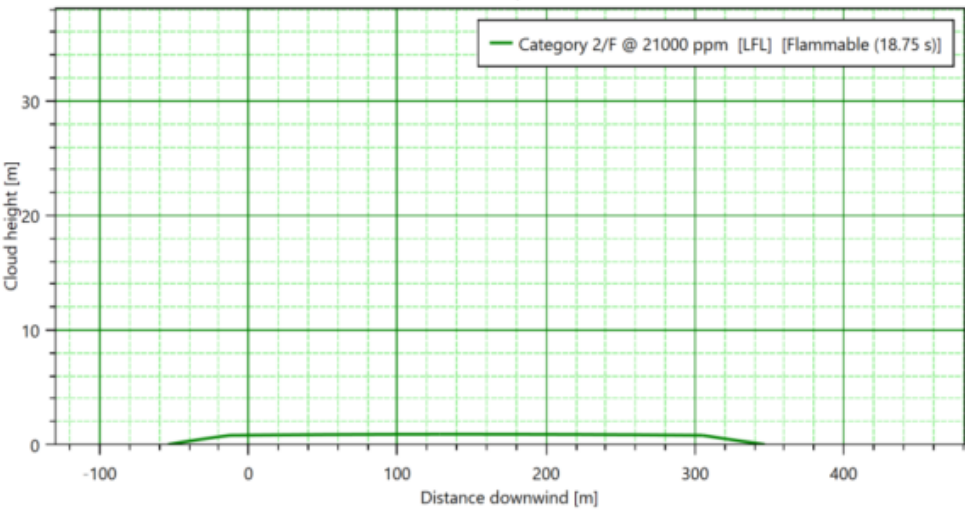
Appendix Figure B-85. LPG Road Tanker Rupture and Flash Fire: Dispersion Side View, Category D5



Appendix Figure B-86. LPG Road Tanker Rupture and Flash Fire: Flash Fire Envelope at 1.5 metre receptor height, Category F2

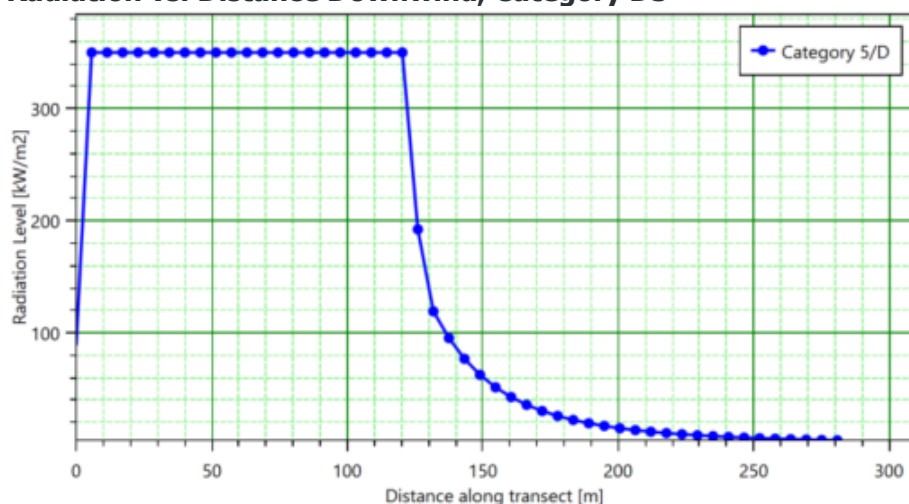


Appendix Figure B-87. LPG Road Tanker Rupture and Flash Fire: Dispersion Side View, Category F2

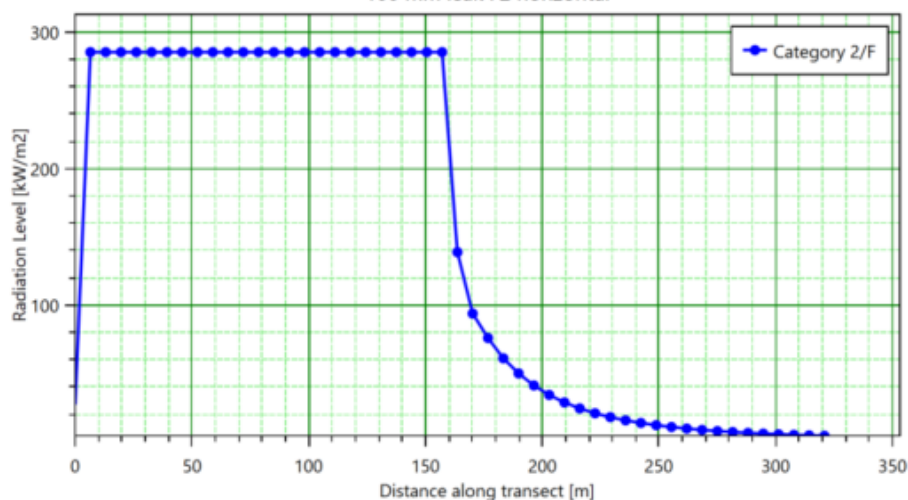


Installation	LPG Road Tanker (Propane)
Scenario	LPG Road Tanker Largest Connection Leak or Hose Rupture (100 mm diameter)
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Jet Fire Cone Model TNO Multi Energy Model
Discharge/ Jet Fire /Dispersion Model Source Term	28000 kg of propane at 25 barg and ambient temperature
Vapour cloud explosion source term	Flammable mass 98/77 kg at source of horizontal release (confined region), Category D5/F2 Flammable mass 104/86 kg at source of vertical release (confined region), Category D5/F2

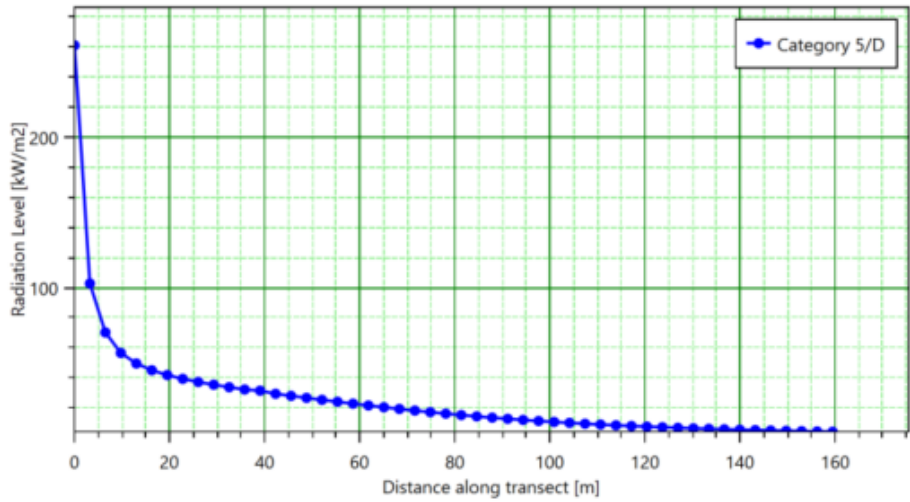
Appendix Figure B-88. LPG Road Tanker 100 mm Leak and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



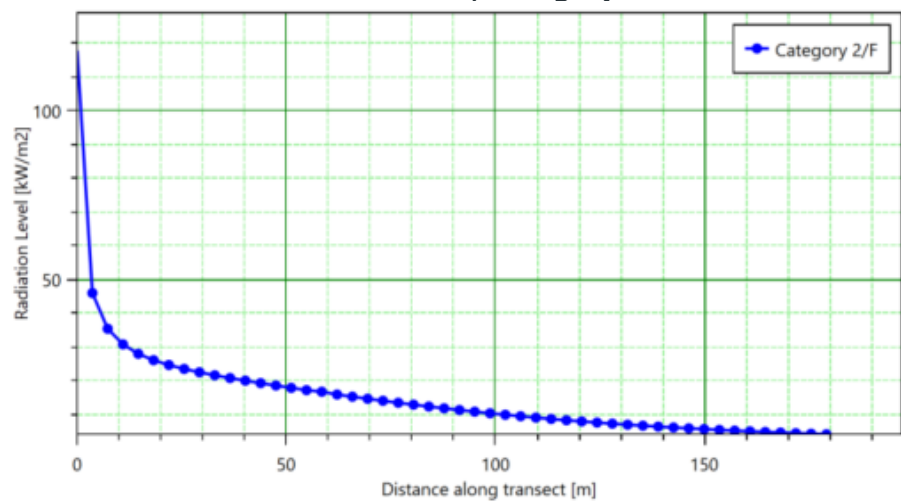
Appendix Figure B-89. LPG Road Tanker 100 mm Leak and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



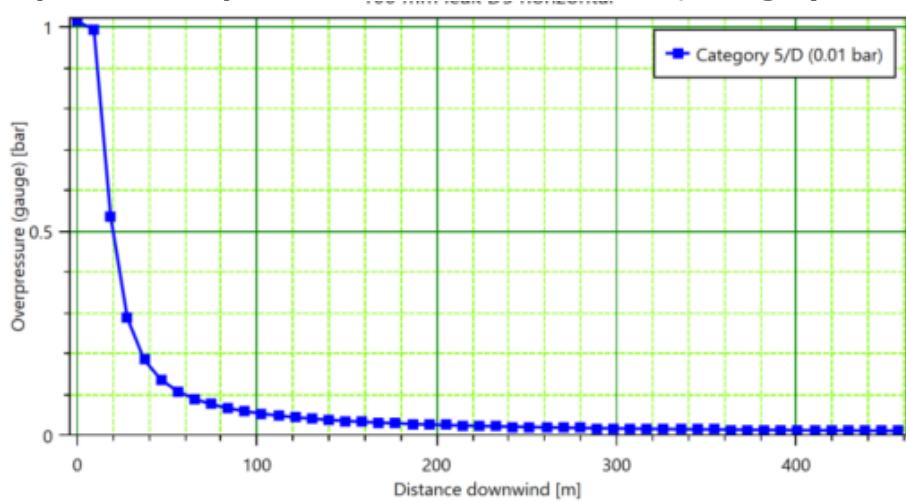
Appendix Figure B-90. LPG Road Tanker 100 mm Leak and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



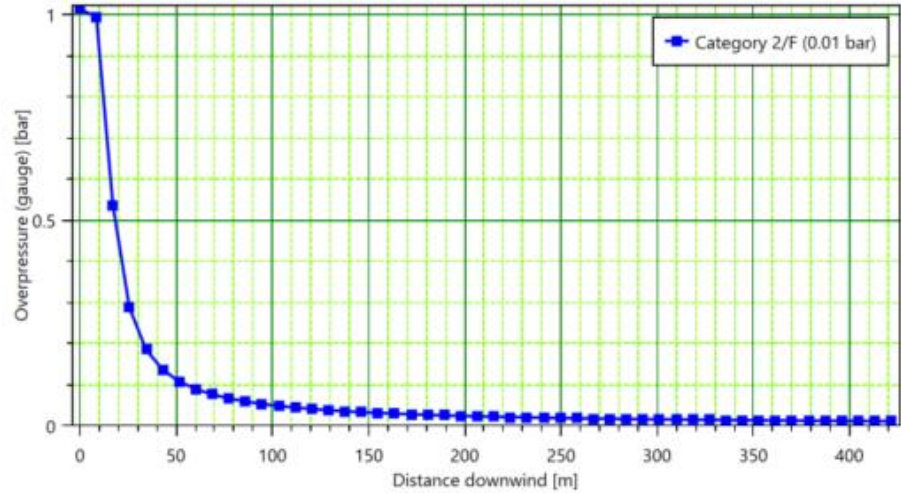
Appendix Figure B-91. LPG Road Tanker 100 mm Leak and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



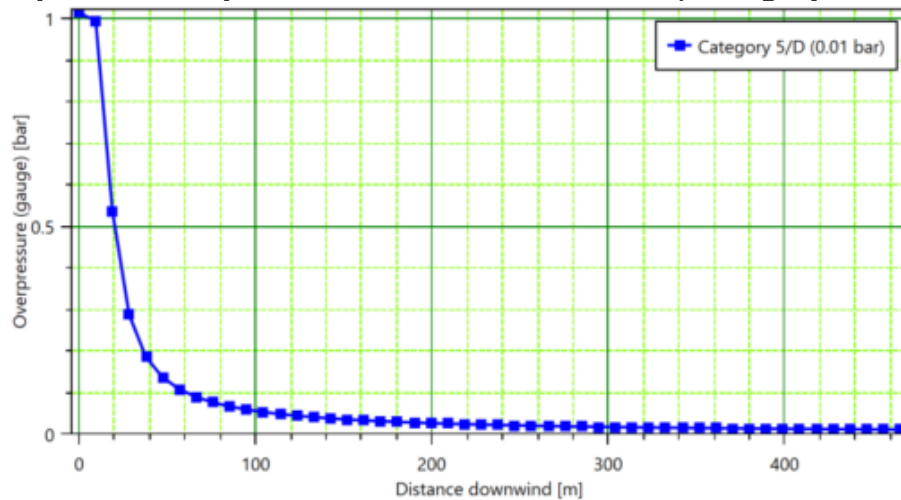
Appendix Figure B-92. LPG Road Tanker 100 mm Leak (Horizontal) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



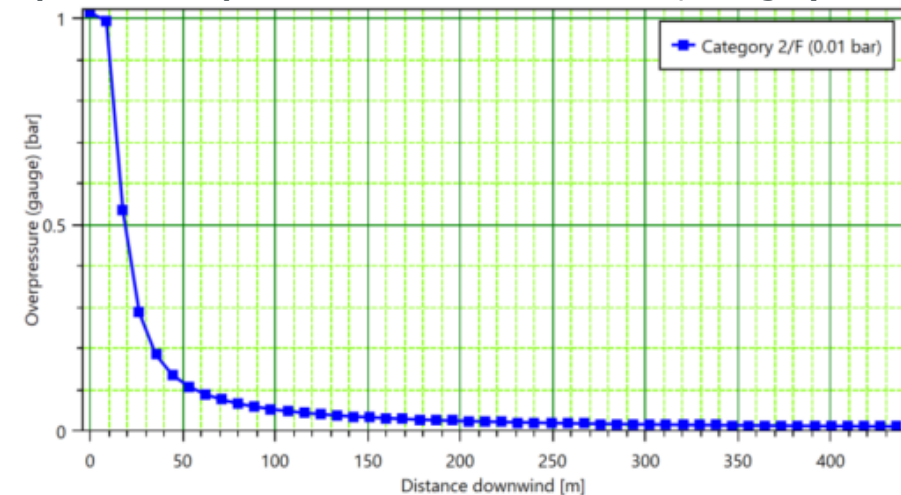
Appendix Figure B-93. LPG Road Tanker 100 mm Leak (Horizontal) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



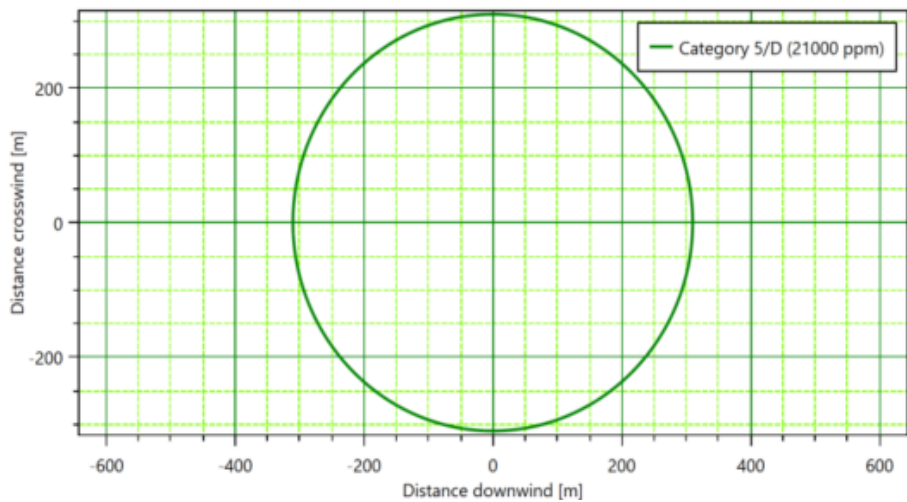
Appendix Figure B-94. LPG Road Tanker 100 mm Leak (Vertical) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



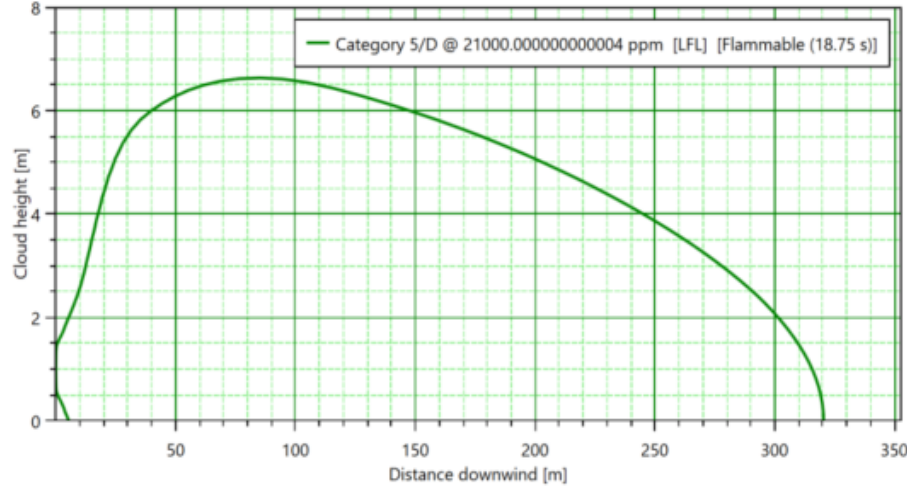
Appendix Figure B-95. LPG Road Tanker 100 mm Leak (Vertical) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



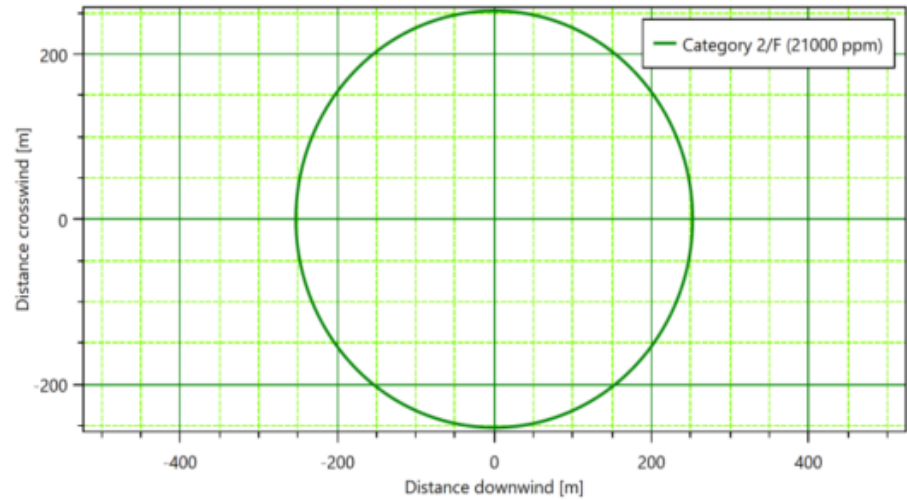
Appendix Figure B-96. LPG Road Tanker 100 mm Leak (Horizontal) and Flash Fire: Flash Fire Envelope, at release height Category D5



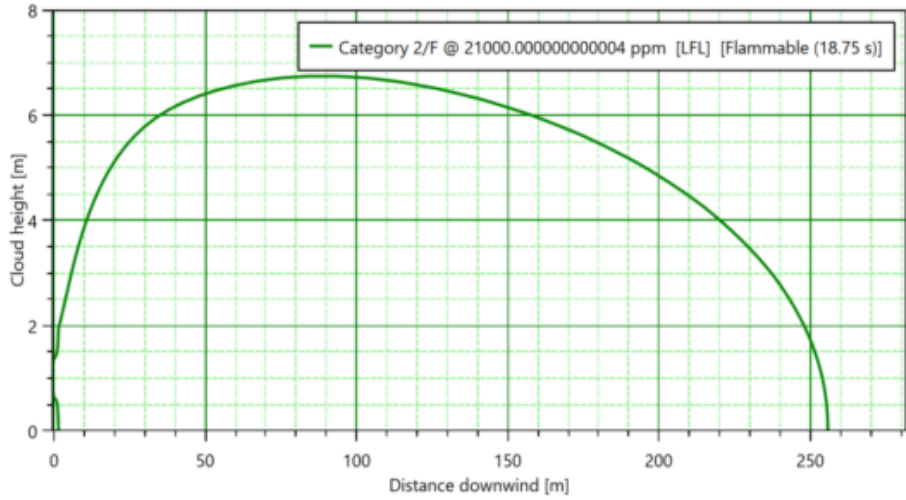
Appendix Figure B-97. LPG Road Tanker 100 mm Leak (Horizontal) and Flash Fire: Dispersion Side View, Category D5



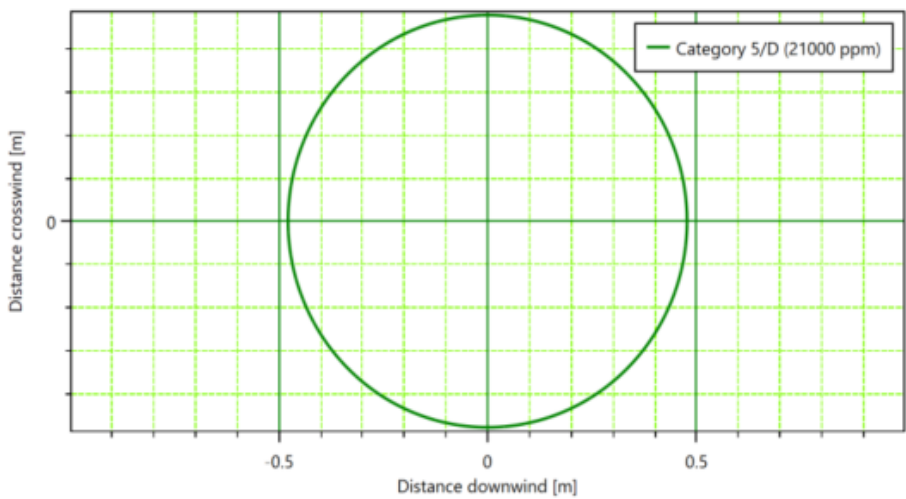
Appendix Figure B-98. LPG Road Tanker 100 mm Leak (Horizontal) and Flash Fire: Flash Fire Envelope at release height, Category F2



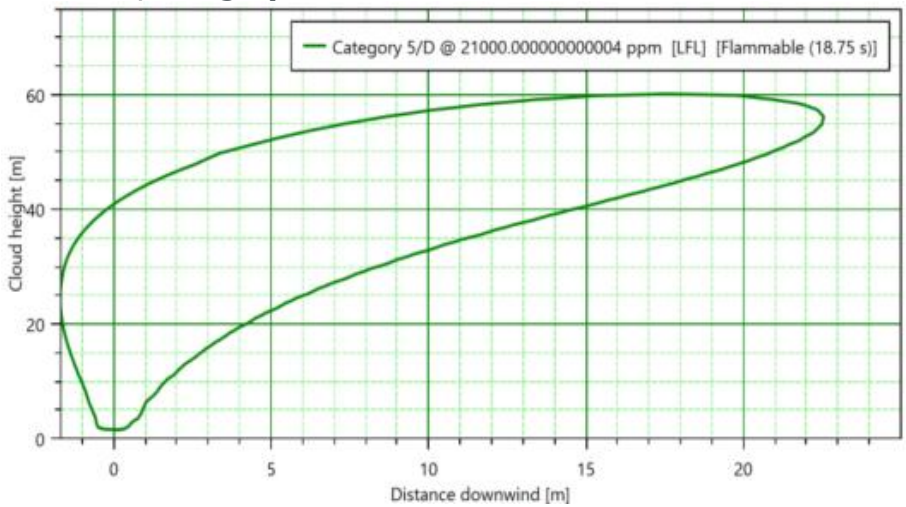
Appendix Figure B-99. LPG Road Tanker 100 mm Leak (Horizontal) and Flash Fire: Dispersion Side View, Category F2



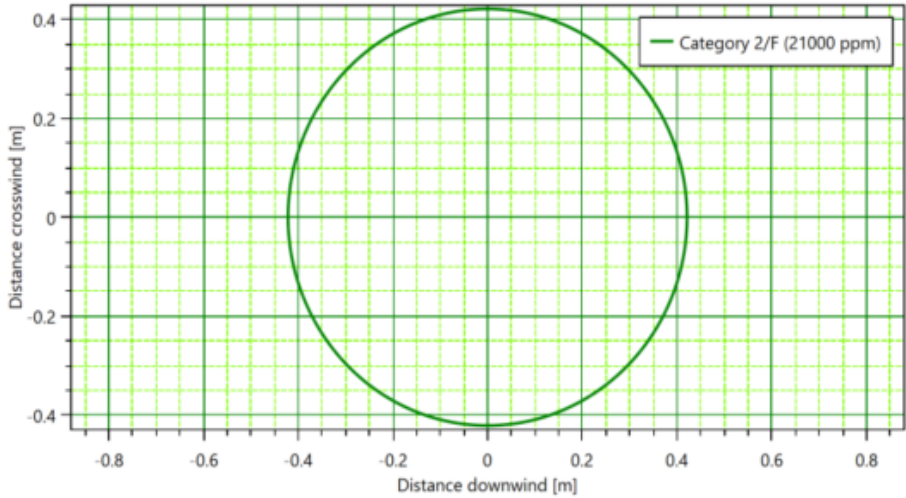
Appendix Figure B-100. LPG Road Tanker 100 mm Leak (Vertical) and Flash Fire: Flash Fire Envelope at release height, Category D5



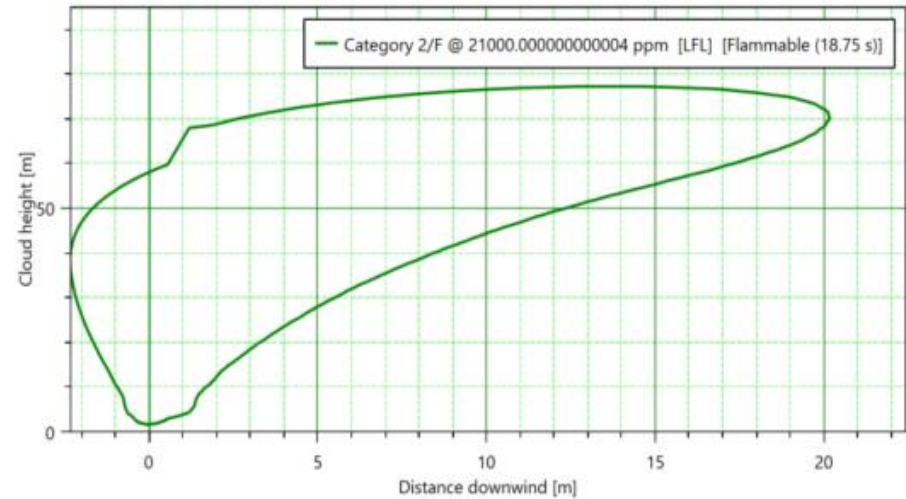
Appendix Figure B-101. LPG Road Tanker 100 mm Leak (Vertical) and Flash Fire: Dispersion Side View, Category D5



Appendix Figure B-102. LPG Road Tanker 100 mm Leak (Vertical) and Flash Fire: Flash Fire Envelope at release height, Category F2

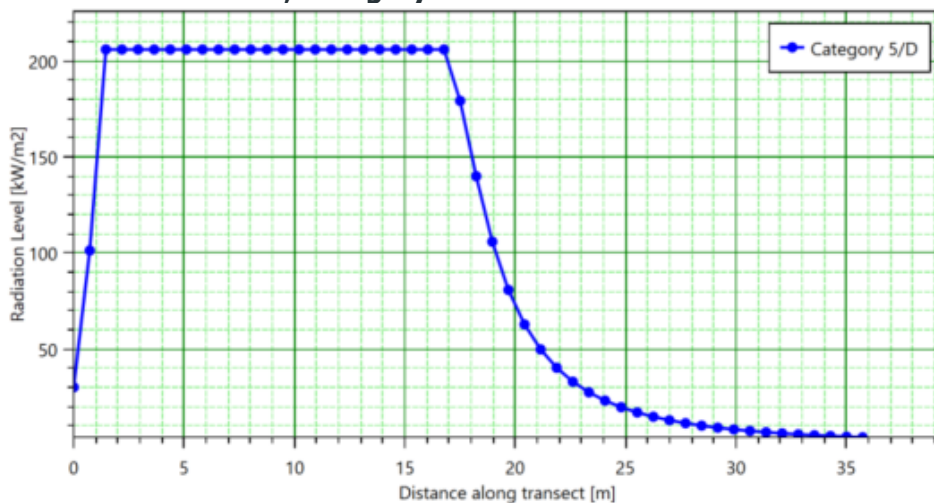


Appendix Figure B-103. LPG Road Tanker 100 mm Leak (Vertical) and Flash Fire: Dispersion Side View, Category F2

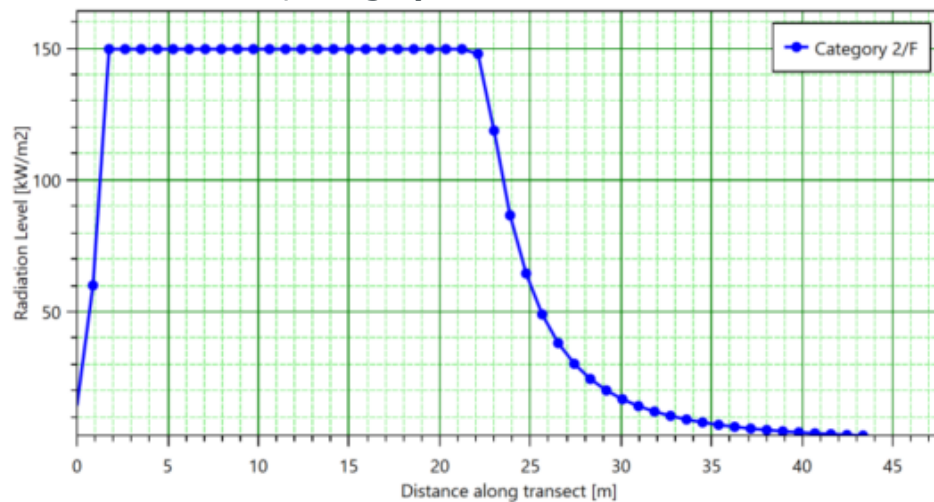


Installation	LPG Road Tanker (Propane)
Scenario	LPG Hose Leak, 10% of Diameter (10 mm diameter hole)
Software/model	DNV PHAST Version 9.1 Leak and Unified Dispersion Models Jet Fire Cone Model TNO Multi Energy Model
Discharge/ Jet Fire /Dispersion Model Source Term	28000 kg of propane at 25 barg and ambient temperature
Vapour cloud explosion source term	Flammable 0.93/1.25 kg at source of horizontal release (confined region), Category D5/F2 Flammable mass 0.39/0.74kg at source of vertical release (confined region), Category D5/F2

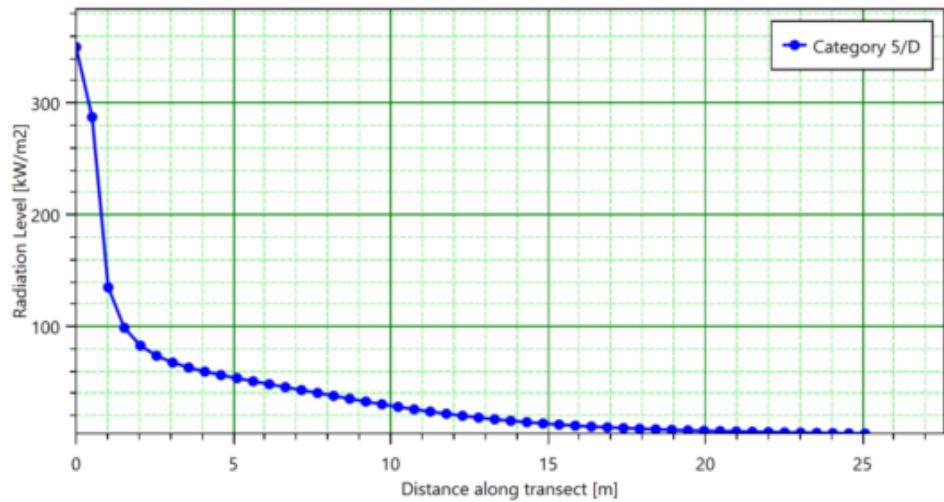
Appendix Figure B-104. LPG Hose Leak 10 mm and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



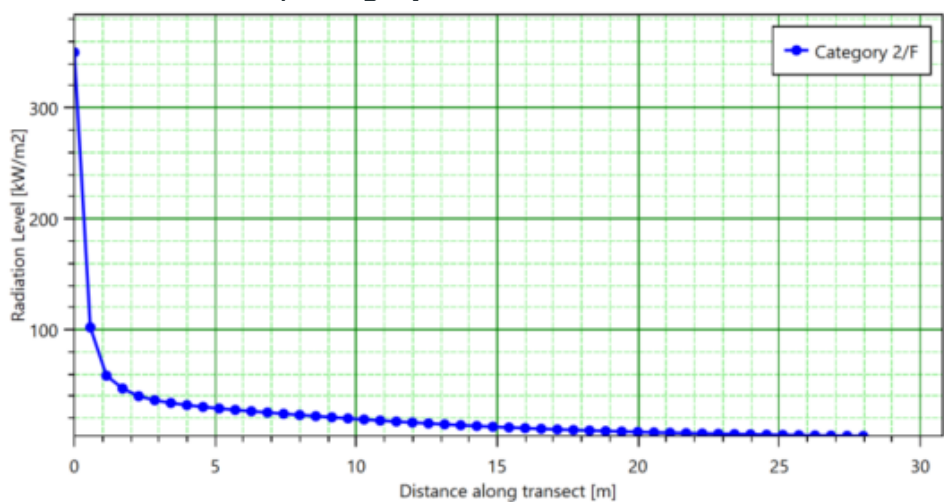
Appendix Figure B-105. LPG Hose Leak 10 mm and Horizontal Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



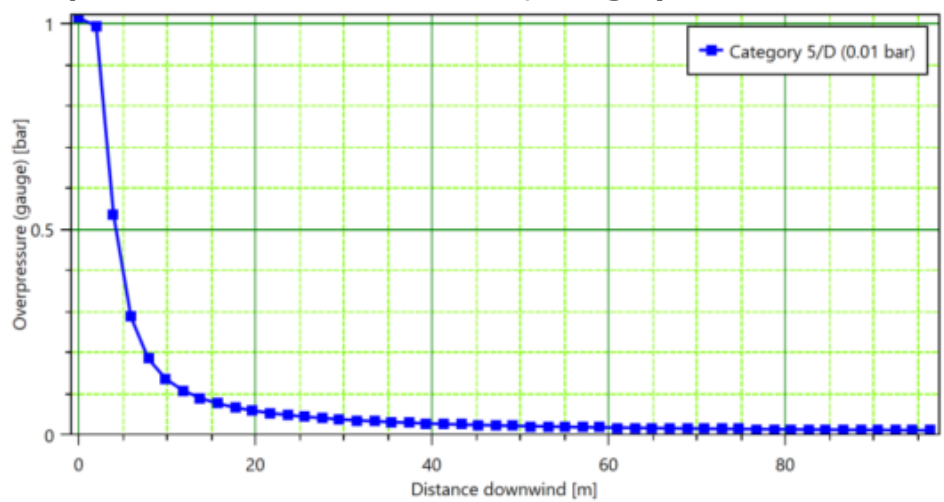
Appendix Figure B-106. LPG Hose Leak 10 mm and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category D5



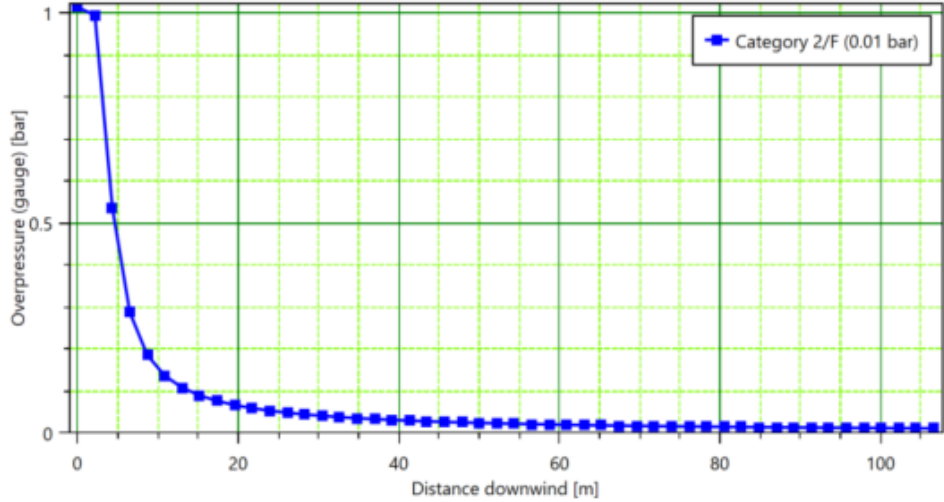
Appendix Figure B-107. LPG Hose Leak 10 mm and Vertical Jet Fire: Thermal Radiation vs. Distance Downwind, Category F2



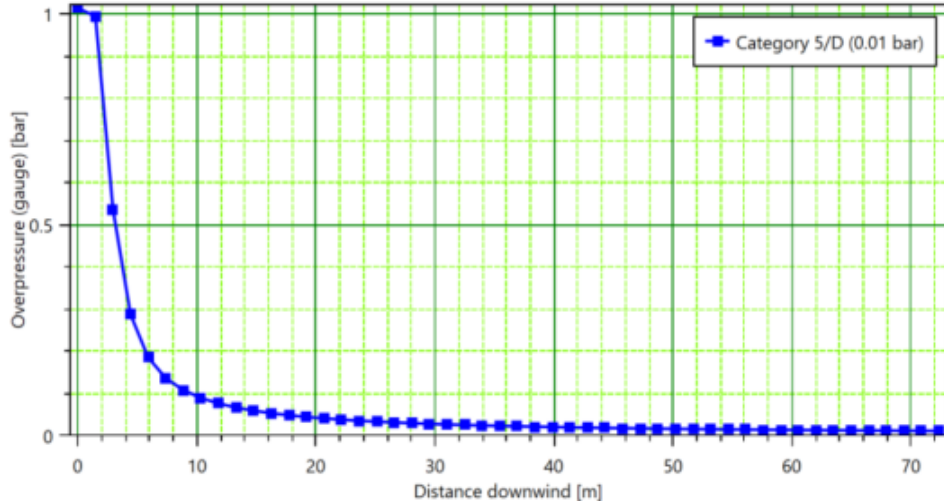
Appendix Figure B-108. LPG Hose Leak 10 mm (Horizontal) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



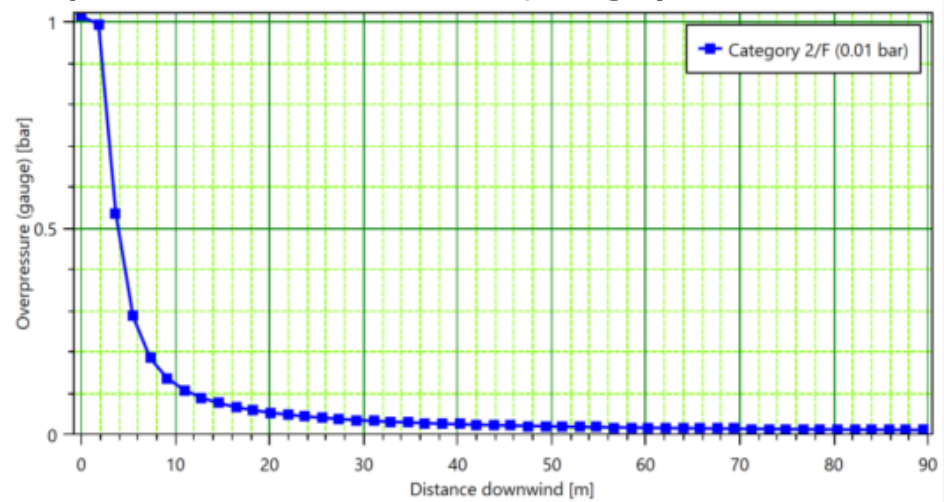
Appendix Figure B-109. LPG Hose Leak 10 mm (Horizontal) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



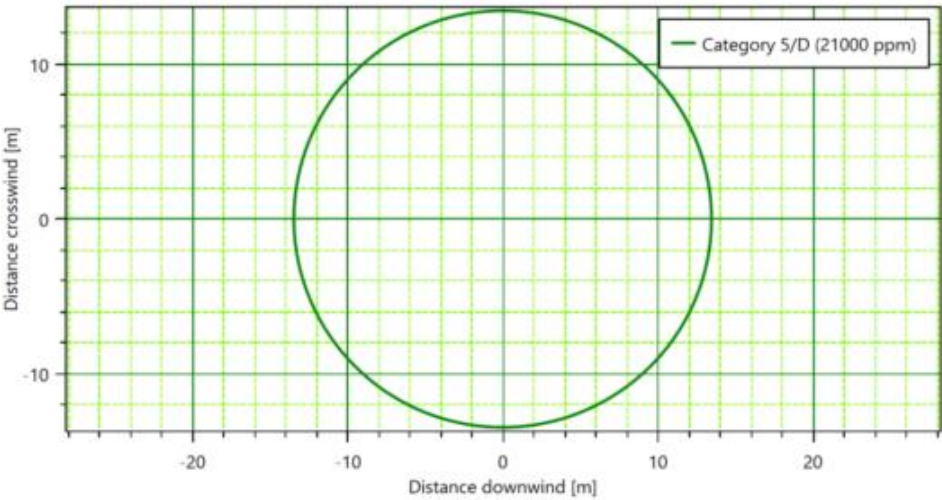
Appendix Figure B-110. LPG Hose Leak 10 mm (Vertical) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category D5



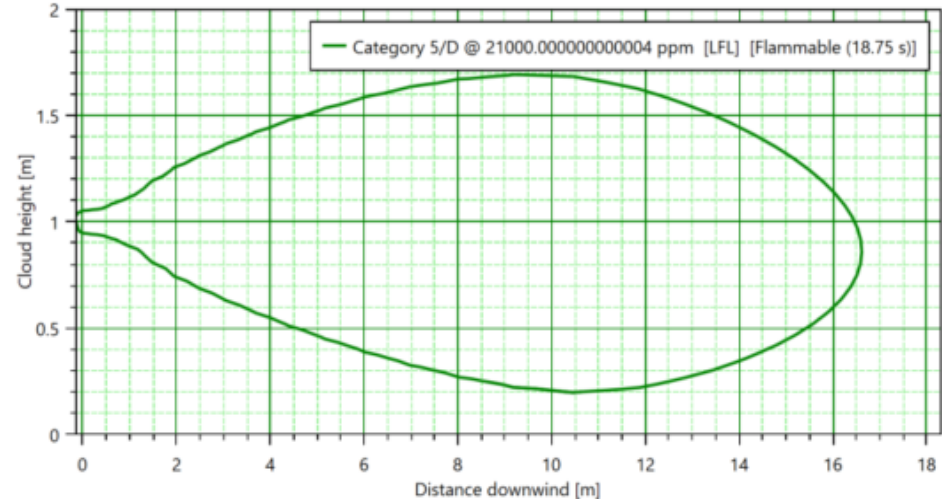
Appendix Figure B-111. LPG Hose Leak 10 mm (Vertical) and Vapour Cloud Explosion: Overpressure vs. Distance Downwind, Category F2



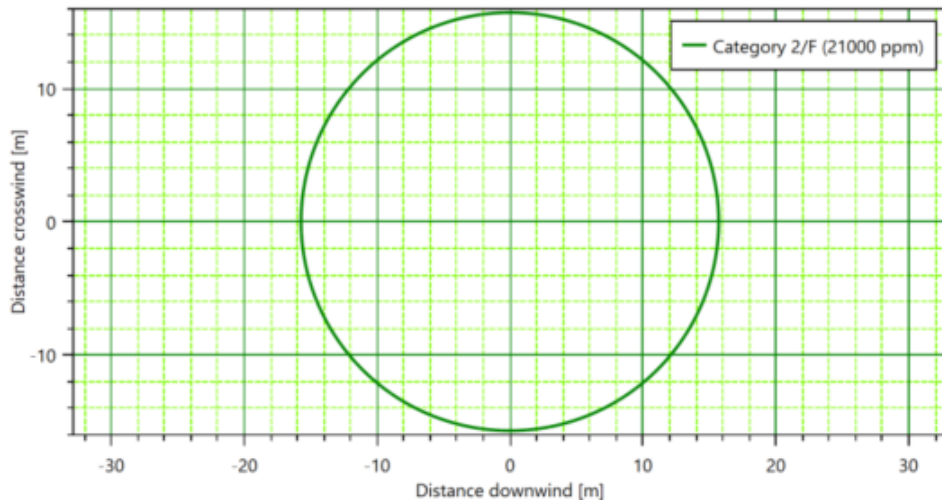
Appendix Figure B-112. LPG Hose Leak 10 mm (Horizontal) and Flash Fire: Flash Fire Envelope, at release height Category D5



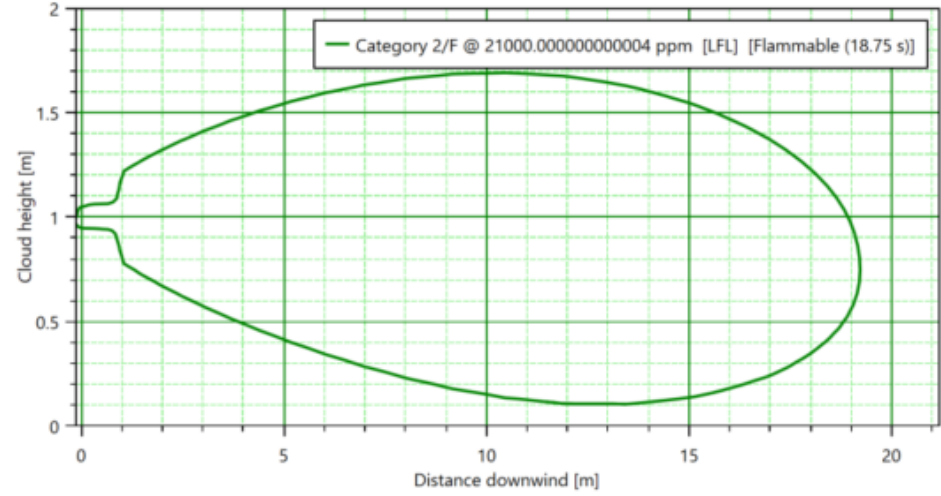
Appendix Figure B-113. LPG Hose Leak 10 mm (Horizontal) and Flash Fire: Dispersion Side View, Category D5



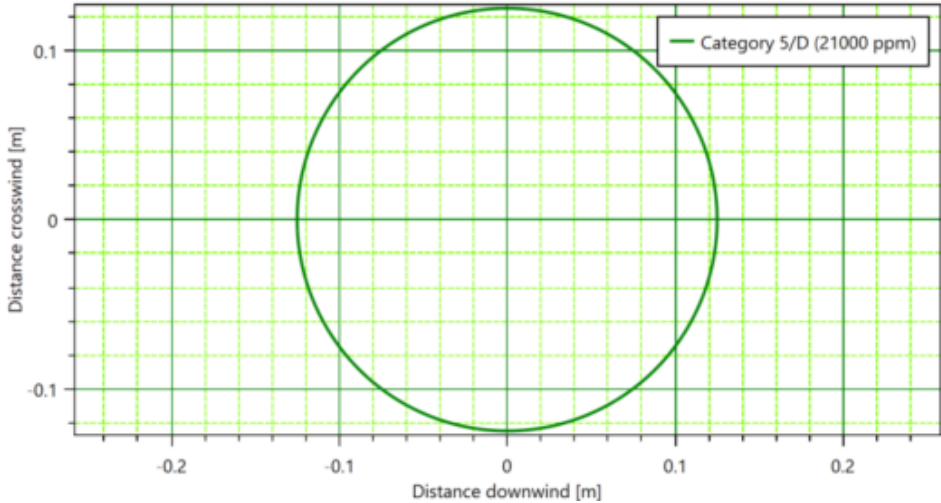
Appendix Figure B-114. LPG Hose Leak 10 mm (Horizontal) and Flash Fire: Flash Fire Envelope at release height, Category F2



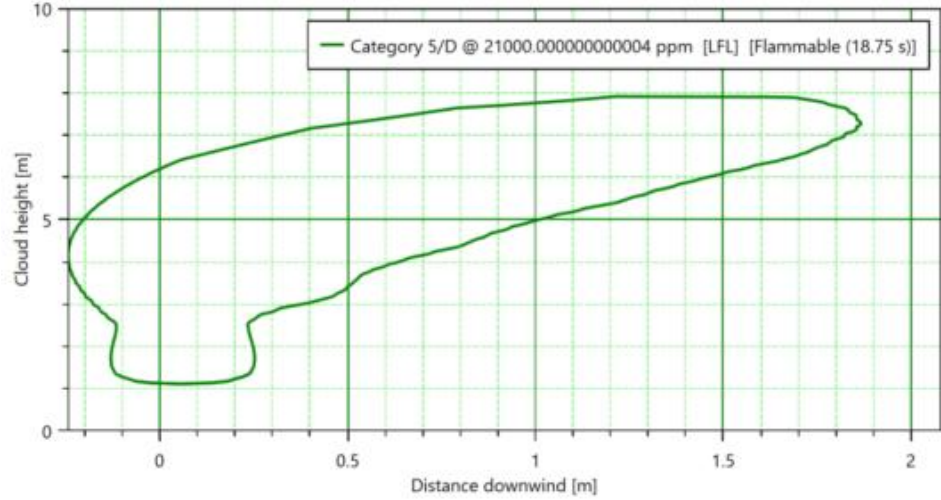
Appendix Figure B-115. LPG Hose Leak 10 mm (Horizontal) and Flash Fire: Dispersion Side View, Category F2



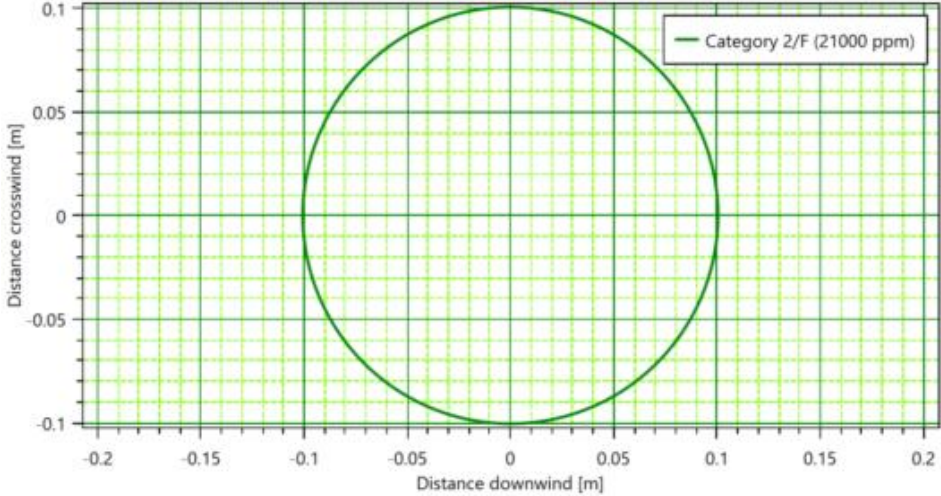
Appendix Figure B-116. LPG Hose Leak 10 mm (Vertical) and Flash Fire: Flash Fire Envelope at release height, Category D5



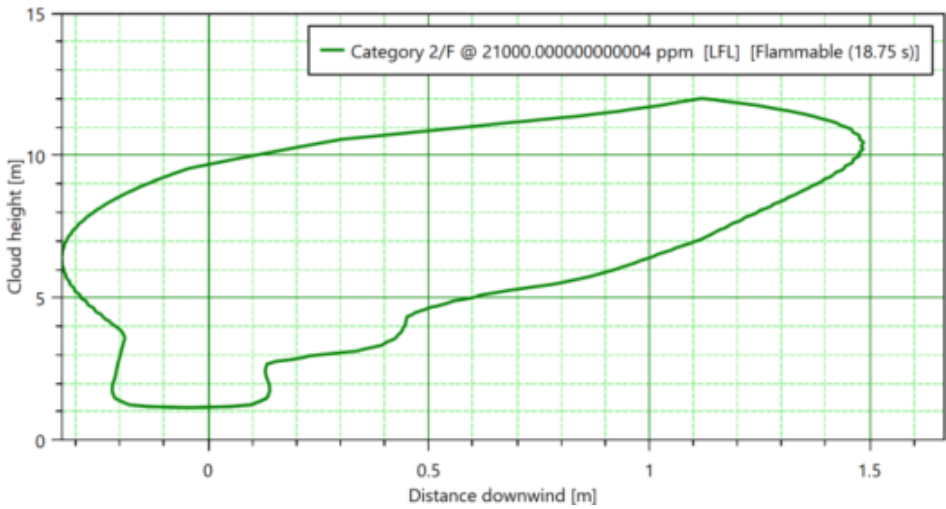
Appendix Figure B-117. LPG Hose Leak 10 mm (Vertical) and Flash Fire: Dispersion Side View, Category D5



Appendix Figure B-118. LPG Hose Leak 10 mm k (Vertical) and Flash Fire: Flash Fire Envelope at release height, Category F2



Appendix Figure B-119. LPG Hose Leak 10 mm (Vertical) and Flash Fire: Dispersion Side View, Category F2



Installation	Bulk Diesel Storage Tanks
Scenario	Tank Rupture (Inner and outer shell), Bund Overtopping, Pool Fire Off site to East
Software/model	DNV PHAST Version 9.1 2-Zone Pool Fire Model
Discharge/ Pool Fire Source Term	1667.5 m ³ of diesel (50% of tank contents) 100 m diameter pool

Appendix Figure B-120. Diesel Tank Rupture and Uncontained Pool Fire: Thermal Radiation vs. Distance Downwind

