AGRI ENERGY LIMITED

PROPOSED ETHANOL PRODUCTION FACILITIES

PRELIMINARY HAZARD ANALYSIS

CONDOBOLIN SITE

ENVIRONMENTAL RESOURCES MANAGEMENT AUSTRALIA PTY LTD

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Title: **Agri Energy Limited** **Proposed Ethanol Production Facilities** **Preliminary Hazard Analysis** **Condobolin Site**	**QA Verified:** K BROOKES
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1. EXECUTIVE SUMMARY AND RECOMMENDATIONS

1.1. Purpose and Scope

Agri Energy Limited (AEL) is in the process of seeking project approval for the development of an ethanol production facility at Condobolin, New South Wales (NSW), under Part 3A of the *Environmental Planning and Assessment Act, 1979 (*EP&A Act). The production facility will be capable of producing 200 Megalitres (ML) of ethanol annually and also stores petrol used to denature the produced ethanol. In addition, several holding dams containing water, an effluent treatment facility and an irrigation area will be developed. The irrigation area will be irrigated with process wastewater as part of a wastewater recycling scheme. The proposal will have a development cost exceeding $30 million and is therefore a 'major project' to which Part 3A of the EP&A Act applies. As such, it will be determined by the Minister for Planning.

ERM advised Sherpa that the Director General's Requirements (DGRs) for the proposed facility include the following requirement:

Hazards and Risk – including a Preliminary Hazard Analysis (PHA) in accordance with Hazardous Industry Planning Advisory Paper No 6 – Guidelines for Hazard Analysis and Multi Level Risk Assessment and details of fire/ emergency measures and procedures

Environmental Resources Management Australia Pty Ltd (ERM) has engaged Sherpa Consulting Pty Ltd (Sherpa) to undertake the PHA.

This PHA relates to the Condobolin development. Separate applications for approval are being lodged by AEL for 200 ML ethanol production facilities at Coleambally and Oaklands in NSW.

1.2. Study Objectives

The need for a PHA was triggered by the DGRs, and the process will be in accordance with the Department of Infrastructure, Planning and Natural Resources (DIPNR) Hazardous Industry Planning Advisory Paper No 6 – Guidelines for Hazard Analysis (Ref.1) and DIPNR Multi Level Risk Assessment (Ref.2).

Reference is also made to the screening methods outlined in NSW State Environmental Planning Policy No. 33 (SEPP33 - Ref.3).

1.3. PHA Process

The DIPNR Multi-level Risk Assessment Guideline (Ref.2) was consulted to identify the most appropriate level of risk assessment.

This PHA is based on a Level 2 Risk Assessment where the results are sufficiently quantified to allow an assessment of the offsite risk levels against acceptance criteria.

The risk assessment process and risk acceptance criteria set out in Hazardous Industry Planning Advisory Paper (HIPAP) No. 6 (Ref.1) and HIPAP 4 (Ref.4) were followed.

1.4. Limitations

- This PHA is based on data supplied by AEL, PDF and ERM. Distances to the site boundary and bund dimensions were interpreted from the preliminary site layout plans.
- This report contains assumptions relating to site layout and process conditions. These are identified in the report.
- The Director General's Requirements for the site included the preparation of for a PHA in accordance with DIPNR Multi-level Risk Assessment Guideline (Ref.2); hence, this document does not include a comprehensive review against SEPP 33; however, Section 4 provides a discussion of SEPP 33 issues relating to Dangerous Goods transport.

1.5. Findings

- The PHA was carried out in accordance with DIPNR guidance: *HIPAP 6* and *Multi-level Risk Assessment*.
- A HAZID review meeting was held between the designers, Process Design and Fabrication (PDF), and Sherpa to identify potential hazard scenarios, their causes, consequence and safeguards in place in the design. The outcome of the HAZID was a set of 5 Major Accidents (MAs) with the potential for offsite impact, which were carried forward for quantification. These were:
  - Ethanol full surface bund fire in the bulk storage area
  - Petrol full surface bund fire in the bulk storage area
  - Ethanol spray fire in the distillation process area
  - Ethanol pool fire at the tank truck loading area
  - Petrol pool fire at the tank truck loading area
- The consequences of the MAs identified were assessed using the proprietary consequence modelling package *Shell FRED* (Version 4). It was found that these events would not have the potential for offsite impact (fatality, injury or offsite escalation) and thus would not affect adjacent public places.
- Accidental emissions (spills) of ethanol, petrol and other chemicals will be captured in the tank bunds and directed to the site interceptor for recovery. Therefore, the potential effects of an accidental emission will not affect the long-term viability of the ecosystem of any sensitive natural environmental areas.

- Whilst there is potential for escalation between the tanks in the Ethanol and Petrol storage area, the consequences would be no worse than the full surface bund fire modelled (found not to have potential for offsite impact).
- The development was screened against *SEPP 33* and it was found that a Route Selection Study (Ref. 5) may be required due to the volume of vehicle movements proposed to transport the produced ethanol.

1.6. Conclusions

- The identified hazardous events at the site, viz. ethanol and petrol fires, would not have the potential for offsite impact (fatality, injury or offsite escalation); therefore:
  - The offsite individual and societal risk of injury, due to heat radiation, from the development would not exceed the 50×10^{-6} per year NSW Land-Use Safety Planning risk criteria for heat radiation injury.
  - The risk of accident propagation offsite from the development would not exceed the 50×10^{-6} per year NSW Land-Use Safety Planning risk criteria for accident propagation.
- The potential effects of an accidental emission will not affect the long-tem viability of the ecosystem of any sensitive natural environmental areas.

1.7. Recommendations

1. As the design develops the project is required to complete a number of other safety and risk studies in accordance with the NSW Department of Planning Seven Stage Approval Process and as requested by the Director General, viz.:

Project Phase	Safety Study
Design Stage	Hazard and Operability Study
	Final Hazard Analysis (updating this PHA)
	Fire Safety Study
	Emergency Plan
Construction/Commissioning Stage	Construction Safety Study
Operational Stage	Safety Management System
	Independent Hazard Audit

2. It is recommended that the project develop a Safety Management System in accordance with HIPAP 9 (Ref.6).
3. It is recommended that the project develop an Emergency Plan in accordance with HIPAP 1 (Ref.7).
4. It is recommended that assumptions made in this report be re-checked when more detailed information is available; e.g. the distance from the Ethanol Storage area to the site boundary should be checked to ensure that the separation distance of greater than 85m is maintained such that the consequences of a fire in this area remain on site (see Section 5).

5. Subject to the Director General's requirements, a Route Selection Study (Ref.5) may be required due to the volume of vehicle movements proposed to transport the produced ethanol.
6. It is recommended that the latest revisions of the appropriate Australian Standards (including those identified in this document, viz.: AS 1940, Building Code of Australia, AS60079.10) are consulted during the Design Stage.

2. SITE DESCRIPTION

2.1. Location

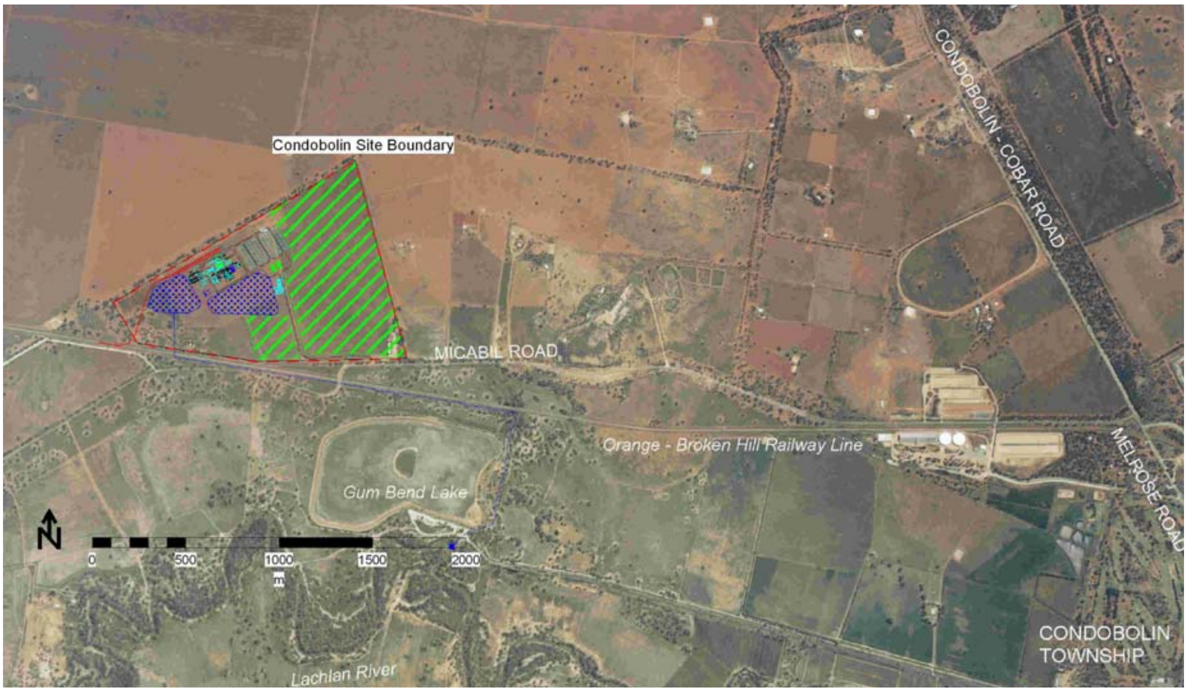
The site of the proposed ethanol production facility is wholly within the local government area of Lachlan. It is located along Micabil Road approximately five kilometres west of Condobolin. Condobolin is situated in the Central West region of NSW, approximately 460 km west of Sydney and 100 km west of Parkes.

The site is approximately 96 hectares (ha) and comprises one land parcel, identified as Lot 32 on Deposited Plan 752093; Parcel ID 5804. An aerial photograph showing the location of the site is presented in Figure 2.1. Topography is relatively flat with a gradual rise to the east.

The land adjacent to the northern, eastern and western site boundaries accommodates open agricultural land and there are scattered rural residences to the east, including a residence approximately 100m from the eastern site boundary. Micabil Road and the Orange-Broken Hill Railway line run along the southern boundary of the site.

The nearest residential area to the site is the Condobolin township, approximately five kilometres to the east. The closest water body is Gum Bend Lake, approximately 330 metres to the south.

FIGURE 2.1: SITE LOCATION



The ethanol production plant will have a footprint of approximately 300m x 300m and will include the following areas:

- Ethanol Production
  - Grain storage

  - Grain milling
  - Fermentation
  - Liquefaction and saccharification
  - Distillation
  - Ethanol storage
- Utilities
  - Steam Raising
  - Petrol Storage
  - Chemical storage
- Other
  - Maintenance workshop and general storage
  - Office/administration

The main areas are shown in Figure 2.2.

FIGURE 2.2: PROCESS PLANT LAYOUT

2.2. Process

2.2.1. Grain Receival and Storage

Grain is hauled to the site by truck and unloaded at one of two unloading areas where the grain will be stored prior to processing:

- a grain receival platform where the grain will be discharged into a collection hopper and conveyed to one of two 7000 tonne storage silos; and
- a grain storage area, which will consist of six separate grain bunkers, each approximately 30m wide, 200m long and up to 20m high, with a capacity of 20,000 tonnes. Once a bunker is formed, it will be covered with plastic tarpaulin to protect the grain from parasites, birds, rain and wind.

A Grain Receiving Dust Collector collects the dust from the grain unloading operation and returns it to the process ahead of the hammermill.

The ethanol production process requires a constant supply of grain. At full production of 200 ML of ethanol per year, the plant will require approximately 1600 tonnes of grain per day or 67 tonnes per hour. This grain will be fed to the plant from a small ‘shift silo’ with a 1300 tonne capacity. Grain is to be transported to the shift silo via two ways, dependent on whether the grain is being sourced from the grain storage silos or from the bunker storage area.

For retrieval from the storage silos, a screw feeder and elevator at the bottom of the source silo will be used to convey grain to the shift silo. This system will include dust extraction and filtering facilities to eliminate dust emissions.

For retrieval from the bunker storage area, grain will be picked up by a front-end loader and fed into a mobile dump hopper positioned over a belt conveyor. The belt conveyor will feed the grain to the main feed conveyor and on to a screening station which will include a dust collecting and filtering system to eliminate dust emissions. The grain will then be elevated to the shift silo.

2.2.2. Milling and Slurry Preparation

As part of the production process the grain needs to be milled and then mixed into slurry via the following process:

1) grain from the shift silo will be gravity fed to the hammermill where it is milled;

2) the hammermill dust collectors extract dust by vacuum from appropriate points in the milling system circuit and direct it to a bag filter, which will collect the dust and return it to the mill discharge conveyor;

3) a monitored weight of milled grain flour will be mechanically conveyed to a pug mixer, where a ‘slops mix’, comprising recycled process water from the distillation and evaporation operations will be added to form a slurry of appropriate density;

4) from the pug mixer, the slurry mix will be directed to a mixing tank where additional slops or process water can be added to make up the correct slurry density and percent solids; and

5) the mixed slurry preparation (mash) will be pumped from the mixing tank to the pre-liquefaction tank via one of two discharge pumps (operating and spare) for liquefaction.

2.2.3. Chemical Preparation

A separate building has been designed to receive and prepare a range of chemicals used as part of the ethanol production process. The chemical preparation area consists of a series of small mixing tanks fitted with access platforms, mixing agitators (where required), dosing delivery pumps and pipe work. Packaged chemicals will be fed by forklift or manually from the bag or container into the respective mixing tank. Once prepared, the chemical mix is to be piped to the required process stage.

2.2.4. Liquefaction Stage

Liquefaction is the process of converting insoluble starch in the mash to a soluble starch mix by enzyme reaction at an elevated temperature. An enzyme mix prepared in the chemical preparation area is metered as a liquid into the pug mixer and the pre-liquefaction tank.

The mash is strained and heated, and then pumped to the liquefaction tank in the preparation building for processing of the insoluble starch. The liquefaction tank is sealed, insulated and agitated and the reaction takes up to four hours depending upon grain type.

From the liquefaction tank the mash is pumped to the pre-saccharification tank via mash coolers, which flash cool the mash with non-contact cooling water and lower its temperature to approximately 60 degrees Celsius.

2.2.5. Saccharification Stage

Saccharification is the enzymatic conversion of the soluble starch to glucose. The reaction occurs in the pre-saccharification tank which is also sealed, insulated and agitated, and continues in the pre-fermentor and the fermentor tanks. The reaction requires the addition of another enzyme mix, which is metered as a liquid into the pre-saccharification tank.

From the pre-saccharification tank the mash is pumped to a pre–fermentor tank via coolers which again flash cool with non-contact cooling water. Vented emissions are collected and sent to the process vent scrubber, where they are scrubbed, using chilled water. Emissions from the scrubber are discharged to the atmosphere, and the water is returned to the beer well for distillation of the dissolved alcohol.

2.2.6. Fermentation Stage

Fermentation is the conversion of glucose to ethanol and carbon dioxide by the action of yeast. Propagated yeast and other chemicals that promote and sustain the reaction are added to the pre–fermentor tank. The mash containing yeast and nutrient is then pumped to one of three stainless steel fermentor tanks. Once a tank is filled, it is allowed to react for the required time to achieve maximum conversion of sugars to ethanol (around 45 to 55 hours). This process produces a fermented mash called beer which is emptied to a beer well. The empty tank is then cleaned by the addition of cold caustic soda solution. Once cleaned the tank is filled again for the next cycle. Fermentation is a batch process that occurs continuously by using all three fermentor tanks in series.

The carbon dioxide produced by the fermentation reaction is vented to a fermentation vent scrubber where water is used to scrub residual amounts of ethanol from the carbon dioxide. The cleaned, scrubbed carbon dioxide gas is emitted to atmosphere while the scrubber water is pumped into the beer well.

The beer contains about ten per cent ethanol in addition to non-fermentable grain solids. The beer well acts as a buffer tank to receive the reacted ethanol and mash mix for feed to the distillation stage.

2.2.7. Distillation, Evaporation and Dehydration Stage

For distillation, beer is pumped from the beer well in the fermentation area to the stainless steel mash distillation column, which will contain a number of heating trays. The column operates under a vacuum at a temperature of up to 125 degrees Celsius and is approximately 12 metres high. Distillation occurs in this column and involves boiling off the ethanol from the beer with steam to produce a hydrous ethanol product containing 95 per cent ethanol and five per cent water. The steam is produced from three boilers which are fuelled by natural gas.

The hydrous ethanol is then dehydrated to a fuel ethanol grade by superheating vapour and liquid from the top of the rectifier distillation column and transferring it to molecular sieve vessels, which remove any water from the ethanol product. Product ethanol is then cooled, filtered and transferred to the ethanol storage area.

Vapours from the distillation area condenser systems flow to the process vent scrubber where chilled water is used to scrub residual amounts of ethanol from the air before it is discharged from the scrubber stack to the atmosphere. The water from the scrubber is pumped to the beer well.

The by-product of distillation is slurry containing all unfermentable products, principally water and distiller’s grain. This slurry is transferred from the base of the mash distillation column to a centrifuge, which removes the majority of water. The wet distiller's grain can then be extracted from the centrifuge as a wet cake.

The liquid by-product is transferred to a slops tank where approximately 60 per cent is returned to liquefaction for addition to the milled grain flour at the start of the process.

The remaining 40 per cent is evaporated in a continuous evaporator to reduce the water content and thicken the product to a more concentrated form (syrup), which is pumped to a syrup collection tank. The water stream from the evaporator system is used as process water at the mixer or flows to the secondary treatment plant, which discharges to the effluent dam for pumping to the 55ha irrigation area.

The wet cake (extracted from the centrifuge) is then combined with the syrup in a paddle mixer to form a product containing approximately 30% solids, called WDGS. Half of this product will be sold in this form. The remaining half will be transferred to a flash dryer where it is dried by steam to produce DDGS which has approximately ten per cent moisture content. The dryer exhaust passes through a Thermal Oxidizer which incinerates the emissions from the dryer and then discharges to the atmosphere. The DDGS is cooled and conveyed to the storage and loadout area.

2.2.8. Distillers Grain Storage and Dispatch

WDGS and DDGS will be stored in a dual-purpose shed, which has a concrete bunded bunker for WDGS storage and open-fronted concrete bins for DDGS storage. WDGS will be pumped into B-doubles or semi trailers for trucking to market. A front end loader will be used to pick up DDGS from the bins and load B-doubles or semi trailers for trucking to market. Dust generated during the DDGS loading process is to be collected by the DDGS Loadout Dust Collector.

2.2.9. Ethanol Storage and Dispatch

The cooled ethanol will be transferred to one of two Anhydrous Ethanol Storage Tanks (approximately 1800 m^3 each). Occasionally, problems with the plant may result in production of off-spec product. If this occurs, the product will be diverted to an Off-Spec Storage Tank.

All storage tanks are vented through a vent pipe fitted with an in-line flame arrester and a breather vent valve. All vapours from the Petrol unloading and ethanol loading are collected in vapour recovery lines and sent to the road tanker or the source tank, respectively.

For the production of fuel grade ethanol, Petrol (denaturant) from the Petrol Storage Tank (approximately 170 m^3) is to be metered continuously into the pure ethanol stream during transfer from the product storage tank to the road tanker. This will yield a finished product containing five per cent denaturant. The denaturant tank is sized to hold sufficient denaturant to cover ten days ethanol production.

Ethanol product will be transported to market via B-double trucks. These trucks will be filled at a dedicated loading area designed to comply with the requirements of AS1940:2004.

2.3. Hazardous Materials

Hazardous substances handled at the site include:

- Natural Gas, used for steam raising;
- Ethanol (product);
- Petrol (denaturant);
- Chemical additives
  - Sulphuric Acid;
  - Sodium Hydroxide;
  - Nitric Acid;
  - Aqueous Ammonia; and
  - Urea.

In addition, grain is included due to its potential for dust explosions, and high pressure steam is considered due to the potential for steam boiler explosions. The approximate quantities of each substance to be stored on site are given in Table 2.1.

TABLE 2.1: QUANTITIES OF HAZARDOUS SUBSTANCES STORED AT SITE

Material	UN No	DG Class	PG	Quantity	Unit
Ethanol	1170	3	II	3600	m^3
Petrol	1203	3	II	189	m^3
Sulphuric Acid (94%)	1830	8	II	9,000[(c)]	kg
Sodium Hydroxide (20%)[(a)]	1824	8	II[(a)]	23,000[(c)]	kg
Nitric Acid (20%)[(a)]	2031	8	II[(a)]	9,000[(c)]	kg
Aqueous Ammonia (25%)	2672	8	III	23,000[(c)]	kg
Urea	Not classified			23,000 [(c)]	kg
Grain	Not classified			Silo: 2x7,000,000 Shift Silo: 1x1,300,000	kg
Steam	Not classified			N/A	
(a) Assumed concentration. (c) Assumed based on tank truck capacity.					

In addition, a natural gas distribution pipeline at a pressure of up to 2 bar will feed the boilers. The pipeline will have a small inventory of methane.

The location of each substance is shown in Table 2.2, using areas identified in Figure 2.2.

TABLE 2.2: LOCATION OF HAZARDOUS SUBSTANCES

Area	Stored Substances
Petrol / Ethanol Storage	Ethanol, Petrol
Chemical Storage	Sulphuric Acid, Sodium Hydroxide, Nitric Acid, Aq. Ammonia
Grain Storage & Milling	Grain
Boiler House	Steam

3. HAZARD IDENTIFICATION

3.1. Overview

The hazard identification exercise comprised:

- review of hazards implicit in the chemicals and materials handled at site;
- review of significant incidents in the ethanol processing industry; and
- hazard identification brainstorming session between PDF (project design engineers) and Sherpa, based on available information from a similar plant at Swan Hill in Victoria.

The identified hazards were then extended and developed into hazardous scenarios which could be carried forward for further analysis.

NOTE: The HAZID findings for the ethanol manufacturing process (Appendix 1) were used as the bases for the PHA studies undertaken for all three proposed sites, viz.: Condobolin, Oaklands and Coleambally.

3.2. Hazardous Substance Review

For each substance, chemical and hazardous properties were obtained from the CHRIS information system published by the US Coastguard (Ref.8). Full details are presented in APPENDIX 2.

3.3. Review of Significant Incidents in the Ethanol Production Industry

An example of a significant incident involving Ethanol was a large explosion and fire in a 7,000m^3 Ethanol storage tank at Port Kembla in 2002 (Ref.9). This incident showed the importance of not allowing ignition sources near a vessel storing volatile material. The incident, although spectacular resulted in no fatalities and only one injury. Furthermore, the burn marks visible in the photographs of the site show that the thermal radiation effects were relatively limited; unburnt grass is visible less than a tank diameter from the fire.

3.4. Hazard Identification Brainstorming

The HAZID was conducted by using the Process Flow Diagrams and Process Plant Layouts supplied by PDF for the Swan Hill Plant which is at a more-mature design stage than the Condobolin plant and is essentially of the same design, albeit of a smaller capacity..

The following drawings were used:

06SO12-1-FLS101 Rev 0 Flow Diagram for Milling Section

06SO12-1-FLS102 Rev 1 Flow Diagram for Liquefaction Section

06SO12-1-FLS103 Rev 1 Flow Diagram for Fermentation Section

06SO12-1-FLS104 Rev 1 Flow Diagram for Distillation Section

06SO12-1-FLS501 Rev 1 Flow Diagram for Thin Slop Evaporation Section

06SO12-1-FLS107 Rev 0 Flow Diagram for Storage Section

M06062-0301 Rev F Swan Hill Site Plan

Hazards associated with each section of the plant were discussed, and noted within a table. This is presented in APPENDIX 1.

3.5. Hazardous Incidents Development

Hazardous incident scenarios were developed for each of the hazardous materials and activities at the site. A hazard identification word diagram is given in APPENDIX 1. The tables show all the scenarios identified. As noted in the Appendix, some potential incidents were considered to have local rather than offsite consequences. These were not carried forward for quantitative analysis of offsite risk levels.

The scenarios not carried forward included:

- Dust/grain fire or explosion in the grain handling area, due to the large separation distance (>70m) to the plant boundary. Also there are many safeguards in place to prevent dust accumulation (extraction system), to prevent ignition (earthing) and to detect fire (smoke detectors in the grain elevators).
- Steam loss of containment, as this type of event is limited in effects to the immediate vicinity of the release. Steam lines do not run in close proximity to the site boundary.
- Chemicals loss of containment, as all chemicals stored in bulk have local corrosive effects and are not toxic at distance.

3.6. Scenarios for Further Assessment

Hazardous incident scenarios identified in APPENDIX 1 with the potential for offsite impacts were considered to be 'significant' hazardous incidents (major accidents). The major accidents identified in relation to Ethanol and Petrol were consolidated into discrete scenarios (refer to Table 3.1 and Table 3.2) to allow a quantitative model to be developed, if necessary. A consequence analysis for these scenarios was conducted, and is described in Section 5.

TABLE 3.1: MAJOR ACCIDENTS – ETHANOL

ID	Plant Area / Activity	Plant Items	Risk Event	Causes	Consequence to be Modelled
E1	Tanker loading / unloading	Loading / unloading hoses	Release of product from loading point, and running pool fire if ignited	Hose failure (faulty) / crimped connection failure Could be caused by wear and tear, defect, etc Operator error making connection	Pool fire contained within paved area by kerbing

ID	Plant Area / Activity	Plant Items	Risk Event	Causes	Consequence to be Modelled
E2	Storage	Ethanol Storage Tanks	Total catastrophic tank failure and full-surface bund leak.	Tank mechanical failure. External impact.	Fire contained within bunded area.
			Full-surface bund fire, if ignited.	Tank overfill due to control system failure, human error whilst loading.	
			Full-surface bund fire, if leak not detected early and ignition occurs.	Equipment failure (corrosion, drain failure, flange leak, etc.) and release to bund.	
E3	Distillation	Pipework	Ethanol release leading to liquid spray fire on ignition.	Pump seal leak, flange leak etc.	Liquid ethanol spray fire

TABLE 3.2: MAJOR ACCIDENTS - PETROL

ID	Plant Area / Activity	Plant Items	Risk Event	Causes	Comments re escalation potential
P1	Tanker loading / unloading	Loading / unloading hoses	Release of product from road gantry from either site or truck	Hose failure (faulty) / crimped connection failure Could be caused by wear and tear, defect, etc Operator error making connection	Pool fire contained within paved area
P2	Storage	Petrol Storage Tanks	Total catastrophic tank failure and full-surface bund leak.	Tank mechanical failure. External impact.	Fire contained within bunded area.

4. LEVEL OF ASSESSMENT

4.1. SEPP 33 Screening

The DGRs for the proposed ethanol facility included the following requirement:

Hazards and Risk – including a Preliminary Hazard Analysis (PHA) in accordance with Hazardous Industry Planning Advisory Paper No 6 – Guidelines for Hazard Analysis and Multi Level Risk Assessment and details of fire/ emergency measures and procedures

Therefore, screening against the requirements of *Applying SEPP3*3 (Ref.3) was not required for determination of its applicability to the Ethanol Plant (and hence the requirement for a PHA). However, a *SEPP 33* screening was undertaken to determine the requirement for a dangerous goods transport route selection study.

4.1.1. Vehicle Movements

The estimated vehicle movements associated with the plant are given in Table 4.1, with associated thresholds from Table 2 in 'Applying SEPP 33'.

TABLE 4.1: GROUPING GOODS BY CLASS AND LOCATION

Material (Class)	Vehicles/ week[(a)]	Quantity per load (tonnes) [(a)]	Threshold		Route Selection Study Required?
			Movements	Minimum Quantity	
Ethanol	90	50	-	-	-
Petrol	4	50	-	-	-
Total (3)	*94*	*50*	*45/ week*	*3 tonnes*	*Yes*
Chemicals (8)	*6 (max)*	*25 (max)[(b)]*	*>30/ week*	*2 tonnes*	*No*

(a) From 0056132_Traffic Table_rev.C, ERM, 2007
(b) Derived from typical road tanker load.

Therefore, a Route Selection Study (Ref.5) may be required due to the volume of vehicle movements proposed to transport the produced ethanol.

4.2. Level of Assessment

Multi Level Risk Assessment sets out three levels of risk assessment that may be appropriate for a PHA. This document was consulted to identify the level of assessment required in this study.

Level	Type of Analysis	Comments
1	Qualitative	Where there are no major offsite consequences and societal risk is negligible
2	Partially Quantitative	Where there are offsite consequences but with a low frequency of occurrence
3	Quantitative	Where level 1 and 2 are exceeded

Based on the findings of the HAZID it would not be credible to state that no events had offsite impact without more detailed consequence analysis. Hence a Level 1 Assessment was not considered suitable.

It was decided to follow a Level 2 Assessment and calculate the consequences of the MAs in more detail and use the impairment criteria set in *HIPAP 6* (Ref. 1) as a basis for assessing the potential for offsite impact.

4.3. Criteria

The applicable criteria to be used in the assessment are presented in Table 4.2 (Ref. 4).

TABLE 4.2: THERMAL RADIATION CRITERIA

Heat Radiation Level	**Effect**	**Critical Criteria**
4.7 kWm^{-2}	Will cause pain in 15-20 seconds and injury after 30 seconds exposure.	Injury
12.6 kWm^{-2}	Significant chance of a fatality for extended exposure.	Fatality
23 kWm^{-2}	Likely fatality for extended exposure; chance of fatality for instantaneous exposure Unprotected steel will reach thermal stress temperatures which can cause failures	Escalation potential

5. CONSEQUENCE ANALYSIS

Consequence analysis was carried out for the events identified in Table 3.1 and Table 3.2.

The modelling was carried out using the Shell FRED model; the input parameters are presented in Table 5.1 and the results for the critical thermal radiation values are presented in Table 5.2. The full consequence input and output files are given in APPENDIX 3.

TABLE 5.1: INPUT PARAMETERS

ID	Location	Substance	Pool Dimensions/ Leak Size	Model	Wind Speed
P1	Road Tanker Loading Area	Petrol	20mx5m	Trench Fire	$5ms^{-1}$
P2	Petrol Tank Bund	Petrol	10m x 10m	Pool Fire	$5ms^{-1}$
E1	Road Tanker Loading Area	Ethanol	20mx5m	Trench Fire	$5ms^{-1}$
E2	Ethanol Tank Bund	Ethanol	25m x 25m	Pool Fire	$5ms^{-1}$
E3	Ethanol Release	Ethanol	25mm hole Process conditions[1]: 80ºC, 3 bara	Spray Fire	$5ms^{-1}$

Note 1: Process conditions were assumed, based on information provided.

TABLE 5.2: CONSEQUENCE RESULTS

ID	Downwind Distance to Critical Thermal Radiation from Fire Centre			Distance to Closest Plant Boundary from Fire Centre	Offsite Impact?
	$4.7\ kWm^{-2}$	$12.6\ kWm^{-2}$	$23\ kWm^{-2}$	(m)	
P1	45	35	30	110	No
P2	34	26	20	114	No
E1	53	32	34	110	No
E2	84	54	35	100	No
E3	38[(a)]	29[(a)]	25[(a)]	158[(a)]	No
(a) Distance from fire source.					

It can be seen from the results that the $4.7\ kW/m^2$ (injury) contour remains on site for all cases.

It is assumed that the two Ethanol and two Petrol storage tanks are in separate bunded areas that will comply with the requirements of AS1940:2004. However, in the event of a fire, radiation levels greater than $23\ kWm^{-2}$ can affect distances of 20m for Petrol and 35m for Ethanol. These distances are well above the assumed separation distances between the storage tanks, and thus there is potential for escalation. The consequences of the escalation scenario are described by the full surface bund fire scenario, and therefore even if escalation occurred, radiation levels greater than $4.7\ kWm^{-2}$ would not go offsite.

5.1. Conclusions

The consequence analysis has demonstrated that:

- The 4.7 kW/m^2 (injury) contour remains on site for all fire cases modelled. Therefore, fires would not have the potential for impact at public places beyond the site boundary.
- A full-surface bund fire may have the potential to escalate to other tanks (containing petrol or ethanol) within the storage area, but the resultant fire would not have a greater impact than the full surface bund fire modelled.

6. FIRE/ EMERGENCY MEASURES AND PROCEDURES

The Director General's Requirements (DGRs) for the proposed facility include the following requirement:

… details of fire/ emergency measures and procedures

Although the design of the facility is at a preliminary stage, the following philosophy is to be adopted with respect to design of fire/ emergency measures and procedures:

Design of all systems shall be in compliance with the appropriate Australian Standard.

With respect to fire protection, extensive use will be made of AS1940:2004, which covers the flammable liquids stored at the site (ethanol and petrol). This standard has the following pertinent sections:

- Section 10: Emergency Management;
- Section 11: Fire Protection;
- Appendix J: Fire Exposure Protection; and
- Appendix N: Emergency Planning and Management.

NOTE: An assessment of the adequacy and survivability of the proposed fire protection system will be undertaken in the Fire Safety Study (see Section 8.2, Recommendation 1) in accordance with NSW DIPNR HIPAP 2 (Ref.10).

Other relevant standards include:

- AS 2444 for the location of fire extinguishers; and
- The Building Code of Australia for fire protection of buildings.
- Classification of hazardous areas for flammable gas and dust will be carried out using AS60079.10 and AS 2430.3.

7. AIR QUALITY REVIEW

DoP (Ref.3) indicates that a facility is “potentially offensive” if, “in the absence of any safeguards, the proposal would emit a polluting discharge which would cause a significant level of offence to the people, property or the environment”.

An “offensive industry” is one that causes a significant level of offence even when safeguards are implemented. The emission level considered significant is determined by the relevant environmental approval authority.

Air quality modelling has been undertaken by ERM as part of the project EA (Ref.11), in which conclusions have been drawn regarding the “potentially offensive” nature of the proposed development.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Findings & Conclusions

- The PHA was carried out in accordance with DIPNR guidance: *HIPAP 6* and *Multi-level Risk Assessment*.
- A HAZID review meeting was held between the designers, Process Design and Fabrication (PDF), and Sherpa to identify potential hazard scenarios, their causes, consequence and safeguards in place in the design. The outcome of the HAZID was a set of 5 Major Accidents (MAs) with the potential for offsite impact, which were carried forward for quantification. These were:
  - Ethanol full surface bund fire in the bulk storage area
  - Petrol full surface bund fire in the bulk storage area
  - Ethanol spray fire in the distillation process area
  - Ethanol pool fire at the tank truck loading area
  - Petrol pool fire at the tank truck loading area
- The consequences of the MAs identified were assessed using the proprietary consequence modelling package *Shell FRED* (Version 4). It was found that these events would not have the potential for offsite impact (fatality, injury or offsite escalation) and thus would not affect adjacent public places. Therefore:
  - the offsite individual and societal risk of injury, due to heat radiation, from the development would not exceed the 50×10^{-6} per year NSW Land-Use Safety Planning risk criteria for heat radiation injury; and
  - the risk of accident propagation offsite from the development would not exceed the 50×10^{-6} per year NSW Land-Use Safety Planning risk criteria for accident propagation.
- Accidental emissions (spills) of ethanol, petrol and other chemicals will be captured in the tank bunds and directed to the site interceptor for recovery. Therefore, the potential effects of an accidental emission will not affect the long-term viability of the ecosystem of any sensitive natural environmental areas.
- Whilst there is potential for escalation between the tanks in the Ethanol and Petrol storage area, the consequences would be no worse than the full surface bund fire modelled (found not to have potential for offsite impact).
- The development was screened against *SEPP 33* and it was found that a Route Selection Study (Ref.5) may be required due to the volume of vehicle movements proposed to transport the produced ethanol.

8.2. Recommendations

1. As the design develops the project is required to complete a number of other safety and risk studies in accordance with the NSW Department of Planning Seven Stage Approval Process and as requested by the Director General, viz.:

Project Phase	Safety Study
Design Stage	Hazard and Operability Study
	Final Hazard Analysis (updating this PHA)
	Fire Safety Study
	Emergency Plan
Construction/Commissioning Stage	Construction Safety Study
Operational Stage	Safety Management System
	Independent Hazard Audit

2. It is recommended that the project develop a Safety Management System in accordance with HIPAP 9 (Ref.6).

3. It is recommended that the project develop an Emergency Plan in accordance with HIPAP 1 (Ref.7).

4. It is recommended that assumptions made in this report be re-checked when more detailed information is available; e.g. the distance from the Ethanol Storage area to the site boundary should be checked to ensure that the separation distance of greater than 85m is maintained such that the consequences of a fire in this area remain on site (see Section 5).

5. Subject to the Director General's requirements, a Route Selection Study (Ref.5) may be required due to the volume of vehicle movements proposed to transport the produced ethanol.

6. It is recommended that the latest revisions of the appropriate Australian Standards (including those identified in this document, viz.: AS 1940, Building Code of Australia, AS60079.10) are consulted during the Design Stage.

APPENDIX 1. HAZARD IDENTIFICATION

ID	Plant Area	Guide Word	Risk Event	Causes	Controls - Prevention	Controls - Detection / Mitigation	Carried Forward for Quantification	Actions	By
1	Grain Receiving and Storage	Fire / explosion (internal to process)	Dust explosion	Dust generated and ignition source found	Dust generation limited. No ignition sources in silo, all electrical/mechanical ignition sources outside.	None.	No		
2	Grain Receiving and Storage	Fire / explosion (internal to process)	Incipient fire within grain store. Possible toxic plume generated due to pesticides used to protect grain.	Ignition source Contamination of grain, e.g. cigarette butt.	Quality Assurance of grain received	None, although structural integrity of silo is such that fire is unlikely to cause damage.	No		
3	Grain Receiving and Storage	Exposure to personnel	Worker trapped within grain silo	Bridging and subsequent release of grain.	Confined space working procedures	When working in confined spaces workers will comply with confined space rules (harness, buddy, ensuring fresh air etc).	No		
4	Milling	Fire / explosion (internal to process)	Dust explosion	Hammer in hammer mill detached and impacts other metal parts causing ignition of dusty atmosphere.	Mechanical integrity of hammer. Dust extract system removes dust as far as possible.	Hammer mill designed to contain dust explosion. If explosion at dust collector, explosion vents prevent destruction.	No		

ID	Plant Area	Guide Word	Risk Event	Causes	Controls - Prevention	Controls - Detection / Mitigation	Carried Forward for Quantification	Actions	By
5	Milling	Fire / explosion (internal to process)	Dust explosion	Static, especially in dust collection system.	All equipment bonded to earthing mat. Dust collection bags have carbon fibres to prevent static build-up.	None	No		
6	Milling	Fire / explosion (internal to process)	Fire in grain elevator	Friction of elevator belts causes ignition of grain.	Regular inspection of elevators to minimise friction.	Detection system alerts operators and then shuts down system if smoke is detected.	No		
7	Milling	Fire / explosion (following release)	Dust explosion	Primary explosion causes loss of containment of ignited dust and produces secondary explosion.	Hammer mill designed to contain explosion (volume within is small). Good housekeeping should minimise dust that may become fuel for secondary explosion.	Equipment installed in an 'open' structure allowing free flow of air and no confinement. Overpressure generation is therefore minimised.	No	Design should minimise horizontal surfaces, and those that exist should be readily accessible for cleaning. Consider vacuum cleaning system.	AEL

ID	Plant Area	Guide Word	Risk Event	Causes	Controls - Prevention	Controls - Detection / Mitigation	Carried Forward for Quantification	Actions	By
8	Milling	Fire / explosion (following release)	Dust explosion	Primary explosion causes loss of containment of ignited dust and produces secondary explosion.	Hammer mill designed to contain explosion (volume within is small). Good housekeeping should minimise dust that may become fuel for secondary explosion.	Equipment installed in an 'open' structure allowing free flow of air and no confinement. Overpressure generation is therefore minimised.	No	Ensure that procedures are in place to minimise dust on floor/ external equipment surfaces especially in milling area.	AEL
9	Liquefaction	Harmful exposure (acute or chronic)	Steam (7 bar) loss of containment at steam cooker. Local jet of steam may impact personnel.	Mechanical failure of equipment	Integrity of equipment. Jet cooker is designed for this service.		No	Ensure that shutdown system on boiler can detect and shutdown for this scenario.	PDF
10	Liquefaction	Harmful exposure (acute or chronic)	Caustic loss of containment, e.g. pump seal failure and possible impact to personnel.	Mechanical failure of equipment	Integrity of equipment. Caustic system is designed for this service.		No	Ensure that location of caustic pump minimises the risk of caustic impacting personnel.	PDF
11	Fermentation	General Discussion	Loss of containment of a fermentation tank (approx 2500m3). Large liquid release.	External event such as earthquake.	Tanks designed beyond requirements of AS1692, and designed for earthquake.	Liquid would be contained onsite due to local kerbing and also distance from site boundary.	No		

ID	Plant Area	Guide Word	Risk Event	Causes	Controls - Prevention	Controls - Detection / Mitigation	Carried Forward for Quantification	Actions	By
12	Distillation	Fire / explosion (following release)	Loss of containment of hot ethanol (~70C) leading to possible pool/spray fire on ignition.	Pump seal leak, flange leak etc.	All equipment designed to appropriate standard for pressures and temperature in process. Area classified as Zone 1, and electrical equipment rated as such. All equipment earthed and bonded to grid to prevent static build-up.	Vapour detection system will alarm at 25% LFL, and shutdown at 50% LFL. Shutdown includes cutting power to motors as well as closing valves. Emergency cooling of critical condensers to reduce pressure. Distillation section remote from plant boundary, and surrounded by kerbing to prevent liquid spread.	Yes		
13	Distillation	Fire / explosion (internal to process)	Leak into the vacuum distillation column leading to internal explosion on ignition.	Flange/seal leak	Mechanical integrity of equipment.	No ignition sources inside the process equipment. Temperature inside column below the autoignition temperature of Ethanol (363C) High pressure detection and shutdown of column.	No		

ID	Plant Area	Guide Word	Risk Event	Causes	Controls - Prevention	Controls - Detection / Mitigation	Carried Forward for Quantification	Actions	By
14	Ethanol Storage	Fire / explosion (following release)	Loss of containment of ethanol in storage area.	Flange leak, overfill	Tanks designed to AS1940, including overfill protection (independent shut-off on high level). Vent condenser minimises ethanol evolution from tank. Pumps outside bund (reduces leak sources and ignition sources).	Fire detection and firewater/ foam/deluge system designed in accordance with AS1940.	Yes		
15	Petrol Storage	Fire / explosion (following release)	Loss of containment of petrol in storage area.	Flange leak, overfill	Tanks designed to AS1940. Pumps outside bund (reduces leak sources and ignition sources).	Fire detection and firewater/ foam/deluge system designed in accordance with AS1940. Tanks have bunds to contain spilled fluid.	Yes		
16	Ethanol loading	Fire / explosion (following release)	Loss of containment while loading ethanol to road tanker.	Hose failure, hose mis-connection, pump seal failure.	Hoses have dry-break couplings. Equipment designed for purpose to relevant standards.	Fire detection and firewater/ foam/deluge system designed in accordance with AS1940. Bunding of tanks, loading bay will have spill containment system.	Yes		

ID	Plant Area	Guide Word	Risk Event	Causes	Controls - Prevention	Controls - Detection / Mitigation	Carried Forward for Quantification	Actions	By
17	Petrol Loading	Fire / explosion (following release)	Loss of containment while loading Petrol to road tanker.	Hose failure, hose mis-connection, pump seal failure.	Hoses have dry-break couplings. Equipment designed for purpose to relevant standards.	Fire detection and firewater/ foam/deluge system designed in accordance with AS1940. Bunding of tanks, loading bay will have spill containment system.	Yes		
17	Chemical Storage	Harmful exposure (acute or chronic)	Mixing of incompatible chemicals leading to overheating and tank failure, or evolution of toxic gas.	Road tanker unloaded into wrong storage tank.	Chemical tanks will be in different bunds, and clearly placarded as specified in the relevant AS and the NSW DG Regulations.	None identified.	No	Ensure that it is extremely difficult to unload incorrect chemicals into a bulk tank, e.g. by different hose couplings and site layout.	PDF

ID	Plant Area	Guide Word	Risk Event	Causes	Controls - Prevention	Controls - Detection / Mitigation	Carried Forward for Quantification	Actions	By
18	Tanker movements	General Discussion	Tanker accident on site.	Driver confusion. Driver fatigue	None identified.	None identified.	No	Ensure that road tankers are strictly controlled within the site, and one way system is used to give smooth traffic flow and reduce likelihood of vehicle impacts.	PDF

APPENDIX 2. REVIEW OF HAZARDOUS SUBSTANCES PROPERTIES

A 2.1. Ethanol

Ethanol is a Class 3 flammable liquid which ignites readily when exposed to an ignition source. Detailed properties are given below.

TABLE 8.1: ETHANOL PROPERTIES

Property	unit	Value
Formula		C_2H_5OH
Boiling point	^oC	78.3
Vapour density (cf air = 1)		1.6
Liquid density (cf water = 1)		0.79
Heat of combustion	MJ/kg	0.837
Flashpoint	^oC	13-18
Lower Flammable Limit (LFL)	vol%	3.3
Upper Flammable Limit (UFL)	vol%	19

TABLE 8.2: HAZARDOUS PROPERTIES & EMERGENCY ADVICE

Incident	Hazardous Properties
Release as Vapour	Irritating to eyes, nose and throat. Move to fresh air.
Release as Liquid	Not harmful.
Fire	FLAMMABLE. Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Extinguish with dry chemical, alcohol foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.

A 2.2. Petrol

Petrol is a Class 3 flammable liquid; detailed properties are given below.

TABLE 8.3: PETROL PROPERTIES

Property	unit	Value
Formula		N/A
Boiling point	^oC	60-199
Vapour density (cf air = 1)		3.4
Liquid density (cf water = 1)		0.732
Heat of combustion	MJ/kg	43.5
Flashpoint	^oC	-38
Lower Flammable Limit (LFL)	vol%	1.4
Upper Flammable Limit (UFL)	vol%	7.4

TABLE 8.4: HAZARDOUS PROPERTIES & EMERGENCY ADVICE

Incident	Hazardous Properties
Release as Vapour	Irritating to eyes, nose and throat. If inhaled, will cause dizziness, headache, difficult breathing or loss of consciousness. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen.
Release as Liquid	Irritating to skin and eyes. If swallowed, will cause nausea or vomiting. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.
Fire	Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Extinguish with dry chemical, foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.

A 2.3. Sulphuric Acid (94%)

Concentrated sulphuric acid is a Class 8 material, which is highly corrosive. Detailed properties are given below.

TABLE 8.5: SULPHURIC ACID PROPERTIES

Property	unit	Value
Formula		H_2SO_4
Boiling point	^oC	340
Vapour density (cf air = 1)		N/A
Liquid density (cf water = 1)		1.84
Heat of combustion	MJ/kg	N/A
Flashpoint	^oC	Not Flammable
Lower Flammable Limit (LFL)	vol%	N/A
Upper Flammable Limit (UFL)	vol%	N/A

TABLE 8.6: HAZARDOUS PROPERTIES & EMERGENCY ADVICE

Incident	Hazardous Properties
Release as Mist	Irritating to eyes, nose and throat. If inhaled, will cause coughing, difficult breathing, or loss of consciousness. Move to fresh air. IF IN EYES, hold eyelids open and flush with plenty of water. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen.
Release as	Will burn skin and eyes.

Liquid	Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.
Fire	Not flammable. Poisonous gas may be produced in fire. Extinguish with dry chemical or carbon dioxide.

A 2.4. Sodium Hydroxide (20%)

Sodium Hydroxide is a Class 8 material, and is corrosive. Detailed properties are given below.

TABLE 8.7: SODIUM HYDROXIDE PROPERTIES

Property	**unit**	**Value**
Formula		NaOH
Boiling point	^oC	Not available
Vapour density (cf air = 1)		N/A
Liquid density (cf water = 1)		1.22
Heat of combustion	MJ/kg	N/A
Flashpoint	^oC	Not Flammable
Lower Flammable Limit (LFL)	vol%	N/A
Upper Flammable Limit (UFL)	vol%	N/A

TABLE 8.8: HAZARDOUS PROPERTIES & EMERGENCY ADVICE

Incident	Hazardous Properties
Release as Mist	N/A
Release as Liquid	POISONOUS IF SWALLOWED Extremely corrosive to eyes, skin, nose, throat, and upper respiratory tract. IF IN EYES: hold eyelids open, flush with running water for at least 15 minutes. Remove contaminated clothing and shoes, flush affected areas with plenty of running water for at least 15 minutes. IF SWALLOWED and victim is CONSCIOUS: have victim drink water, milk, dilute vinegar, lemon juice, or olive oil to dilute the material. IF SWALLOWED and victim is UNCONSCIOUS OR HAVING CONVULSIONS: do nothing except keep victim warm. DO NOT INDUCE VOMITING
Fire	Non-combustible

A 2.5. Nitric Acid (20%)

Nitric Acid is a Class 8 material, and is corrosive. Detailed properties are given below.

TABLE 8.9: NITRIC ACID PROPERTIES

Property	**unit**	**Value**
Formula		HNO_3
Boiling point	^oC	88.9
Vapour density (cf air = 1)		N/A
Liquid density (cf water = 1)		1.49
Heat of combustion	MJ/kg	N/A
Flashpoint	^oC	Not Flammable
Lower Flammable Limit (LFL)	vol%	N/A
Upper Flammable Limit (UFL)	vol%	N/A

TABLE 8.10: HAZARDOUS PROPERTIES & EMERGENCY ADVICE

Incident	Hazardous Properties
Release as Vapour	Will burn eyes, nose and throat. If inhaled, will cause difficult breathing or loss of consciousness. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen.
Release as Liquid	Will burn skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.
Fire	Not flammable. May cause fire on contact with combustibles. Flammable gas may be formed on contact with metals. Poisonous gases are produced when heated. Wear chemical protective suit with self-contained breathing apparatus. Cool exposed containers with water.

A 2.6. Aqueous Ammonia (25%)

Aqueous Ammonia is a Class 8 material, and is corrosive. Detailed properties are given below.

TABLE 8.11: AQUEOUS AMMONIA PROPERTIES

Property	**unit**	**Value**
Formula		NH_3
Boiling point	^oC	N/A
Vapour density (cf air = 1)		N/A
Liquid density (cf water = 1)		0.89
Heat of combustion	MJ/kg	N/A

Property	unit	Value
Flashpoint	^{o}C	Not Flammable
Lower Flammable Limit (LFL)	vol%	N/A
Upper Flammable Limit (UFL)	vol%	N/A

TABLE 8.12: HAZARDOUS PROPERTIES & EMERGENCY ADVICE

Incident	Hazardous Properties
Release as Vapour	Irritating to skin, eyes, nose and throat. If inhaled, will cause nausea, vomiting, difficult breathing, or loss of consciousness. Move to fresh air. IF IN EYES, hold eyelids open and flush with plenty of water. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen.
Release as Liquid	Will burn skin and eyes. Harmful is swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
Fire	

A 2.7. Urea

Urea is not classified in the ADG Code. It is not harmful, but may be combustible in solid pellet form.

A 2.8. Grain

Although not classified as a dangerous good, grain does have hazardous properties. It is prone forming dust which can explode violently. In the US from 1988 to 1998 there were 129 reported grain dust explosions; 64 were in grain elevators, 48 were in grain milling facilities (Ref.12).

Another hazardous situation that could present itself may be an incipient fire within the grain silo. This may then lead to either release of toxic fumes, or initiate an explosion.

A 2.9. Steam

Steam is used to heat the vacuum distillation column. It is generated in boilers with a maximum temperature of 180°C and a pressure of 7 bar.

APPENDIX 3. CONSEQUENCE ANALYSIS DETAILS

Proposed Ethanol Plants

Author	I. Ninic
Company	Sherpa Consulting Pty Ltd
Department	Safety/ Risk
Revision	0
Notes	Checked by P.Johnson
Revision date	Wednesday, January 31, 2007

Table of Contents

P2

Scenario Summary

Scenario

Scenario = P2
Fluid = Gasoline

Pool

Diameter = 11.3 m
Surface elevation = 0 m

Weather

Ambient conditions

Temperature = 20 °C
Relative humidity = 70 %
Wind speed = 5 m/s
Direction wind is going to = 0 deg
(measured clockwise from North)

Atmospheric stability conditions

Define by = Pasquill class
Pasquill class = D Neutral

Thermal radiation

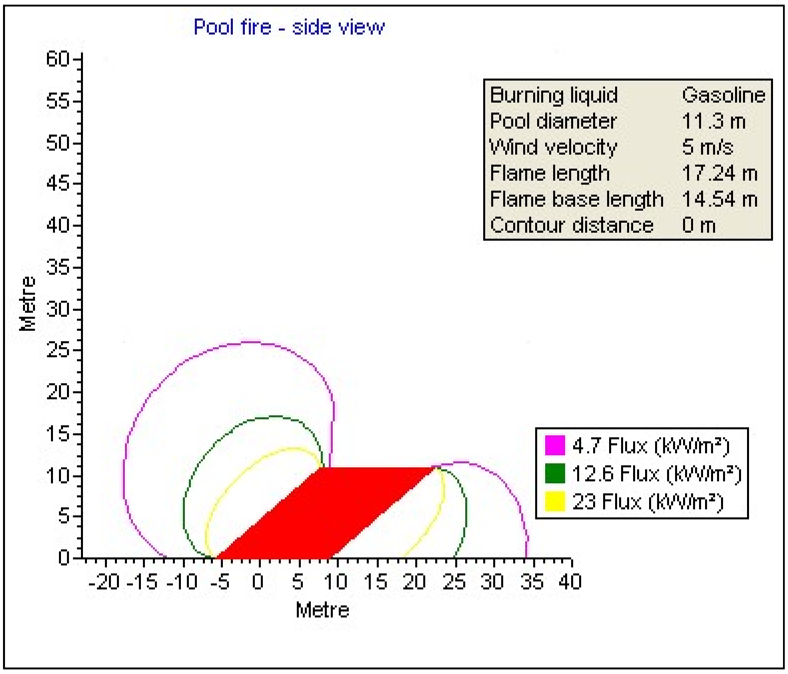
Radiation contours = 4.7, 12.6, 23 kW/m^2
Height at which plan view contours to be plotted = 1.5 m
Cross flame distance at which side view contours to be plotted = 0 m

Pool Fire

Pool Fire Summary

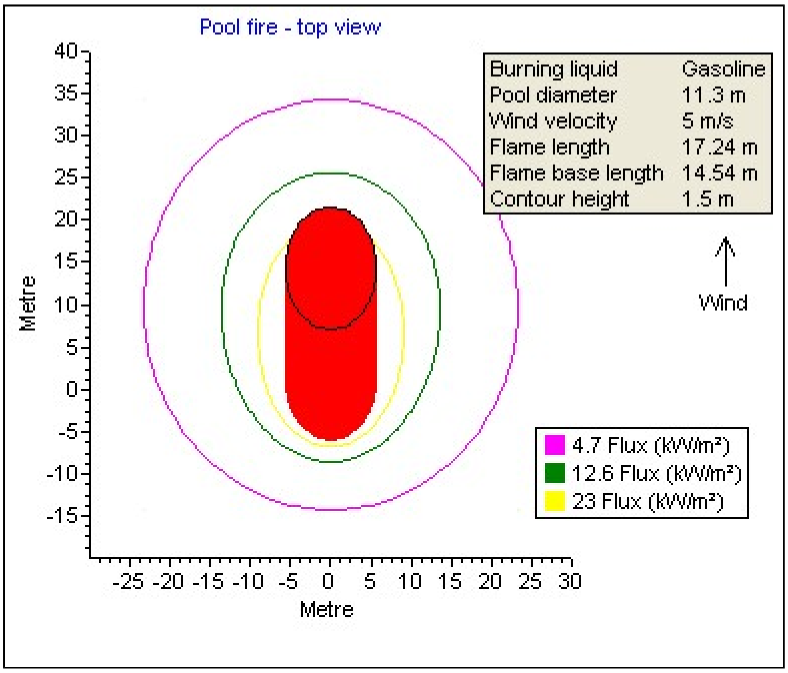
Flame length = 17.24 m
Flame angle from vertical = 50.56 deg
Flame base length = 14.54 m
Surface emissive power = 58.76 kW/m²

Side view



Raw plot data

Top view



Raw plot data

Warnings

None.

top

E2

Scenario Summary

Scenario

Scenario = E2
Fluid = Ethanol

Pool

Diameter = 28.2 m
Surface elevation = 0 m

Weather

Ambient conditions

Temperature = 20 °C
Relative humidity = 70 %
Wind speed = 5 m/s
Direction wind is going to = 0 deg
(measured clockwise from North)

Atmospheric stability conditions

Define by = Pasquill class
Pasquill class = D Neutral

Thermal radiation

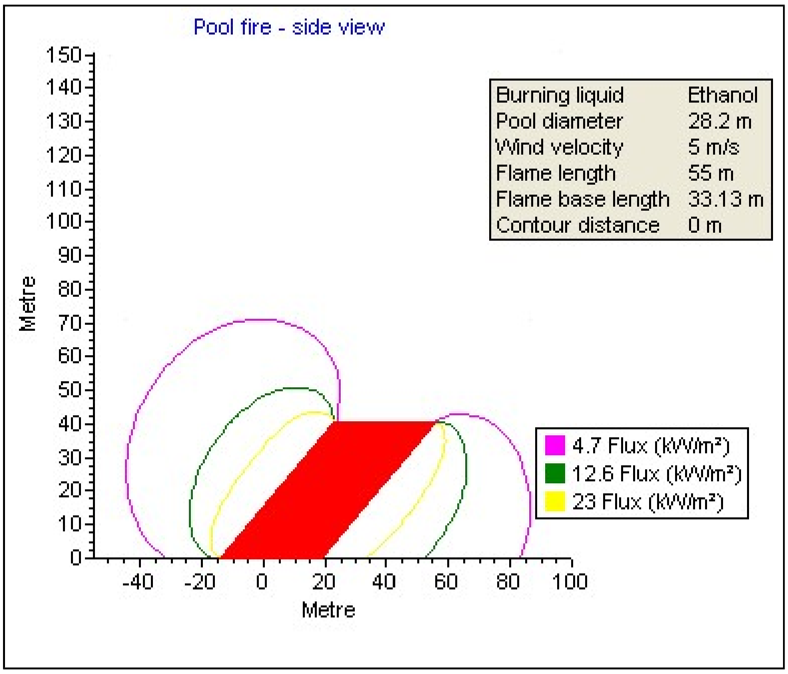
Radiation contours = 4.7, 12.6, 23 kW/m²
Height at which plan view contours to be plotted = 1.5 m
Cross flame distance at which side view contours to be plotted = 0 m

Pool Fire

Pool Fire Summary

Flame length = 55 m
Flame angle from vertical = 42.19 deg
Flame base length = 33.13 m
Surface emissive power = 51.54 kW/m²

Side view



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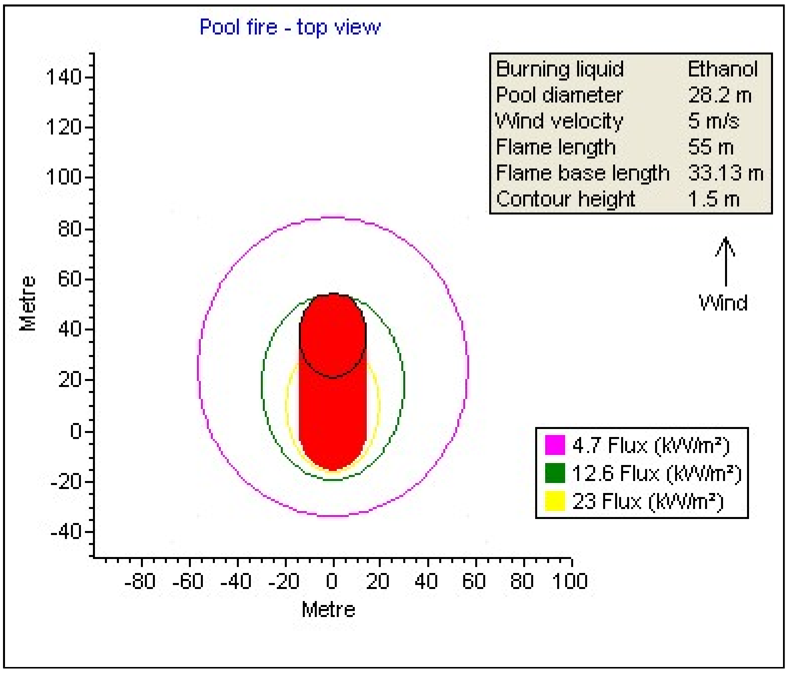
Top view



Raw plot data

Warnings

None.

top

P1

Scenario Summary

Scenario

Scenario = P1
Fluid = Gasoline

Trench

Width = 5 m
Length = 20 m
Angle from north = 90 deg

Weather

Ambient conditions

Temperature = 20 °C
Relative humidity = 70 %
Wind speed = 5 m/s
Direction wind is going to = 0 deg
(measured clockwise from North)

Atmospheric stability conditions

Define by = Pasquill class
Pasquill class = D Neutral

Thermal radiation

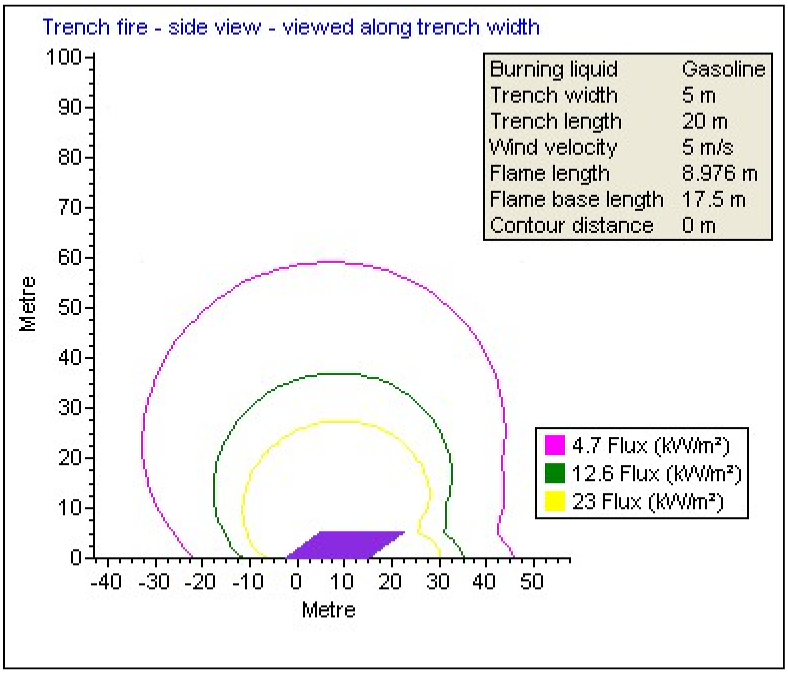
Radiation contours = 4.7, 12.6, 23 kW/m²
Height at which plan view contours to be plotted = 1.5 m
Cross flame distance at which side view contours to be plotted = 0 m

Trench Fire

Trench Fire Summary

Flame length = 8.976 m
Flame angle from vertical = 55.94 deg
Flame base length = 17.5 m
Surface emissive power (top) = 130 kW/m²
Surface emissive power (bottom) = 130 kW/m²
Clear flame height = 5.027 m

Side view



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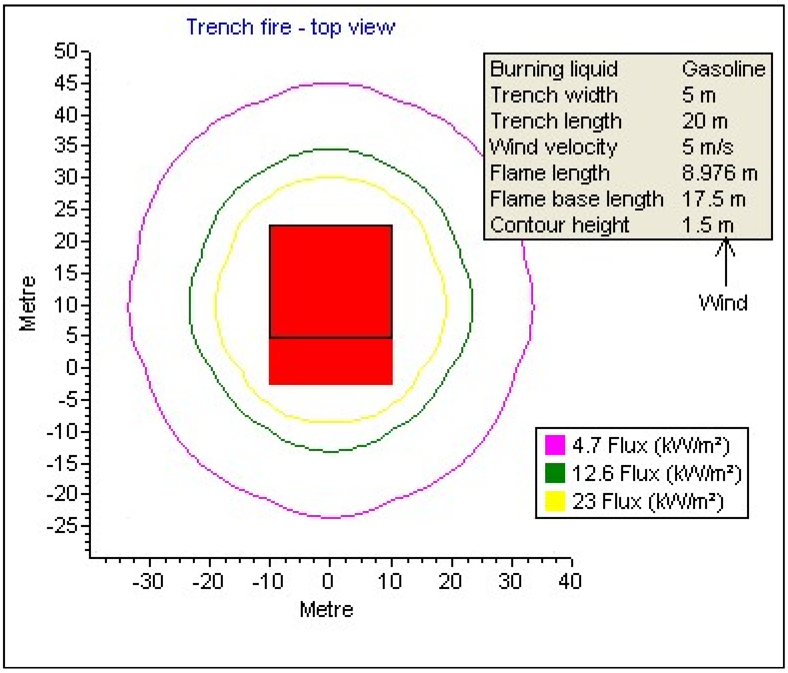
Top view



[Raw plot data]

Warnings

1 - Ambient temperature outside experimental range 0 to 15 C
2 - Trench width outside experimental range 0.82 to 4 m
3 - Contour value outside experimental range 0 to 20 kW/m2

top

E1

Scenario Summary

Scenario

Scenario = E1
Fluid = Ethanol

Trench

Width = 5 m
Length = 20 m
Angle from north = 90 deg

Weather

Ambient conditions

Temperature = 20 °C
Relative humidity = 70 %
Wind speed = 5 m/s
Direction wind is going to = 0 deg
(measured clockwise from North)

Atmospheric stability conditions

Define by = Pasquill class
Pasquill class = D Neutral

Thermal radiation

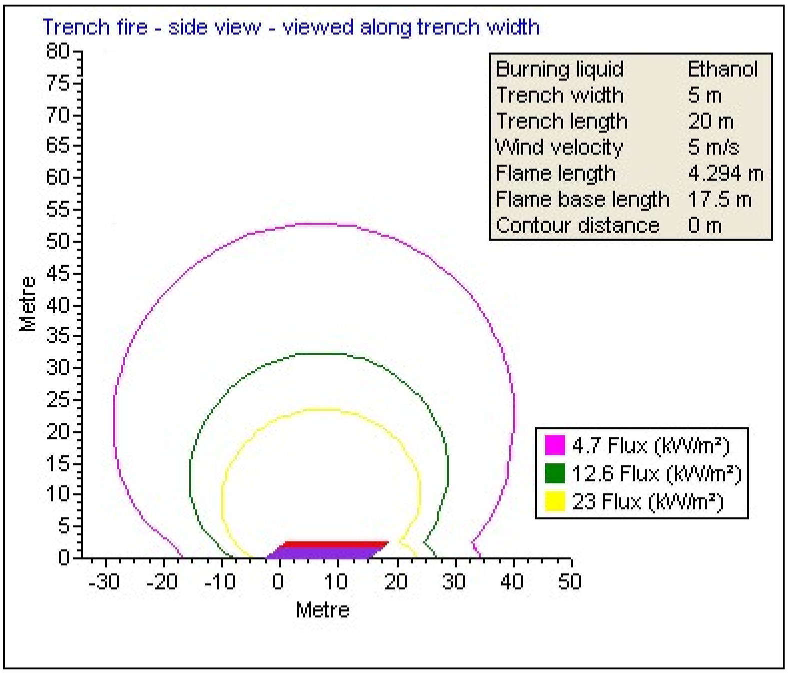
Radiation contours = 4.7, 12.6, 23 kW/m²
Height at which plan view contours to be plotted = 1.5 m
Cross flame distance at which side view contours to be plotted = 0 m

Trench Fire

Trench Fire Summary

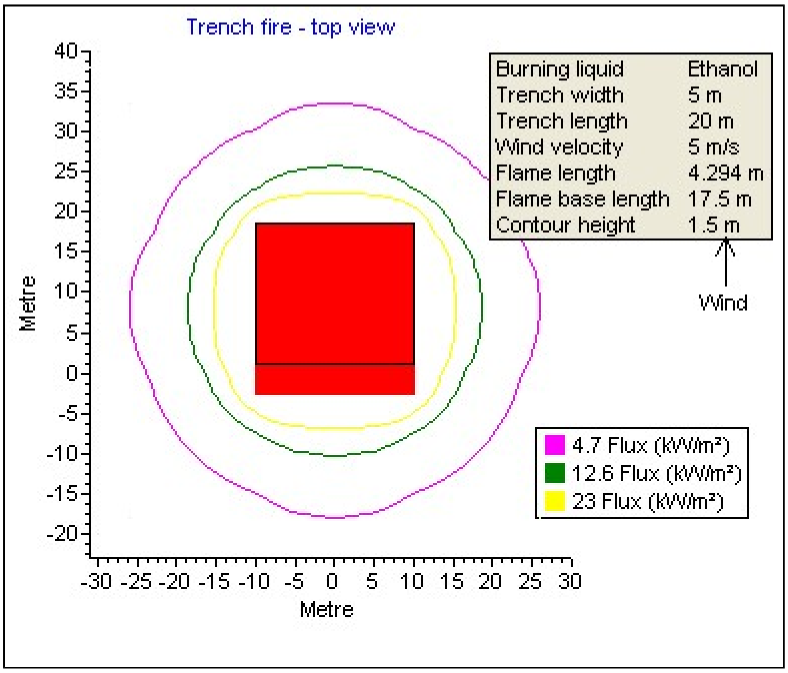
Flame length = 4.294 m
Flame angle from vertical = 55.94 deg
Flame base length = 17.5 m
Surface emissive power (top) = 130 kW/m²
Surface emissive power (bottom) = 130 kW/m²
Clear flame height = 1.579 m

Side view



Raw plot data

Top view



Raw plot data

Warnings

1 - Ambient temperature outside experimental range 0 to 15 C
2 - Trench width outside experimental range 0.82 to 4 m
3 - Contour value outside experimental range 0 to 20 kW/m2

top

Ethanol Leak from Process

Scenario Summary

Scenario

Scenario = Ethanol Leak from Process
Fluid = Ethanol

Process conditions

Calculate at = User input mass flow rate
Temperature = 78.12 °C
Pressure = 2.961 bara
Mass flow rate = 5 kg/s

Pressure downstream of release

Pressure = 1.013 bara
Use standard atmospheric pressure = yes

Release from

Release source = Liquid space
Liquid head = 0.1 m
Releasable liquid volume = 1000.0 m³

Hole & release geometry

Hole geometry

Failure type = Custom
Hole diameter = 0.025 m
Discharge coefficient = 0.6

Pipe

Pipe length = 0 m

Release

Release height = 5 m
Release angle from vertical = 90 deg
Release angle, clockwise from North = 0 deg

Weather

Ambient conditions

Temperature = 20 °C
Relative humidity = 70 %
Wind speed = 5 m/s
Direction wind is going to = 0 deg
(measured clockwise from North)

Atmospheric stability conditions

Define by = Pasquill class
Pasquill class = D Neutral

Thermal radiation

Radiation contours = 4.7, 12.6, 23 kW/m²
Height at which plan view contours to be plotted = 1.5 m
Cross flame distance at which side view contours to be plotted = 0 m

Dispersion

Surface roughness = 0.1 m
Contours to plot:
16500.0 ppm 33000.0 ppm 190000.0 ppm
Plot type = User
Sampling time = Instantaneous

Release summary

Mass flow rate = 5 kg/s
Flux = 10185.7 kg/m²/s
Static exit pressure = 2.264 bara
Exit temperature = 78.12 °C
Exit density = 737.2 kg/m³
Exit velocity = 13.82 m/s
Residence time = 0 s
Vapour fraction at exit = 0 mol/mol
Expanded exit velocity = 26.1 m/s
Air equivalent source diameter = 0.4508 m

Release Composition

Molecular Weight of Release = 46.07 kg/kmol

Component	Weight Fraction norm	Mole Fraction norm	Critical Temp °C	Critical Pressure bara	Molecular Weight kg/kmol	Atmos BP °C	Freeze Pt °C	Heat of Comb kJ/kg
Ethanol	1.0000	1.0000	240.8	61.32	46.07	78.29	-114.1	27760.3

Reservoir summary (at reservoir pressure)

Bubble point temperature = 108.1 °C
Dew point temperature = 108.1 °C
Vapour fraction = 0

Properties of phases (for reservoir release)

	Vapour	Liquid
Molecular weight (kg/kmol)	0	46.07
Density (kg/m³)	0	737.2
Enthalpy (kJ/kmol)	0	-34660.4
Entropy (kJ/kmol*K)	0	-96.78
Cv (kJ/kg*K)	0	2.438
Cp (kJ/kg*K)	0	3.181
Sound velocity (m/s)	0	1233.1
Viscosity (e-3 kg/m*s)	0	0.4486
Surface tension (e-3 N/m)	0	17.16

Jet Fire

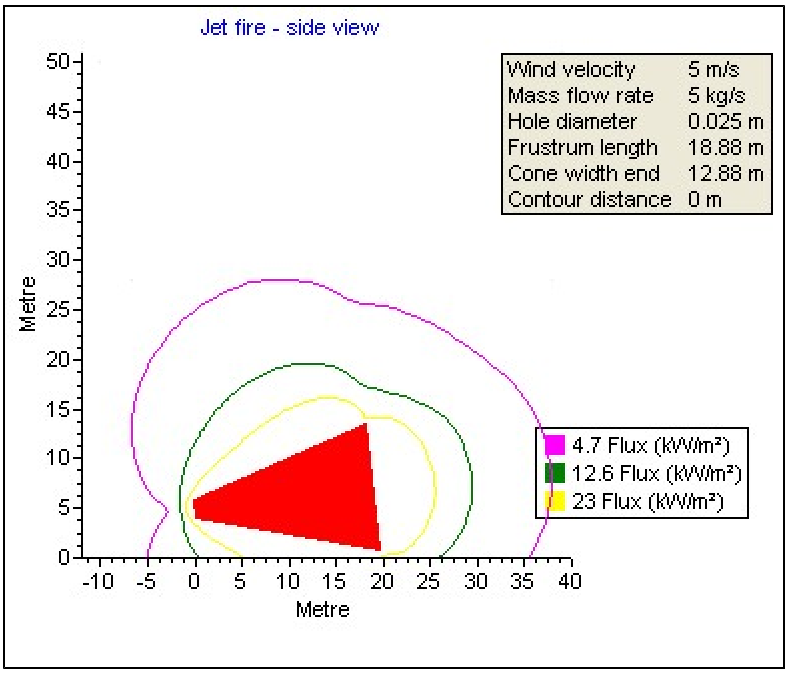
Jet Fire Summary

Flame length (of frustum) = 18.88 m
Cone width of flame base = 1.892 m
Cone width of flame end = 12.88 m
Flame lift-off = 0.04115 m

Flame angle from vertical = 83.6 deg
Flame angle, clockwise from North = 0 deg

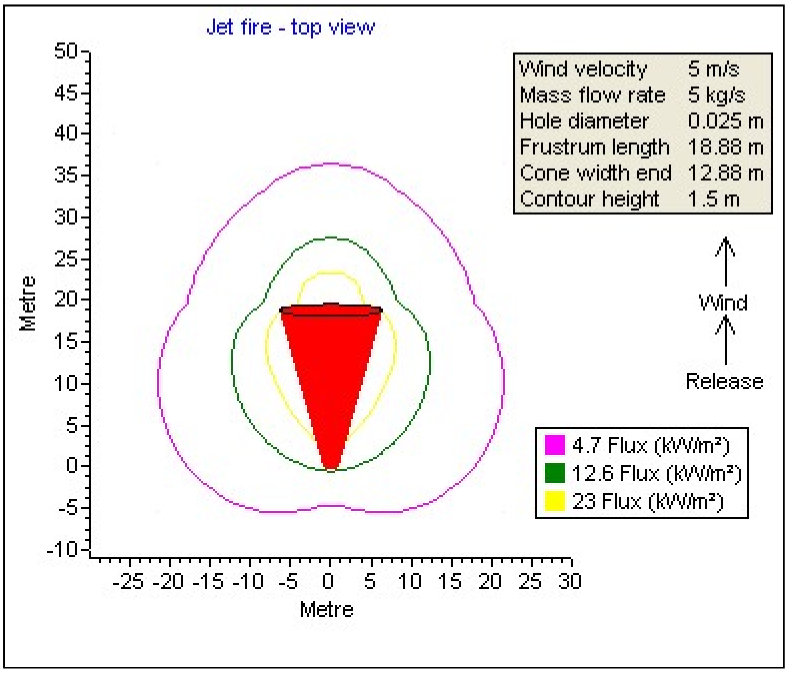
Surface emissive power = 55.7 kW/m²
Fraction of heat radiated = 0.2364
Total combustion power = 138.8 MW
Heat of combustion = 27760.3 kJ/kg

Side view



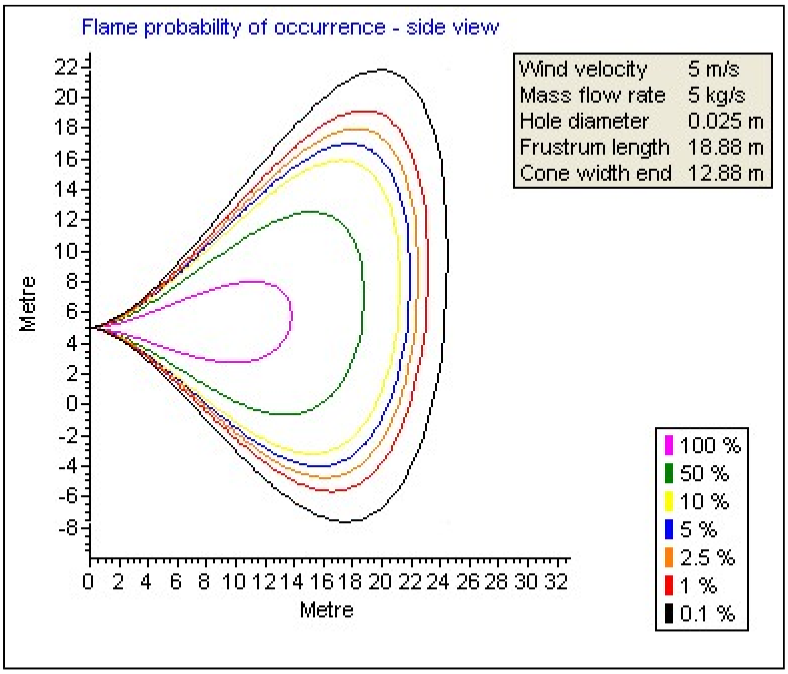
Raw plot data

Top view



Raw plot data

Impingement



Raw plot data

Pool Chart

No pool can form

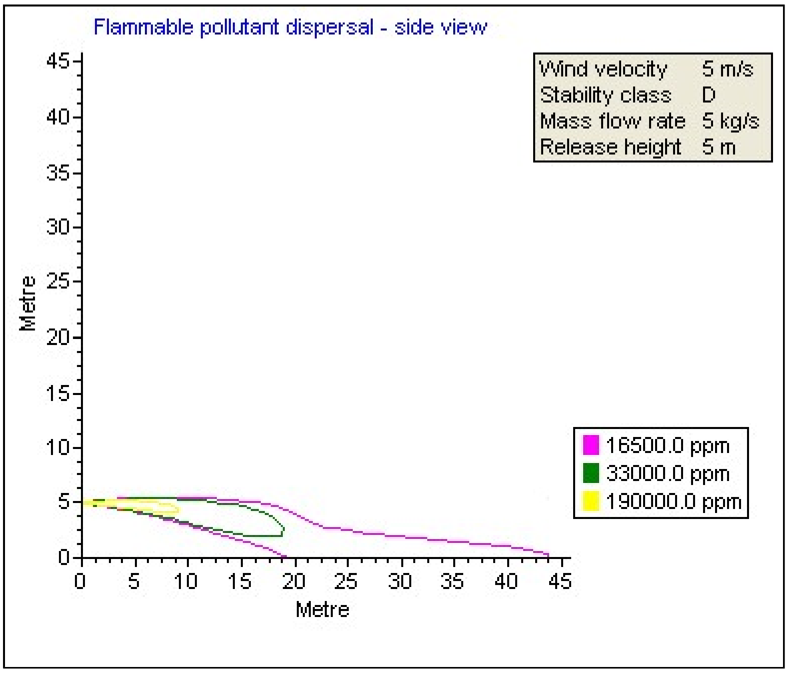
Dispersion

Dispersion Summary

Contour value (ppm)	16500.0	33000.0	190000.0
Downwind distance (m)	43.77	18.88	9.001
Height above ground (m)	0.4274	2.711	4.611

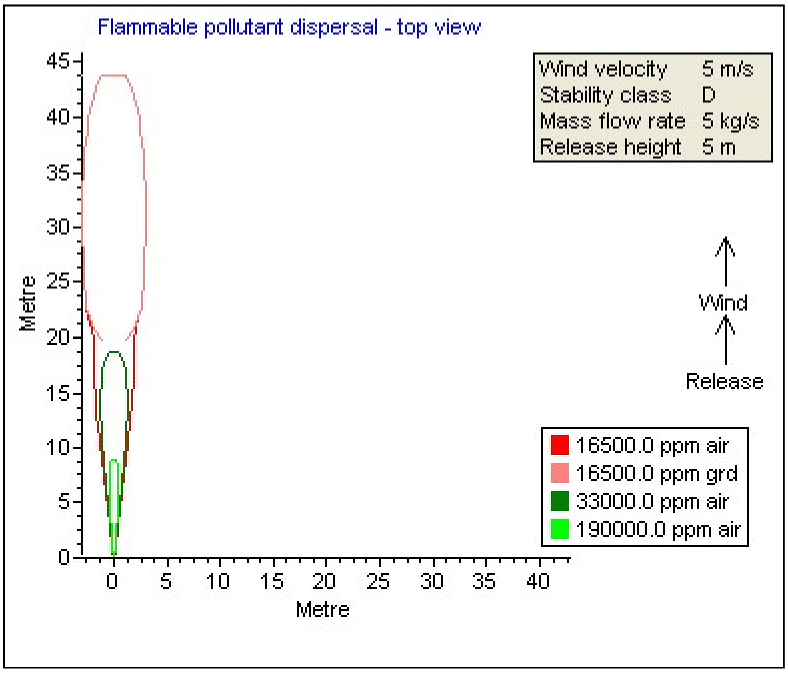
Mass in plume between specified limits = 225.4 kg
Volume of plume containing this mass = 172.5 m³
Pollutant-only mass in this volume = 13.04 kg
Specified minimum = 1.65 vol%
Specified maximum = 100 vol%

Jet - side



Raw plot data

Jet - top



[Raw plot data]

Warnings

1 - Temperature outside extrapolated range -50 to 50 C
2 - Temperature outside experimental range -5 to 15 C
3 - Liquid head parameter has not been experimentally determined
4 - Pressure downstream parameter has not been experimentally determined
5 - Ambient temperature outside experimental range 0 to 15 C
6 - Ambient pressure parameter has not been experimentally determined
7 - Surface roughness parameter has not been experimentally determined

top

Model Versions

(Produced by Shell FRED 4.0.1.1 using Fortran.dll 4.0.0.12, VLEOS.dll 4.0.0.4, VesselBurst.dll 4.0.0.1, GenericBleve.dll 4.0.0.1, TrenchFire.dll 4.0.0.1, HEATUP.dll 4.0.0.2, TwoPhaseBlowdown.dll 4.0.0.1, BubblePlume.dll 4.0.0.1, GasMix.dll 2.0.0.4, HGsystemWrapper.dll 1.0.2.2, HGsystem.dll 1.2.6.0, APMAIN.exe 2.2.3.2, HSMAIN.exe 3.4.3.2, PGMAIN.exe 2.2.0.2)

APPENDIX 4. REFERENCES

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