Pinnacle
Risk Management Pty Ltd

Pinnacle Risk Management response to the queries from the Department of Planning and Environment dated 20/2/17 re the Preliminary Hazard Analysis for the proposed distillery at Shoalhaven Starches, Bomaderry.

Dean Shewring

21/2/17

1. The PHA assumes SEP of 50kW/m^2 for large pool fires (pool diameter >25 m) and 60 kW/m^2 for smaller fires. Taking into account that the ethanol fires are luminous, the SEPs used in the analysis appears to be optimistic. Please provide the basis for the assumed SEPs.

PRM Comment: The SEP data is based on the results of the ETANKFIRE research, published data and previous studies for ethanol fires, e.g. SHERPA Consulting for Vopak at Port Botany. Data from the ETANKFIRE study for small and large diameter fires are shown below.

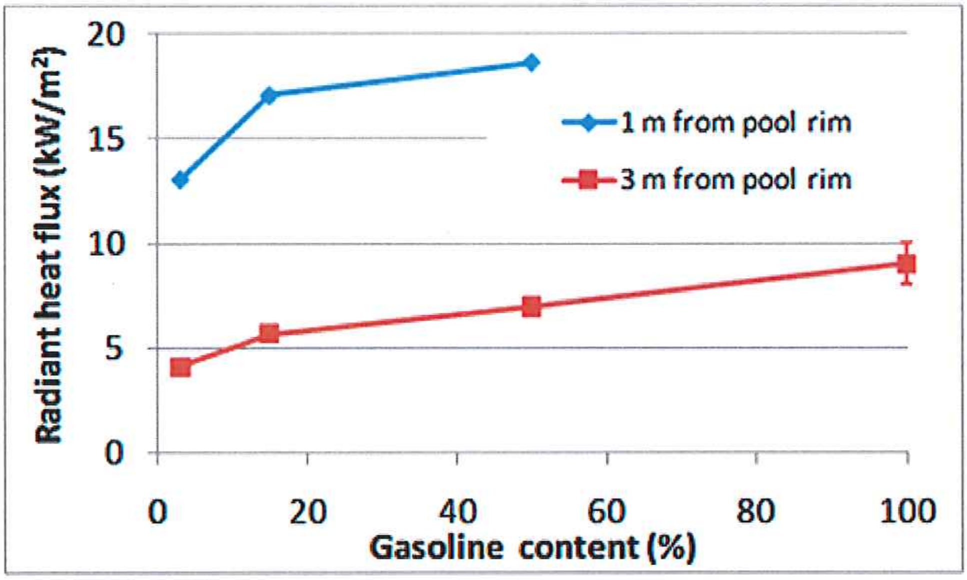


Diagram showing the heat flux at various distances from 2 m^2 fires with various fuel mixtures of ethanol and gasoline. That is, gasoline has the higher SEP for small diameter fires.

For large diameter pool fires, the test results show that the heat exposure can be as much as 3 times higher for ethanol than for gasoline. Using the Mudan equation for gasoline, the SEP is 20 kW/m^2 for large diameter fires. Therefore, the SEP for ethanol is taken to be 50 kW/m^2, i.e. an average of 2.5 times the gasoline SEP. This is very similar to the modelling work by SHERPA Consulting for Vopak at Port Botany.

Note that Tewarson A. & Marlair G., "Handbook of Building Materials for Fire Protection", 2003, quote an ethanol SEP of 30 kW/m^2 for a 5 m diameter fire. The data used is more conservative than this.

2. An ethanol burndown rate of 1mm/min is used in the analysis and it is referenced to Lees and the Yellow book. However, this value was not found in any of these references. Please clarify if the quoted burning rate is based on further calculation provided in the references, such as based on the mass burning rate? Please provide further details.

PRM Comment: As an example, please see Lees, Table 16.65. Ethanol's infinite pool burning rate is 0.0015 kg/m^2.s. For the quoted density of 794 kg/m^3, this equates to approximately 1 mm/min.

3. A release rate of 1kg/s ethanol is estimated for a 50 mm hole leak and provided in Table 6 and Section 5.3.1 of the PHA. Please provide the parameters used for the estimation of the rate and details on the methodology used for the calculation. Please provide the maximum inventory of ethanol that can be released if the hole is located at the top of the column?

PRM Comment: The release rate was determined using the CCPS methodology (from their Guidelines for Chemical Process Quantitative Risk Analysis book) as shown below. The parameters used are also included.

The column and piping volume was estimated to be 137 m^3 and 4.2 m^3, respectively. That is, a total of 141 m^3. At 3 kg/m^3, this equates to 423 kg of ethanol (as used and stated in the study). This is assuming the hole is anywhere in the column where vapour can escape, i.e. including the top.

Example 2.4: Gas Discharge through a Hole						
Input Data:						
Heat capacity ratio of gas:		1.13			Hydrogen	1.4 at atmospheric
Hole size:		50	mm			1.35 at pressure
Upstream pressure:		2.1	bar abs			
Dowstream pressure:		1.01	bar abs			
Temperature:		371	K			
Gas molecular weight:		46				
Excess Head Loss Factors:						
Entrance:	0					
Exit:	1					
Others:	0					
TOTAL:	1					
Calculated Results:						
Hole area:		0.001963495	m**2			
Upstream gas density:		3.13	kg/m**3			
Expansion factor, Y:		0.588				
Actual pressure ratio:		0.52	<-- Must be greater than sonic pressure ratio below to insure sonic flow.			
Heat capacity ratio, k:		1.2	1.4	1.67		
Sonic pressure ratios:		0.484	0.524	0.569		
Choked pressure:		1.08	1.00	0.90	bar	
Mass flow:		0.9222	0.9595	0.9997	kg/s	
Interpolation table:	1.2	0.922174311				
	1.4	0.959473085				
Interpolated mass flow:		0.9091	kg/s			

4. The jet flame The jet flame will extend 8 metre from the release source. If any equipment/building is located within this distance, the jet fire impingement my result in a failure. Was this domino effect considered in the analysis and how? Please provide details on the preventive and mitigation measures proposed to be implemented to minimise the risk from domino effect within the facility.

PRM Comment: The domino effect was reviewed and the only credible impact target was the control room (see Recommendation 2 in the PHA re structural integrity).

The main controls re large jet fires is the design of the distillery (due to the recycle streams, it will stop working if a large loss of containment occurs), the equipment is being designed using stainless steel (corrosion resistant) to AS1210 (pressure vessels) and AS4041 (pressure piping) and ignition controls include the hazardous area assessment. In addition to these, the plant is 24/7 manned with emergency response by the operators. This includes activating the emergency shutdown system that isolates the plant feed and product streams.

As the query regards a jet fire, it is not recommended to extinguish any jet fire using firewater (i.e. given the risk of re-ignition and a flash fire or explosion). However, firewater can be used, e.g. from hydrants and monitors, for cooling nearby structures. However, once the plant is tripped, the source for the release will stop as the pressure column will equilibrate with the vacuum systems.

5. A flash fire (50mm hole leak) may reach 18m from the release source, hence there is potential to damage the surrounding equipment if an ignition source is present. Was this considered in the PHA and how?

PRM Comment: As flash fires durations are relatively short, i.e. seconds, the risk of damage to property is normally neglected in risk analyses (as was the case for this PHA). The main concern is people within the flash fire who can breathe in the flames.

6. Section 5.4 of the PHA identifies that a potential pool fire in the distillery may impact on the control room. A number of preventive control measures, aiming to reduce the likelihood of this event, are identified and listed in the HazID. However, only a limited number of mitigation measures are identified the PHA: emergency egress and???. While these measures may be sufficient to protect the people working in the control room, what measures will be in place if the control room is not accessible due to the fire. It is also noted that not only the control room, but the equipment in the vicinity may also suffer high heat stress and result in structural failure. Has this event been considered and what are the proposed safety measures?

PRM Comment: The control room is the only major receptor of concern if a pool fire were to occur. The other impacted equipment were reviewed on-site but as these are not occupied nor critical then the focus is on the control integrity only.

Mitigation measures for a potential pool fire are still in the design stage. This will include a review of the fire protection via a Fire Safety Study.

7. The failure frequencies presented in Table 8 of the PHA appear to be optimistic. For example, the frequency suggested in TNO purple book is with 1 order of magnitude higher than the frequencies used in the PHA. Using the TNO frequency, the overall frequency for the flash fire/explosion event would be around 3.5E-06. Please provide a justification on the used data or otherwise ensure that the analysis err on conservative side by using conservative failure frequencies

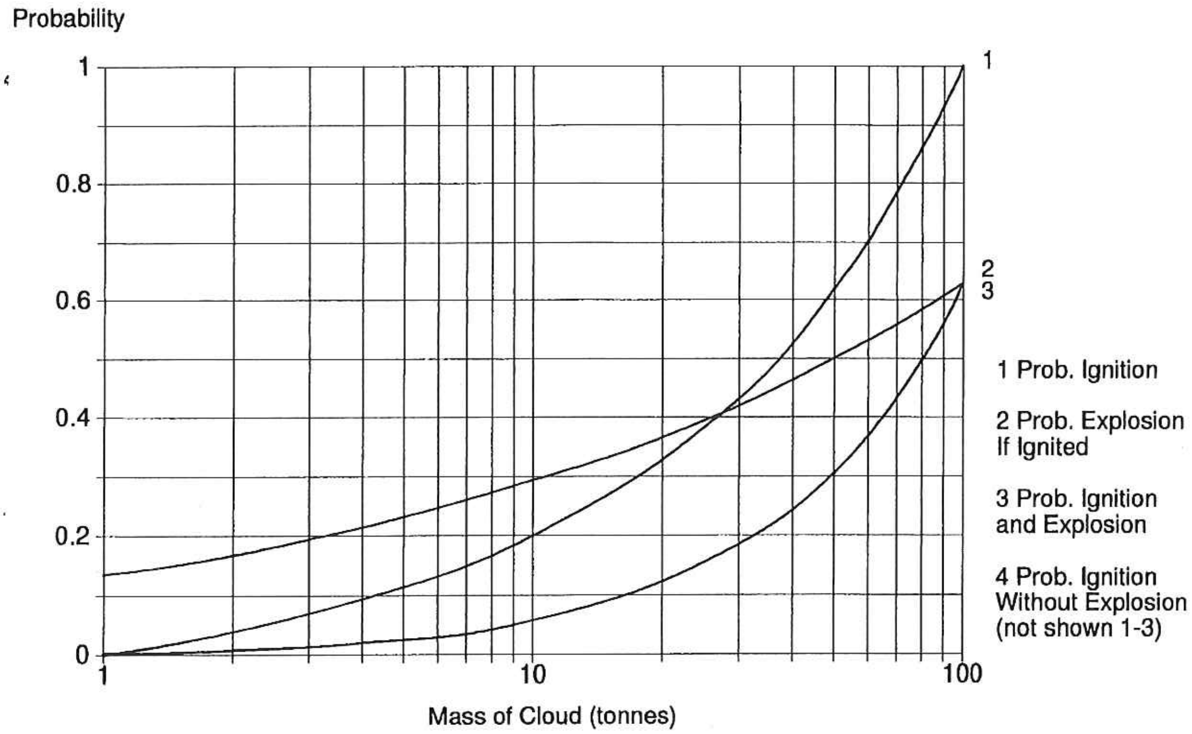
PRM Comment: The data used in Table 8 has been used for approximately 20 years and has been accepted each time by the Department of Planning. It is based on research and is likely to be conservative now that improved design, construction and safety management systems are in place.

Please note that CCPS, Layer of Protection Analysis, Simplified Process Risk Assessment, 2001, quote a pressure vessel failure range of 1×10^{-7}/yr to 1×10^{-5}/yr with 1×10^{-6}/yr as a mean value.

8. The PHA concludes that an explosion is not a credible scenario and the overpressure effect is not estimated. However, the area in the vicinity of the control room is quite congested and therefore an explosion cannot be ruled out in the event of release. The PHA should be updated to consider the explosion events in the analysis.

PRM Comment: Section 5.3.1 calculates the likelihood of a vapour cloud igniting to yield either a flash fire or explosion. This value is 1.7×10^{-7}/yr. As this is below the DoP risk criteria then no further analysis is warranted, i.e. compliance is shown. Therefore, it is not recommended to further detail this event in a revised PHA.

An explosion is very unlikely as the largest release case was estimated to be 423 kg. Using the following graph from the ICI HAZAN Course Manual it is possible to see the low explosion probability.



9. A bund fire frequency of 1E-5 per year is assumed (Section 5.4) and it is based on LASTFIRE and IChemE publications. Does the chosen bund fire frequency accounts for the higher flammability of ethanol ? It is noted that LASTFIRE quotes a range from 2E-5 to 26E-5 based on statistical analysis, while IChemE states 1.2E-4 for highly flammable liquid, such as Ethanol. Please provide justification on the adopted frequency or consider using frequency that reflect the ethanol characteristic.

PRM Comment: 1×10^{-5}/yr as quoted in the PHA as an approximation only.

The above bund fire likelihood was quoted in the section for potential propagation from bund fires to adjacent equipment. However, the storage area is to be designed to meet at least the requirements of AS1940, i.e. to achieve ALARP. Irrespective of the bund fire value chosen, the design is to be compliant with the requirements of AS1940. This will include compliance with the required separation distances to lower the risk of propagation.