Permanent Aviation Fuel Facility
Overview of Issues relating to Hazard Assessment

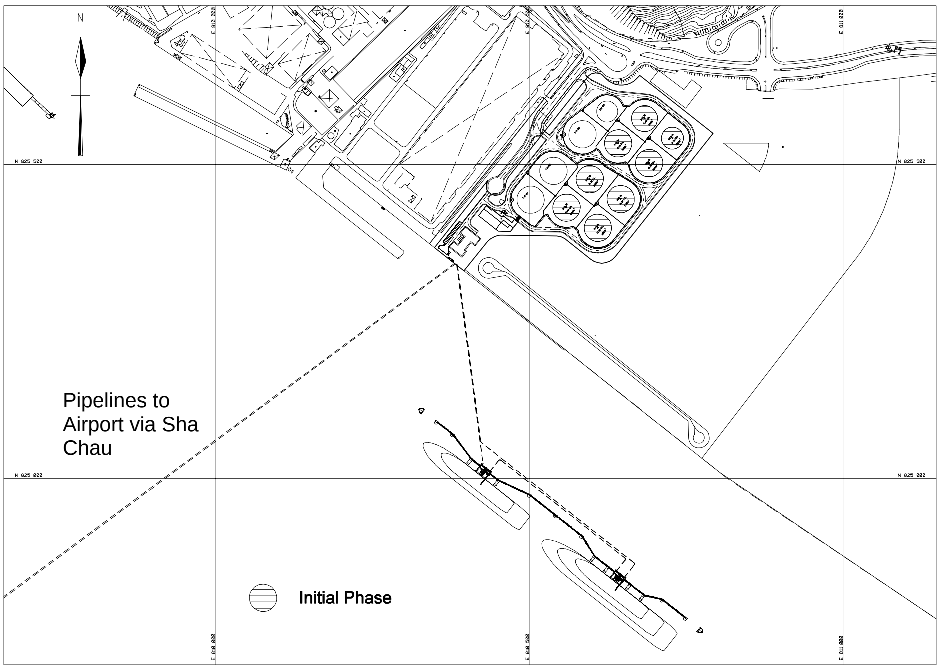
This overview of the Permanent Aviation Fuel Facility (PAFF) focuses on its safety and hazard to life assessment as detailed in the EIA Report.

Why does Hong Kong need PAFF?

- Hong Kong International Airport (HKIA) is the pride of Hong Kong and needs a steady supply of fuel for the nearly 400 departing flights each day.
- PAFF will replace the existing temporary fuel receipt facility at Sha Chau, which will reach capacity in 2009.
- The granting of Sha Chau's temporary use was conditional upon expediting the PAFF.
- Aviation makes a large contribution to Hong Kong's economy, which in 2005 directly accounted for 3%, or $40 billion, of our gross domestic product and made an indirect contribution of $106 billion (8% of GDP).
- HKIA provides about 60,000 jobs and about three times more indirect employment opportunities.

What is PAFF?

- PAFF is a receipt and storage facility for aviation fuel to ensure continuous and sufficient supply for aircraft operations.
- Aviation fuel (Jet A-1) is a much safer fuel than other common fuels like petrol and LPG.
- Aviation fuel will be delivered to PAFF by tankers with double hulls using pilots and tugs, and supplied to the airport by undersea pipelines, raising the overall safety of the fuel supply process, as compared with Sha Chau.
- The diagram below shows the layout of tanks, jetty and pipelines.



Photomontage of PAFF in 2009

Characteristics of Aviation Fuel (Jet A-1)

- Jet A-1 is similar to kerosene which is used for domestic heating and cooking worldwide.
- It is safe to handle and difficult to ignite. Its characteristics are very different from more hazardous fuels such as petrol and LPG.
- Its flash point is 38ºC. Thus it does not produce a flammable vapour at ambient temperatures, unlike petrol (flash point -42ºC) and LNG (flash point -188ºC).
- PAFF is not a PHI (potentially hazardous installation) unlike petrol or LPG fuel depots.
- PHI as defined in the Hong Kong Planning Standards and Guidelines, does not cover Jet A-1 which is a relatively non-hazardous material.

Fuel Storage

There are many cases where fuel tanks including those storing relatively more hazardous fuels like petrol and LPG are located next to industrial and residential developments, and even in the proximity of the high temperature works, like furnaces. Some examples worldwide and locally are shown below.

Refinery showing proximity of hot furnace and tanks, Netherlands

Houses adjacent to tanks, Melbourne, Australia

Industrial facilities adjacent to tanks, Melbourne, Australia

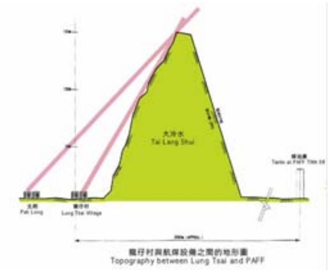
Industrial developments, dockyards close to fuel depots, Tsing Yi

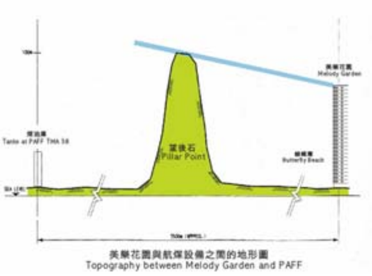
Industrial and residential developments close to Towngas Plant, Tai Po

Industrial and residential developments close to CRC oil depot, Chai Wan

As for PAFF in Tuen Mun Area 38:

- It is located in a Special Industries Area which in landuse terms includes fuel depots
- It is safe to be co-located with neighbouring industrial facilities, like the Shui Wing Steel Mill and the EcoPark
- It is well away (2 to 3 kilometres) from residential developments with intervening high terrain, thus posing no risk to the Tuen Mun residential community





Previous EIA/Judicial Review

- An exhaustive site search for PAFF concluded that Area 38 in Tuen Mun was the only suitable site. The Airport Authority prepared the PAFF EIA Report for this site.[1]
- Upon approval of the EIA Report, the Environmental Permit (EP) for PAFF was granted in August 2002.
- In November 2002, Shiu Wing Steel Ltd lodged a judicial review, which was heard by the Court of First Instance in September 2003 and by the Court of Appeal in September 2004. Both courts ruled in favour of the Director of Environmental Protection.
- In July 2006, the Court of Final Appeal (CFA) ruled that a quantitative risk assessment (QRA) should be conducted even for a very unlikely scenario of an instantaneous loss of a 100% of a tank's contents.
- The court recognized that other issues have already been addressed, comments have been obtained and evaluated, hence there was no need to go back to square one.
- The Airport Authority stopped all construction at the PAFF site on the day the Court of Final Appeal issued its ruling.
- The completed works include piling for the jetty (potentially more disruptive to marine life, like dolphins), formation of site, replanting of trees and foundation of some tanks.
- A revised environmental impact assessment, which addresses the 100% loss scenario, was available for public inspection from 23 February to 24 March 2007.

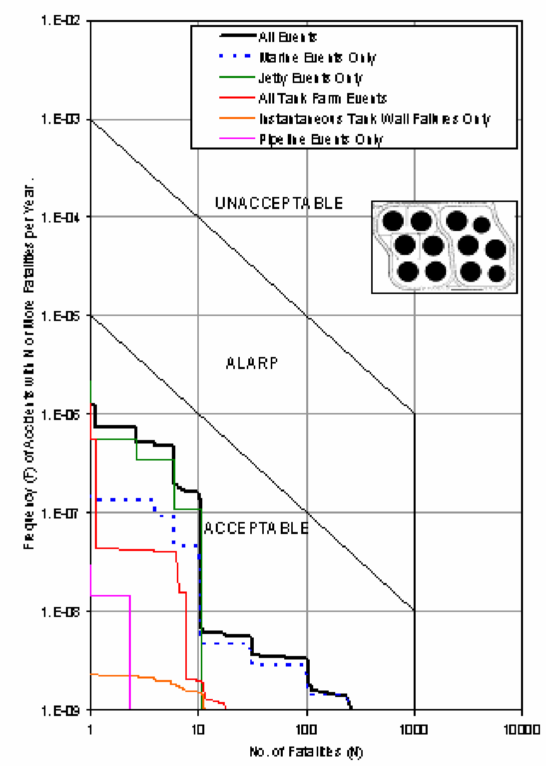
How safe is PAFF?

- Safety is the No. 1 priority of the Airport Authority and the aviation industry as a whole, particularly because HKIA currently handles 800 departing and arriving flights daily, with large aircraft on average carrying about 100,000 litres of aviation fuel each.
- The Airport Authority revised the EIA report addressing the Court of Final Appeal's concern and updating several other aspects of the assessment, including the new EcoPark and changes to the area near the PAFF site. The Buncefield incident in the UK was also considered.
- The assessment for the 100% instantaneous release scenario included a thorough review of historical incidents and a physical model at 1/30 scale of the worst case scenarios.
- The report concluded that the risk from the PAFF is very low and well within the acceptable region according to the Technical Memorandum of EIAO.
- PAFF is one of the safest fuel storage facilities in the world.

---

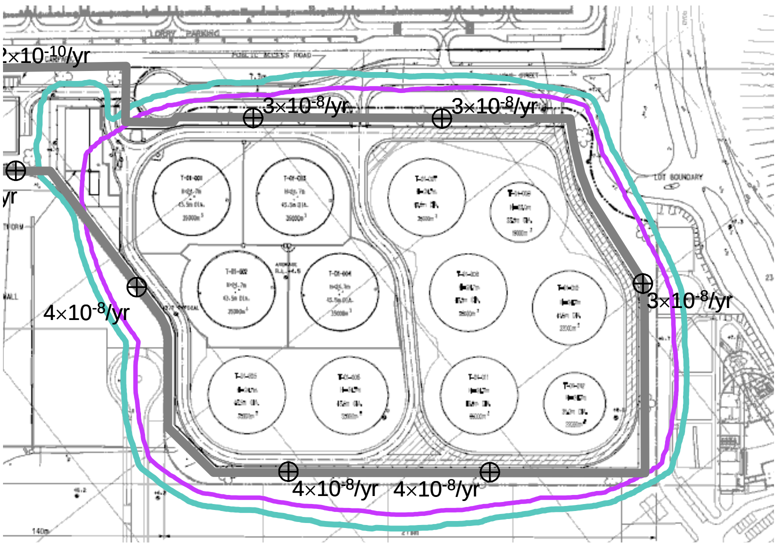
[1] Under Hong Kong Environmental Impact Assessment Ordinance (EIAO), quantitative risk assessment is required for a facility such as PAFF with Jet A-1. This is not universally true around the world, for example, the UK Health and Safety Executive (HSE), an authority similar to EPD in the UK, does not specifically require a quantitative risk assessment for a facility like the PAFF.

Societal Risk Results



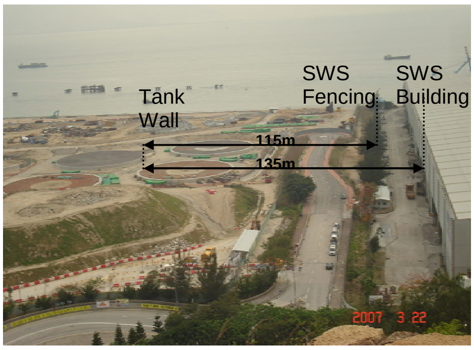
- All risk levels shown are very low
- 100% tank scenario risks are extremely low
- Jet A-1 does not produce flammable vapour and is difficult to ignite
- PAFF has extensive safety features including spill containment

Individual Risk Results



- Maximum off-site risks to neighours on fence line is 4 x 10^{-8} per year i.e. 1000 times lower than the acceptable criterion of 1 x 10^{-5} per year
- In real life, an individual's risk of death in a traffic accident is about 1 x 10^{-4} per year
- 100% instantaneous scenario included but risks are extremely low
- No significant risk outside PAFF boundary

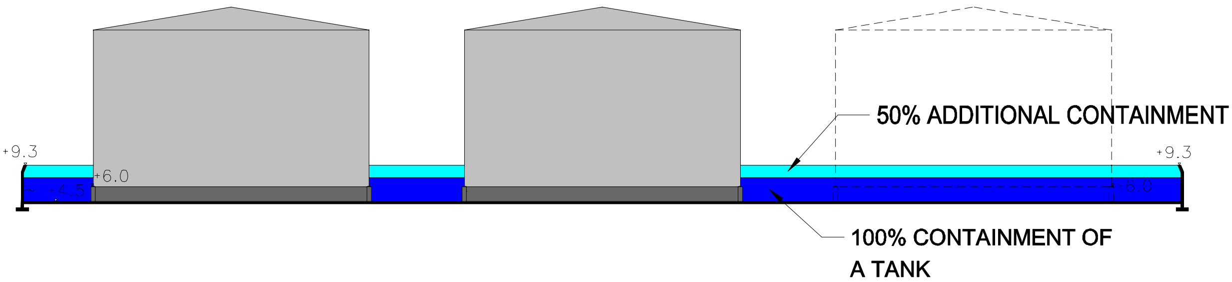
- PAFF is equipped with extensive safety features endorsed by the Fire Services Department, including a spill-containment system.
- It meets or exceeds Hong Kong and international standards for:
    - The distance between the tanks and the PAFF boundary which is 28.5 metres (compared to 10 metres required under Hong Kong standards and 15 metres according to some international standards)



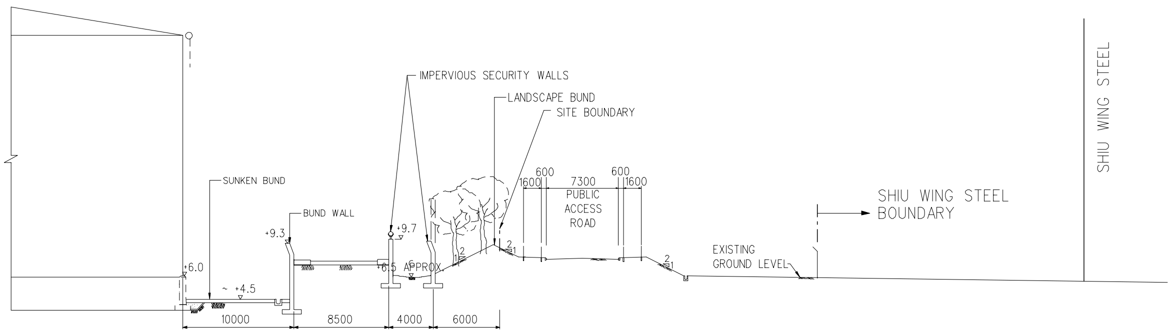
Initial Phase

Final Phase

    - The containment capacity of the bunds surrounding the tanks (over 150% compared to standards of 100% and 110%)
    - Having bunds that are beneath the surrounding ground level, for added integrity



    - Having two additional impervious security walls
    - Having a landscape bund



    - Comprehensive security, shutdown and fire-fighting systems

- PAFF will be operated effectively and controlled by well experienced and conscientious management.
- PAFF will reduce the level of marine traffic carrying Jet A-1 from 2009 by at least 80%, from about 1,100 to 150 vessels a year, in the Ma Wan Channel, Urmston Road and Sha Chau and Lung Kwu Chau Marine Park.
- PAFF will receive larger tankers with double hulls using pilots and tugs, thus further reducing marine traffic risks
- Mitigation measures will minimize risks to the marine environment, including Chinese white dolphins.

Can PAFF be delayed?

- Demand for aviation fuel will exceed the capacity of the Sha Chau facility by 2009
- If PAFF is not available by then, there will be fuel rationing and a reduction in the number of flights, airlines and destinations served by HKIA. This will have an adverse impact on the aviation industry and Hong Kong's economy.

Conclusion

- PAFF is one of the safest fuel storage facilities in the world.
- It will have no unacceptable environmental impacts.
- The probability of the PAFF posing a hazard to life is extremely low.
- Aviation is an important engine of Hong Kong's economic growth.
- HKIA's role as a leading international and regional hub depends on a reliable, steady supply of aviation fuel. To safeguard this role, PAFF must be in operation by 2009.

Airport Authority Hong Kong
March 2007

Part 1B to Annex C

Permanent Aviation Fuel Facility
100% Scenario of Instantaneous Loss of Fuel

What is this 100% Scenario and why is it important?

During the Judicial Review lodged by Shiu Wing Steel Limited challenging Director of Environmental Protection's decision to have approved the PAFF EIA Report and have granted the Environmental Permit, the scenario of instantaneous or near instantaneous loss of a 100% of a tank's content ("100% Scenario") was the most important element as the Court of Final Appeal hearings and judgment were based on this 100% Scenario.

However, it should be noted that during these hearings, particularly in the Court of First Instance and partly in the Court of Appeal, this 100% Scenario was fairly loosely used encompassing various meanings. The Court of Appeal therefore defined this 100% Scenario in its judgment (paragraph 18) that 100% Scenario "... is the momentum surge resulting in overtopping of the bund that so worries SWS, for any flow of fuel onto mill's site carries with it the obvious danger of a conflagration at the mill with the resulting risk to the lives of those working there. A scenario which would cause such a surge and overtopping would be what has been referred to in this appeal, as well as in the court below, as catastrophic tank failure, meaning an instantaneous, or almost instantaneous, loss of the entire contents of a tank such as to result in significant overtopping of the bund" . The Court of Final Appeal judgment (paragraph 37) further defined the 100% Scenario as "..a catastrophic tank failure involving an instantaneous or almost instantaneous loss of the entire contents of a tank resulting in a surge of fuel that would significantly overtop and flow on to the steel mill's site where it would be ignited with resultant risk to life."

This 100% Scenario is important because it was the only case put forward by Shui Wing Steel Limited in the Court of Final Appeal stating that the EIA Report (2002) had not quantified the hazard to life of this Scenario, in effect alleging that in this Scenario the fuel would go off site into the neighbouring facilities such as the steel mill and then igniting and causing fatalities. In all other cases the fuel is contained within the PAFF site. The other cases of instantaneous loss of content where fuel would not go offsite include: (a) if the tank is not 100% full, meaning that it is partially full. It should be noted as stated in the PAFF EIA Report (2007) that because of the operational reasons the tanks would not be full all the time but would be 100% full only 40% of the time; and (b) if the speed of flow from the tank is slower than instantaneous as in the case of a 1 metre high by 10 metre wide hole in a tank or a split of 1 metre high all the way around the base of the tank. In all these cases of "instantaneous loss", the fuel would be contained within the PAFF site except for some potential splashing immediately close to the site boundary (and certainly not flow into the steel mill).

The above is an important distinction because many historical incidents termed catastrophic are far less severe than the scenario of concern and would not generate the same potential consequences.

So what is this 100% Scenario?

The 100% Scenario refers to the loss of fuel from a tank with the tank 100% full of fuel such that the failure of the tank would be instantaneous or near instantaneous meaning it splits in matter of seconds whereby the speed of flow of fuel would be so great as to cause a surge of fuel similar to a tsunami. For the steel mill, this is only relevant for the tanks adjacent to the mill. The surge would have to go over the bund wall, two impervious walls and a landscape bund, all within the PAFF site, and then it would have to go over the elevated public road into the boundary of the mill and then into the steel mill building where it would have to overtop the step and come in contact with the hot works to ignite. This really is the worst possible, though highly incredible, scenario as explained below, but has been quantified in EIA Report (2007) because of Court of Final Appeal's judgment.

How can this 100% Scenario happen?

The PAFF EIA Report (2007) states that this 100% Scenario (which can have impact offsite such as to the steel mill) can take place as demonstrated by a 1/30 scale physical model for the tank nearest to the steel mill, undertaken by the Airport Authority: (a) either by the whole tank being lifted up and the column of fuel standing which then flows creating a surge with a part of it flowing off site. In this case, fuel would not be expected to reach the hot processes such as the furnace and hot metal route in the steel mill building so it is likely that it would not be ignited even if such an incident occurred; (b) or by the tank nearest to the steel mill unzipping precisely in the direction of the steel mill creating a 10 metre wide complete gap from top to bottom on that side of the tank (on the assumption that the tank would remain intact and would not be forced backwards which is unlikely to occur under the laws of physics) with the fuel surging offsite, over the public road into the mill and coming in contact with the hot works and then igniting.

The circumstances of physical tests with 1/30 scale model were idealized to create the worst possible flows. In practice the extent of the flows would be expected to be less even if a tank instantaneously unzipped all the way up on one side.

It should be noted however that the PAFF tanks are not susceptible to the main mechanisms that could generate a 100% instantaneous failure such as (a) low temperature embrittlement as there was an agreement by all parties in the courts that because of climate of Hong Kong, low temperature embrittlement cannot happen in Hong Kong. Furthermore, it should be noted that the modern metallurgy of the tank and weld materials and the fact that the tank plates are staggered, the unzipping 100% Scenario is very improbable, and even more so in one direction such as the direction of the steel mill, which may or may not occur; (b) or a major explosion within a tank because the fuel in the tanks is below the explosive range.

Taking into account this, and the history of tank failures in which there are no cases, not even one, where a tank has failed causing instantaneous or near instantaneous loss of a 100% of a tank's content, that are relevant to Jet A1 storage at the PAFF, the PAFF EIA Report (2007) shows that the frequency of fatalities due to these types of 100% Scenario is close to 1×10^{-9} per year, that is, once in around a billion years, an extremely low probability of such an event occurring and thereby causing fatalities.

Comparison of Assumptions and Basis of Hazard Assessment in the PAFF EIA Report and Public Comment PA#01323 (HSL)

Summary

This note addresses the assumptions used and basis adopted for the hazard assessment conducted by the Airport Authority Hong Kong as compared with those used and adopted by other different parties contained in the public comments on the EIA report; specifically Comment PA#01323 (HSL) [1].

HSL [1] suggest that the "*EIA Report has grossly underestimated the frequency of catastrophic failure of a tank*" and "*Had the calculation of the catastrophic tank failure frequency been carried out on a true cautious best estimate approach, the overall F-N curve for the PAFF moves significantly upwards from the 'Acceptable' region of Annex 4, to the 'ALARP' region.*"

In this Part 2 to Annex C, it is concluded that the difference between the 100% instantaneous tank failure frequencies used in the EIA (5×10^{-9} /yr) and by HSL (2.8×10^{-6} /yr [1]) is based on:

- HSL's inclusion of incidents not relevant to the 100% instantaneous failure of a PAFF tank.
- HSL's use of a catastrophic tank failure frequency which includes much smaller failures than the 100% instantaneous case required by the Court of Final Appeal (CFA).
- HSL's use of a lower estimate of tank population based on less than 10% of the US tanks identified in the survey they quote (i.e. only the large ones) and no other tanks world-wide.

The overall differences between HSL's assessment [1] of 100% instantaneous failure frequency and the estimate in the EIA are:

- A factor of ~30 for the inclusion of events not applicable to100% instantaneous failure of the PAFF tanks.
- A factor of ~6 for the different estimates of US tank population.
- A factor of ~4 for the not including any tanks outside the US.

These three factors need to be included together to produce a societal risk level that significantly enters the ALARP region of the Technical Memorandum criteria.

However, the HSL assessment [1] is based on generic information and can be stated to be grossly pessimistic for the PAFF tanks as it fails to take account of the details of the PAFF project, as required by CFA which states that "*The historical data must be adjusted, however, to take account of the specific features of the instant project.*" (Para 53 of [7]).

For the sake of argument, even if HSL's 100% instantaneous tank failure frequency of 2.8×10^{-6} /yr is used (Figure 1), the Initial Development is completely acceptable and the Final Development (beyond year 2025) is also acceptable, providing the risks for the Final Development are kept As Low As Reasonably Practicable[1].

HSL also suggest an even higher 100% instantaneous failure frequency of 1×10^{-5} /yr [1]. This is considered to have no valid basis since it is based on an erroneous interpretation of earthquake failure data.

The reasons for the main differences cited above between the assessments are:

- HSL include incidents not relevant to a 100% instantaneous failure of a PAFF tank in making their estimate of a "catastrophic" release frequency and have failed to take into account the specific properties of Jet A1 (it is a Class 2 liquid stored below its flash point) and the specific circumstances of the PAFF location.
- HSL's frequency estimate refers to "catastrophic" failures rather than "100% instantaneous" failures. HSL's definition of "catastrophic" failure [9] includes failures much smaller (300 to 4,000 times smaller) than 100% instantaneous. However, HSL [1] apply this catastrophic failure rate to 100% instantaneous failure of the PAFF tanks. This is grossly pessimistic and is not in line with the definition of 100% instantaneous failure of the CFA.
- HSL [1] base their frequency estimate on a tank population of 97,800 in the US only, whereas the EIA bases the frequency estimate on a tank population of 600,000 in the US, leading to an estimate of 2,400,000 tanks world-wide. Since the frequency of failures is derived from the number of incidents divided by the tank population, then a lower population leads to a higher frequency estimate.
- HSL have excluded over 90% of the US tank population estimated in the "*more authoritative source of information*" they quote [8] (the total number of tanks in the US estimated in this source is 700,073 [8] which this is greater than the US tank population used in the EIA). In their analysis, HSL ([9], [1]) have eliminated a very large proportion of the tank population, which is considered pessimistic.
- HSL fail to include any tanks outside the US in their tank population estimate, although failures outside the US are cited; the EIA has taken a cautious approach to assessing the world-wide tank population.
- HSL have also grossly over-estimated the 100% instantaneous failure frequency due to earthquake again by using a frequency for a much smaller failure (moderate loss) to apply the 100% instantaneous case. HSL follow the same approach to continue with their criticisms towards the assessment related to typhoons and aircraft impact. This is very pessimistic and leads to an overstatement of the risks.

[1] Based on using HSL's predicted "catastrophic" tank failure frequency of 2.8×10^{-6} /yr to apply to "100% instantaneous" tank failure instead of the EIA figure of 5×10^{-9} /yr specifically for 100% instantaneous failure of a PAFF tank. HSL [1] also suggest an even higher failure frequency based on a grossly pessimistic assessment of seismic risk, which is not included in Figure 1.

HSL [1] have also cited a planning inquiry into proposed storage at a tank farm at Portland in the UK as relevant to the case of the PAFF. However, there are however many differences between the cases which makes the outcome of the Portland Inquiry of little relevance to the PAFF:

- The Portland inquiry was under UK planning regulation. The UK land use planning system does not require a QRA for flammable storage facilities, whereas the Hong Kong EIAO does for the PAFF. This means that HSL's [1] discussion of whether a QRA is appropriate, based on the Portland Inquiry, is irrelevant for the PAFF.
- The HSE's concerns were related to the adjacent land use for Weymouth & Portland National Sailing Academy (WPNSA). The WPNSA is a major recreation facility, directly adjacent to the tank farm boundary, intended to attract large numbers of the public including the disabled and children. WPNSA will host the sailing events for the London 2012 Olympic Games [21]. This is an entirely different land use to that adjacent to the PAFF and it is treated differently by HSE.
- The HSE did not express a concern over the adjacent land use for a boat yard, which would potentially include hot works and a large number of workers being present, but which falls under a different category of land use which is much more similar to the steelworks and EcoPark.
- There were various other factors, including: the tanks were old and of riveted/bolted construction, they were sited much closer to the site boundary than the PAFF tanks and the WPNSA buildings were also very close.
- The location of the tank farm and sailing academy are quite unusual and could make rapid escape very difficult as large numbers of people could be gathered on a narrow strip of beach between the tank farm and the sea. This is not the case for the PAFF.

In summary:

- The EIA assessment provides a more appropriate and soundly based cautious best estimate for the risk levels at the PAFF than that of HSL [1].
- The assumptions used by HSL [1] are not in line with the CFA judgement.
- The criticisms put forward by HSL [1] do not contain anything which would significantly alter our views on the risk levels at the PAFF, which lie entirely within the acceptable region of the Technical Memorandum criteria.

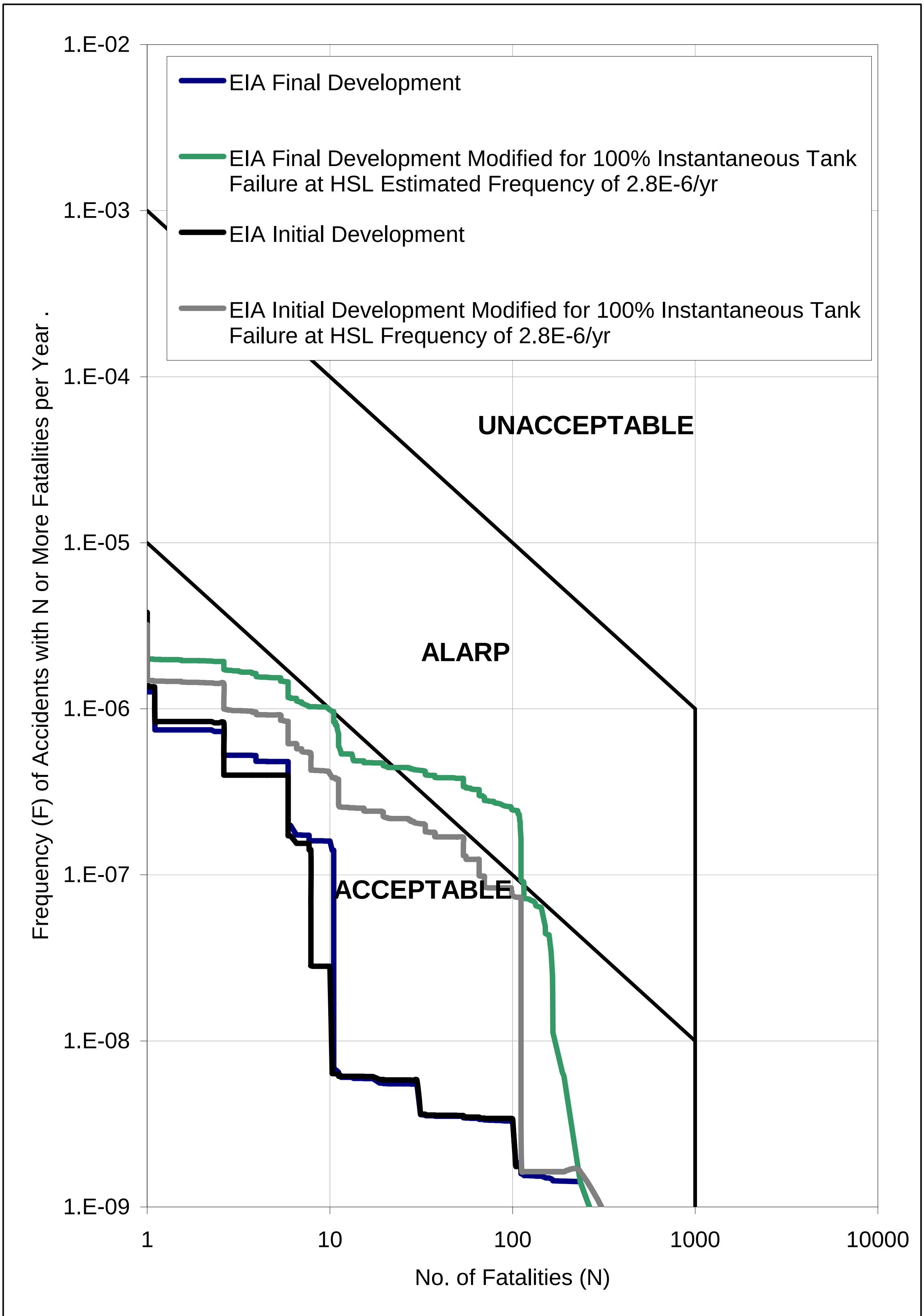


Figure 1: Comparison of EIA and HSL Total Societal Risk Estimates for PAFF[1]

1 Introduction

Following the discussions of the EIA report on "Permanent Aviation Fuel Facility for Hong Kong International Airport" at the ACE EIA Subcommittee meeting on March 19, the EIA subcommittee has requested the Airport Authority Hong Kong, the project proponent, to provide the following supplementary information in writing:

(a) the assumptions used and basis adopted for the hazard assessment conducted by the Airport Authority Hong Kong as compared with those used and adopted by other different parties contained in the public comments on the EIA report; and

(b) the responses to the public comments received in the aspect of hazard assessment.

This note has been prepared by ESR Technology, who prepared the hazard to life assessment in the EIA, to address item (a).

2 Differences in Assumptions

2.1 100% INSTANTANEOUS TANK FAILURE FREQUENCY

HSL assert (first paragraph of 3-1 [1]) that the "*EIA has grossly underestimated (by three orders of magnitude, or a factor of 1000) the frequency of catastrophic failure of a tank.*" The report then goes on to consider the "*flaws in EIA estimate of catastrophic failure frequency*". These are discussed below

2.1.1 Tank Populations

The EIA has taken a tank population for the United States of 600,000, based on Prokop [10], which HSL [1] claim as unreliable.

The total number of tanks world-wide of 2,400,000 in the EIA is estimated on the assumption that the US accounts for ¼ of the tanks. This factor is based on the proportion of the world's petroleum consumed by the US (EIA Para H3.4.1.8); the proportion produced by the US is much lower and would lead to a higher world-wide tank population estimate.

The lower the tank population, the higher the predicted incident frequency will be.

HSL [1] base their assessment on their own analysis of the tank population (Glossop 2001 [9]). In this they derive a population for the number of above ground tanks >450 m^3 in the US of 62,500, which they then increase by a factor of 50% to account for tanks in the chemical sector to give a figure of 97,800. HSL [1] make no allowance for the population of tanks outside the US.

These figures are clearly much lower than those used in the EIA. However, HSL [1] fail to mention that the actual number of tanks estimated in the US in the API survey (1991 edition [8]) is 700,073, i.e. 17% higher than the estimate from Prokop [10] used in the EIA report and ten times higher than the HSL [1] figure. It may also be noted that in relation to tanks at production facilities (over 80% of the total) the API survey says "*The estimation of the total number of tanks in the U.S. in the production sector on this survey is probably an under-estimate of the actual U.S. total...*" [8].

The HSL (Glossop [9]) figure of 62,500 tanks ignores over 90% of the tanks in the API survey on the basis of their size. Such a major departure from the total number of tanks in the API survey appears potentially very pessimistic.

Glossop's cut-off in tank size also includes interpolation of the API study and is inconsistent with HSL's own commentary on the EIA in which they consider that a failure of a "*small tank in lubricating oil service*" is relevant to the PAFF EIA (HSL 3-1.4 "Case Study" [1]).

The total figure of 700,073 tanks in the API survey is not mentioned in either HSL's failure rate analysis (Glossop [9]) or HSL's comments on the EIA [1].

HSL, in their comments on the EIA [1], also say that "*HSE's criticisms are documented in Glossop (2001)*". We note that these are actually HSL's criticisms (HSL is an agency of the HSE) rather than HSE's criticisms since the report referenced [9] is actually an HSL report and not an HSE publication. Glossop [9] criticises the Prokop frequency by reference to a perceived disparity between the population of tanks in the UK and the US. He cites the failure rates published in Davies [12] of $<2\times10^{-5}$ /yr based on no major incidents in an estimated 150,000 tank years of operation in the UK in past 50 years (quoted value is the statistical upper limit on the actual failure rate) and the failure rate estimated from Prokop of 2×10^{-7} /yr based on two tank failures in USA in period 1968-1988 and a tank population of 600,000, as discussed earlier. These two figures in Davies [12] are derived from different sources. Glossop [9] says "*It is believed that there might be an error in these calculations as the values for the number of atmospheric vessels in the UK and USA are 3000 and 600000 respectively. It is believed that it is unlikely that there is such a significant difference in the number of atmospheric vessels present in these countries.*" Certainly, we would agree with the second half of the statement, but the major discrepancy is actually because the UK figure relates to a single company rather than the whole of the UK tank population – although this is made clear by the reference in the original work [4] the reference only appeared as "private communication" in the Davies paper [12]. Presumably this is the cause of Glossop's confusion at the apparent discrepancy in tank populations and leads to a criticism of the Prokop based failure frequency and population based on a completely invalid comparison by Glossop.

Glossop derives a catastrophic failure frequency of 3.0×10^{-6} /yr for the UK tank population by dividing a single collapse of a water tank in 1998 by his estimate of the population of oil and chemical storage tanks in the UK derived by reference to the API survey and ratios between the expected numbers of tanks in the UK and US [9]. Water tanks are not typically built to the same specification as petroleum tanks and Glossop, in assessing this catastrophic frequency, appears to have completely ignored this fact and also completely ignored the population of water tanks in the UK. The basis of Glossop's [9] estimate is therefore grossly unsound.

Glossop's basis for a catastrophic failure frequency for tanks in the US has a better statistical basis, but does include failures of tanks containing water, asphalt, gasoline, acid solvents, creosote, diesel and oil, and relates to "*catastrophic*" failure rather than "*100% instantaneous failure*" (see Section 2.1.2 for more detail).

In the EIA report, comparisons were also made with estimates of other tank populations and total storage capacity data to examine their consistency with the tank population from Prokop. This was found to be consistent with available information. This remains the case, and it is also consistent with the API survey [8].

The situation may be summarised as:

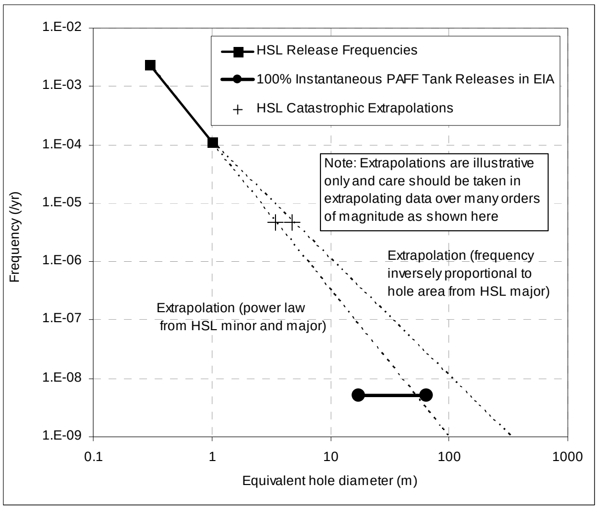
- The tank population HSL suggest [1] is based on less than 10% of the total numbers of above ground atmospheric pressure storage tanks estimated in the US in the API survey [8]. Although some reduction may be appropriate, HSL have assumed a very large reduction without mentioning its extent.
- The tank population in the EIA is based on the estimate for the US tank population from Prokop [10]. The API survey [8] estimate of the total tank population in the US is 17% higher than this. The EIA has not included any uplift for tanks in other industries (if the same 50% uplift used by HSL [1] to account for other industries is included, this is equivalent to the EIA tank population for the US being based on 57% of the API survey population [8]).
- The tank population HSL [1] suggest makes no allowance for any tanks in the rest of the world. The EIA cautiously assumes that the US accounts for 25% of the tanks in the world based on the proportion of the worlds petroleum consumed by the US. An alternative, particularly since a high proportion of tanks in the US are associated with production, would be to assume the US only accounted for 10% of tanks in the world based on the proportion of the worlds oil production which comes from the US.
- ESR consider that, at an absolute minimum, HSL must include a factor of at least 4 to obtain an applicable world tank population estimate of 97,800 × 4 = 391,200. ESR consider that this is at the very lowest end of the spectrum of figures that could be justified and is highly conservative.
- The upper end of the spectrum may be assessed by taking the total numbers of tanks from the API survey, including the 50% uplift for other industries (which is probably conservative), and allowing for the US representing only 10% of the world tanks based on the US share of oil production. This would lead to an upper estimate of 700,073 × 1.5 × 10 = 10,000,000.
- The EIA estimate of world tank population of 2,400,000 is 6 times the lowest estimate and one quarter of the upper estimate. It could be viewed as a reasonable compromise between the most pessimistic and most optimistic assessments based on the available figures from the EIA, the HSL comments [1] and the API survey [8].

2.1.2 Definitions of Catastrophic and 100% Instantaneous Failures

Glossop [9] in the HSL study defines "catastrophic failure" as anything resulting in a release larger than an equivalent hole size of 1m in diameter. This is a very important distinction because this is a long way from the equivalent hole sizes of an instantaneous failure of one of the PAFF tanks. These are compared below.

Failure	Hole Size (m^2)	Notes
HSL Catastrophic definition [9]	> 0.78	1m diameter
Instantaneous loss of PAFF Tank (Test A*)	3,200	Whole wall
Unzipping of PAFF tank (Test B*)	235	10m wide
Failure at base 1m high by 10m wide (Test D*)	10	Offsite flows were only small
Failure 1m high around floor seam (Test E*)	137	
* Tests refer to the physical modelling used for the EIA (EIA Table 10.48)		

The PAFF tank unzipping failure is approximately 300 times the flow area of the HSL criterion for a catastrophic failure and the flow area for the loss of the whole PAFF tank wall is over 4,000 times the HSL criterion. A PAFF tank failure of 174 times the flow area of the HSL criterion (1m high split around the floor seam) was shown in the physical tests to produce only small off-site flows that would not impact SWS.



The effects of the extrapolations of data are shown in the adjacent figure using the power law derived directly from the HSL [9] minor and major release sizes and frequencies and also by assuming the frequency is inversely proportional to hole area. Within these limits, the hole size one might assume for the HSL catastrophic failure frequency of 4.8×10^{-6} /yr is 3-5m (~10-20 m^2). Whilst such failures are "catastrophic" they are much smaller than the 100% instantaneous failure sizes for the PAFF tanks. Compared to these extrapolations from Glossop's figures, the frequencies used for the size of release required for a 100% instantaneous failure of a PAFF tank are realistic (rather than optimistic as asserted by HSL [1]). However, one should always be cautious with extrapolating data, particularly when the data is very limited and the extrapolation is over many orders of magnitude. The main point to note is that the frequencies for "catastrophic" failure and "100% instantaneous failure" should be different because the definitions of the incidents are different; HSL [1] have not allowed for this.

The HSL analysis [1], therefore introduces a potentially very large degree of pessimism by treating all catastrophic (>1m equivalent diameter) failures as equivalent to 100% instantaneous releases.

It should also be recalled that the scenario of concern to the court was *"catastrophic failure of a fuel storage tank with instantaneous or almost instantaneous loss of a 100% of the tank's contents."* (Para 16 [7]). This is not the same as the definition used by HSL as the basis on which they have derived a frequency for the scenario.

HSL in the detailed findings of their 2002 report also stated "*In summary, the Hazard Assessment fails to consider the scenario of catastrophic tank failure (i.e.*

instantaneous loss of the full inventory of the tank), which could lead to significant bund overtopping and risk to neighbouring sites." (Para 63 of [6]). As shown in the physical tests conducted for the PAFF facility, and as discussed above, significant liquid loss overtopping of the PAFF boundary is only expected from 100% instantaneous failure scenarios and not smaller, but still catastrophic, scenarios. It is therefore important to correctly assign a frequency for "*100% instantaneous failure*" rather than all "catastrophic" failures. This is also noted in the EIA (Section H3.1.1), but, in selecting the failure frequency for the analysis, HSL [1] have failed to make this distinction.

2.1.3 Numbers of Incidents

HSL (3-1.4 [1]) say that "*the upper estimate applied for catastrophic tank failure frequency is based on flawed analysis which overlooks and omits certain key issues.*" These are then discussed in HSL's following points [1].

The first point to note is that the estimate in the EIA is the frequency of "*instantaneous tank failure*" and not "*catastrophic*" failure. As noted in the EIA (Section H3.1.1) it is very important to distinguish between "catastrophic" failures and 100% instantaneous failures, in the assessment for the PAFF. HSL [1] have not done this, as discussed in Section 2.1.2 如上 and as noted for the incidents referred to by HSL [1] below.

2.1.3.1 Failure to Take Into Account Relevant Incidents

HSL (3-1.4a [1]) suggest that all 11 incidents in Table H3.2 of the EIA should be included in deriving a "catastrophic" tank failure frequency for the PAFF. However, only 4 of the incidents were identified as involving bund overtopping due to the momentum of the release (3 in the US, one elsewhere) and all included significant causative factors that are not present for the PAFF tanks. HSL's apparent view [1] that all of these failures should be considered for the PAFF tanks is inappropriate:

- If the PAFF tanks were constructed of a material brittle at ambient temperatures or the Jet A1 was stored well below 0^{o}C then the brittle failures may be applicable. However, as HSL say in their 2002 report [6] on the previous EIA "*The EIA report is correct to state that low temperature embrittlement and boilover are not relevant to Hong Kong and storage of aviation fuel*". (Para 59 of [6]).
- If the vapour in the PAFF tanks was above the lower flammability limit under ambient conditions then the incidents involving ignition of flammable vapour inside the tanks leading to an explosion overpressure may also be relevant.
- If Hong Kong was an area of high seismicity then the failures in an earthquake may also be more relevant. This is discussed in Section 2.1.5.

It is important to note the words of the court of final appeal in this context: "*a QRA, in order to satisfy the exigencies of Annex 4, must be both generic and project-specific, that the methodology searches for the relevant scenarios in the history of projects of the same genus - and thus identifies scenarios for the purposes of para.(i) - then quantifies risk by reference to that history and the specific features of the instant project – the QRA for the purposes of para.(ii).*" (Para 72 of [7]). This has been done in the EIA, but HSL [1] appear to have ignored the specific features of the instant project.

HSL cite a number of examples of catastrophic failures [1]:

- The note on BP tank failure in 2005 (HSL Figure 3.1 [1]) covers the failure of tanks in fire and correctly identifies the need for caution in fire fighting tanks exposed to fire. This is not relevant to a 100% instantaneous failure of the PAFF tanks as considered in the EIA since it occurred during a fire rather than suddenly and without warning.
- The rupture of a shell to bottom weld due to overpressure during purging (HSL Figure 3.2 [1]) is not relevant to a 100% instantaneous failure of the PAFF because there would be very little product inside during the purging operation and the PAFF tanks have open vents rather than PV valves so they are not effectively sealed and therefore much more difficult to overpressure.
- The tank internal explosion caused by lightning strike (HSL Figure 3.3 [1]) is not relevant to a 100% instantaneous failure of the PAFF because the tank contained MTBE (Methyl Tert-Butyl Ether). MTBE is a component of gasoline with a flash point around -28^{o}C. Unlike Jet A1 in the PAFF tanks, MTBE will form a flammable vapour which can be ignited. It may also be noted that the tank still has a largely intact wall except at the top (Figure 3.3 of HSL Comments [1]), despite this major failure.

For the reasons identified above, none of the above incidents are relevant to the consideration of a 100% instantaneous failure of one of the PAFF tanks.

2.1.3.2 Failure to take into account incidents with unknown causes

HSL Comment 3-1.4(b) [1] notes four catastrophic failures which have occurred in the past due to unknown or non-specific causes. It is implied that these should be taken into account. For the four cases identified, we have noted the following, based on the additional data records held in MHIDAS [22]:

Incident	Original Description	Further Information
El Dorado 1980	Solvent tank ruptured. Cause cited as mechanical failure.	According to reports at the time, the blaze involved three tanks containing petroleum solvents, which would therefore potentially be expected to have flammable vapour above the liquid. In one report "*a tank ruptured causing sparks that ignited petroleum solvent inside*", a second report based on information from a Refinery spokesman however states "*...fires began late yesterday afternoon at the Getty Refinery and Marketing Co. refinery when one of the tanks exploded. The resulting fire set off a blaze in the second tank. Two hours later the side of one of the tanks burst, triggering a series of explosions that set a third tank on fire.*" Clearly, the actual causes therefore involved an explosion in the tank head space and a failure under fire attack. Unlike Jet A1 at the

		PAFF the liquid stored, may reasonably have been expected to produce a flammable vapour. There is no mention of any bund overtopping or loss outside a bund as might be expected if the releases had been 100% instantaneous. There were 4 injuries and no fatalities.
Colon, 1986	Light crude oil storage tank ruptured, spilling contents. Cause not cited.	The detailed records state that "*Storage tank ruptured spilling entire contents of 240,000 barrels of light crude oil. The force of oil ruptured dyke allowing oil; to flow into refinery area. Oil entered drains and overloaded oil/water separator allowing oil to enter Las Minas Bay (20-30,000 barrels)*." The spill did not ignite despite it being light crude oil, which would be easy to ignite, and spilling into a refinery area, which may have been expected to contain some potential ignition sources. There are no reports of any injuries or fatalities. The HSE report on secondary containment failure [5] cites "*inadequate bund design*" as the secondary containment issue for this event, noting "*The force of the oil caused a section of the bund wall to collapse*" and the "*design was inadequate for the transient hydrodynamic loads which it experienced*." In the case of the PAFF, the bunds are reinforced concrete and sunken in, giving much improved integrity for the containment of the contents of one tank.
El Segundo, 1993	Fuel oil tank ruptured and bund held all but a few percent of the spill, which entered a storm drain.	A report at the time states "*A storage tank at the Los Angeles Water and Power Company in El Segundo, Calif, spilled 2.52m gallons of No. 6 fuel oil on July 29. All but 5,000 gallons were contained in a berm that surrounded the tank. The oil that did leak out flowed into the storm water sewer system, reached a point within 40 yards of Santa Monica Bay and was stopped by a natural berm of sand at the mouth of the storm drain. Clean-up crews used vacuum trucks to remove oil from the storm drain and the berm. The storage tank, containing 8.4m gallons of oil ruptured due to an "unknown cause," according to a report from the United States Coast Guard.*" Based on the report, 0.2% of the tank contents were not contained by the bund in this case and the incident is variously referred to as a leak or a rupture, so it is not clear how rapid the release was. However, the loss of such a small fraction over the bund wall implies that this incident was not of the 100% instantaneous variety being considered here. The fuel did not ignite and no fatalities or injuries resulted.
Fawley, 1993	Bunker oil tank developed a 15ft split and spilled oil. Mist blown onto	The detailed records note that the HMIP report on the incident says "*the leak happened due to a fracture of the tank wall and floor joint.*" The release was actually a fine mist and one report notes "*A 20,000 tonne storage tank developed a 15ft split, allowing ships' bunker oil to spill into a surrounding reservoir*" and "*strong winds carried oil mist into a residential area and it landed on cars and*

	cars and houses by strong wind, but no ignition.	*houses*". There is no suggestion that the release was instantaneous, but was rather a spray release from a split over some time. The fuel did not ignite and no fatalities or injuries resulted.

As a result, ESR consider it entirely reasonable to omit these failures from the potential failures of interest to a 100% instantaneous failure of a PAFF tank; one (El Dorado) occurred due to an explosion of flammable vapour within the tank, one (Colon) involved a failure of the bund wall due to the oil flow rather than any implication that the incident was sufficiently rapid to overtop the bund (the tank also contained crude oil which has many differences to the refined product Jet A-1 stored in the PAFF tanks and is typically stored in floating roof tanks), one (Fawley) was definitely not instantaneous, and one (El Segundo) was very unlikely to have been instantaneous due to the very small percentage loss outside the bund.

2.1.3.3 Over-reliance on the adoption of modern standards

HSL [1] suggest that "*there is too much reliance on modern design standards in an attempt to justify factoring down the historical frequency of catastrophic tank failures*" (HSL 3-1.4(c) [1]). However, the two particular points which make 100% instantaneous failure less likely for the PAFF tanks are:

- The properties of the Jet A1 at ambient temperatures in Hong Kong, meaning that it does not form a flammable vapour above its surface.
- The ambient temperature in Hong Kong and storage conditions being such that the tanks wall material will not be brittle.

These two factors are fundamental to the PAFF operation rather than associated specifically with the design standards and directly affect the fundamental failure mechanisms associated with 100% catastrophic failure. Human errors would therefore have to overcome these inherent physical barriers to lead to a 100% instantaneous failure.

It might also be noted that the Dutch guidelines on risk assessment suggest instantaneous failure frequencies for double and full containment tanks of 1.25×10^{-8} /yr and 1×10^{-8} /yr (Table 3.5 of [3]), although the populations of these tanks (used primarily for refrigerated storage) are much lower than those of above ground atmospheric storage tanks. The suggested failure frequencies must therefore be based on a reliance on the different construction and the associated standards. Therefore, reliance on improvements in design, even if it were a major part of the basis for the 100% instantaneous failure rate of a PAFF tanks, is certainly not unique.

The example of the failure of the poorly maintained Belgian tank (HSL Figure 3.4 [1]) shows that, although the failure is major, it is clearly not a 100% instantaneous failure since the tank wall, although badly distorted, is still largely intact.

The case study of a lubricating oil tank failure of the shell to base seam (HSL 3-1.4(c) [1]) involved a number of issues not relevant to the PAFF tanks: air will not be injected for mixing in the PAFF tanks and the PAFF tanks include open vents rather than a PV valve that could stick. The discussion of the incident also makes it clear that this did not involve the sudden loss of the entire tank wall, but rather a break around the tank base, since a vacuum was then formed inside the tank. This is analogous to the failure around the tank base considered in the physical model Test E, resulting in only a small loss outside the PAFF boundary, rather than a major loss due to 100% instantaneous failure.

Similarly, the Buncefield incident, although lessons have been learned and incorporated in the PAFF design, has little direct relevance to the PAFF, as discussed in Appendix H4.8 of the EIA.

2.1.4 HSL Estimate of Catastrophic Failure Frequency

HSL [1] suggest that the "*EIA Report has grossly underestimated the frequency of catastrophic failure of a tank*" and "*Had the calculation of the catastrophic tank failure frequency been carried out on a true cautious best estimate approach, the overall F-N curve for the PAFF moves significantly upwards from the 'Acceptable' region of Annex 4, to the 'ALARP' region.*"

It should be recognised that if an assessment is made sufficiently pessimistic, it is always possible to over-estimate the risks such that they appear higher on the criteria plot. However, in ESR's opinion, the HSL assertion above is not correct.

It might also be noted that in their 2002 report [6] HSL asserted (Para 71 of [6]): "*Finally, it should be noted that, as with any QRA study, there is a significant margin of error associated with these risk estimates (typically plus or minus an order of magnitude). Given this margin of error, the F-N curve (Figure 3.1) spans the unacceptable and ALARP regions of the Risk Guidelines. These errors should be taken into account in the demonstration that risks have been reduced ALARP.*"

Clearly the above statement from HSL's 2002 assessment grossly overstates the risks even in comparison to their more recent assessment. It is ESR's view that in their recent assessment [1], HSL have once again grossly overstated the risks. In particular:

- HSL [1] suggest that 11 incidents should be taken into account in assessing the failure frequency. As discussed in Section 2.1.3 these, and other incidents cited by HSL [1], are not relevant to a 100% instantaneous failure of a PAFF tank for very good reasons associated with the fuel stored and the conditions it is stored under.
- HSL [1] have failed to take into account the specific properties of Jet A1 (it is a Class 2 liquid stored below its flash point) and the specific circumstances of the location despite HSL considering low temperature embrittlement (one of the main failure mechanisms for 100% instantaneous releases historically) "*not relevant to Hong Kong and storage of aviation fuel*". (Para 59 of [6]).
- HSL [1] have confused "catastrophic" failures with "100% instantaneous" failures that could lead to bund overtopping and a significant off-site flow of fuel, as discussed in Section 2.1.2. HSL [1] have therefore used a "catastrophic" failure

frequency which grossly overstates the frequency of a "100% instantaneous" failure.

- Based on their own research report [9], HSL have greatly reduced the tank population that is taken into account, as discussed in Section 2.1.1. This is despite the fact that the total tank population in the US in the "*more authoritative source of information*" [1] quoted by HSL ([8] 1991 edition) actually estimates a greater number of above ground storage tanks in the US than is estimated in the EIA.
- HSL [1] also fail to take account of any tanks outside the US in calculating the tank population, although failures outside the US are cited. The EIA has taken a cautious approach to assessing the world-wide tank population.
- HSL [1] have also grossly over-estimated the 100% instantaneous failure frequency due to earthquake again by using a frequency for a much smaller failure to apply the 100% instantaneous case and also by suggesting that the seismic hazard in the area is much higher than identified by the Hong Kong SAR Geotechnical Engineering Office, as discussed in Section 2.1.5.

As a result, HSL [1] suggest two failure frequencies for a PAFF tank. The first is based on their analysis of the data, as discussed above, and concludes that a frequency of 2.8×10^{-6} /yr is appropriate. This may be compared with a frequency of 5×10^{-9} /yr in the EIA report, derived specifically for the PAFF tanks. The second figure of 1×10^{-5} /yr is based on including a grossly pessimistic assessment of the 100% instantaneous failure frequency due to earthquake, as discussed in Section 2.1.5.

Figure 2 shows a comparison of the results from the EIA with those modified for HSL's [1] suggested 100% instantaneous tank failure frequencies for the Initial Development (8 tanks) and Figure 3 shows the same information for the Final Development (12 tanks). The basis is the same as shown in HSL's comments [1]

HSL [1] suggest that the 100% instantaneous failure frequency should be a factor of between 560 and 2000 greater than the frequency identified in the EIA. On this basis HSL [1] evaluate results that fall within the lower part of the ALARP region for some of the cases considered.

If all other calculations remain unchanged, as per the HSL comments on the EIA [1], the 100% instantaneous release frequency for a PAFF tank would need to exceed 3×10^{-6} for the initial development and 1×10^{-6} /yr for the final development, in order that the total societal risk would not fall entirely within the acceptable region of the Technical Memorandum Criteria.

Based on HSL's [1] assessed frequency for 100% instantaneous tank failure of 2.8×10^{-6} /yr, the risk from the PAFF:

- is entirely within the acceptable region for the initial development.
- is within the acceptable region for the final development except between 20 and 100 fatalities where it would enter the lower part of the ALARP region.

That is, HSL [1] are saying, based on their overall assessment of a 100% instantaneous tank failure frequency of 2.8×10^{-6} /yr, that the Initial Development is completely acceptable and the Final Development is also acceptable, providing the risks for the Final Development are kept As Low As Reasonably Practicable.

However, as discussed above, this assessment is grossly pessimistic for the PAFF tanks and fails to take account of the details of the PAFF project, as required by CFA which states that "*The historical data must be adjusted, however, to take account of the specific features of the instant project.*" (Para 53 of [7]). HSL's suggested upper estimate of the 100% instantaneous release frequency for a PAFF tank of 1×10^{-5} /yr [1] appears to be grossly pessimistic and not soundly based, as discussed in Section 2.1.5.

2.1.5 Earthquake Induced Failures

HSL point out (HSL 4-1.1 [1]), based on CEDD information [15], that "*Hong Kong is an area of low-to-moderate seismic risk*". CEDD further point out in the same publication [15] that "*There is little evidence of significant recent fault activity in Hong Kong, either onshore or offshore*." and "*The possibility of significant earthquake damage to slopes, retaining walls and reclamations in Hong Kong is low.*" [15]. Before noting (as per HSL [1]) that "*Earthquake risk cannot be regarded as negligible*", the note goes on to say "*The earthquake hazard in Hong Kong is therefore considered to be very much lower than in areas such as Japan, Taiwan and the western USA which lie close to the earth's more seismically active zones along the crustal plate boundaries.*" [15].

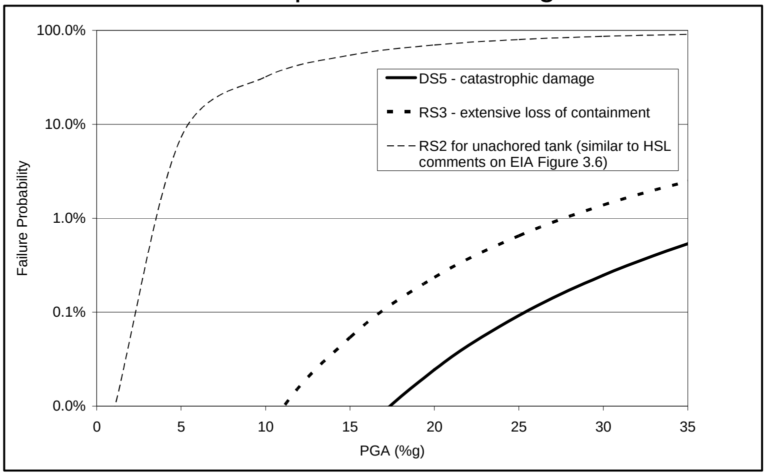
In comparison, the one earthquake failure in Table H3.2 of the EIA for which we have a specific location occurred in Richmond, (near San Francisco) California (and the others were in the USA). As noted in the EIA Report (Para 10.6.2.17) "*the spill was stated to be contained within the bund and not ignited*"; there is no suggestion of bund overtopping due to the momentum of the release. This failure occurred in the 1989 Loma Prieta (magnitude 7.1) earthquake, described as the worst earthquake to strike the San Francisco Bay area since 1906 [18].

The seismic risk around California includes a PGA (Peak Ground Acceleration) of >0.32g with a 2% probability of occurrence in 50 years [16]. The HSL note on the EIA (HSL 4-1.1 [1]) suggests a similar PGA with a similar return period for Hong Kong (0.35g with a 2% probability of occurrence in 50 years) may be applicable, but this seems to over-state the risk.

HSL [1] go on to cite work on atmospheric steel tank fragility by Salzano and co-workers, suggesting that such tanks have "*around an 80% probability of catastrophic failure*" for the peak ground acceleration HSL identify in the Tuen Mun area with a 2% chance of exceedance in 50 years (2 ms^{-2}) [1]. This would imply a catastrophic failure frequency for atmospheric steel tanks in a low-to-moderate seismic risk region of 3×10^{-4} /yr. Even applying this to the HSL's identified US tank population of 97,800 would imply that catastrophic large tank failures were occurring approximately monthly in the US. Using the estimate of world-wide tank population in the EIA report, this would suggest tanks were failing catastrophically in earthquakes around the world at a rate of more than one per day. Clearly, there is something wrong with this assessment and HSL rightly suggest that this "*may be considered as over-conservative*" [1]. HSL then go on to suggest that the failure frequency should be between 10^{-5} and 10^{-6} per year, but provide little basis. This also appears inconsistent as their own analysis of catastrophic failures in the US (a more seismically active location) since their analysis in Glossop [9] would imply that seismic failures were already included in HSL's estimates of catastrophic failure frequency based on a more seismically active location and that they contribute between 12.5% and 21% of that frequency (depending on whether their 1978 incident is counted as 1 or 3 incidents).

Based on HSL's own analysis [1], this would place the frequency of catastrophic failure between 10^{-7} and 10^{-6} /yr for the US, and identify that it is already included in their catastrophic failure frequency estimate. ESR would expect that the risk of a catastrophic tank failure due to earthquake in low-to-moderate seismic risk region of Hong Kong would be lower.

To put the analysis in perspective the Geotechnical Engineering Office, of The Hong Kong SAR [19], estimate the PGA with a 2% probability of occurring in 50 years for Kowloon is 180gal (0.18g) and more recent work by Salzano and co-workers [17] has provided probit[2] relationships for the failure of atmospheric steel storage tanks. Fragility curves derived from this work [17] are shown adjacent for anchored steel storage tanks (such as the PAFF tanks) and a comparative line similar to that used in HSL's comments on the EIA [1]. The estimated failure probability for Damages State 5 (catastrophic damage) at 0.18g is 0.014% (the RS-2 curve for moderate loss to an unanchored tank at 0.2g gives a failure probability of 70% similar to that identified by HSL [1]). Combining these figures together would give a failure probability for catastrophic damage of $0.02/50 \times 0.00014 = 6 \times 10^{-8}$ /yr.



The above estimate for catastrophic damage to a PAFF tank is far removed from HSL's frequency estimate of 10^{-6} to 10^{-5} /yr [1] and it is still not clear what proportion of such failures would be 100% instantaneous. It is clear that, as also discussed in Section 2.1.2 in relation to the general frequencies used, HSL [1] have again identified a frequency for a failure much less severe than 100% instantaneous failure and then used it directly to represent 100% instantaneous failure. Whilst this is certainly a cautious approach it is also very pessimistic and leads to a large overstatement of the risks.

Analysis such as that above, based on generic tank fragility models, is necessarily approximate, particularly at low failure probabilities. However, it does serve to

[2] A probit is simply a mathematical means of deriving a probability from basic data.

demonstrate, together with the limited number of catastrophic failures that were caused by earthquakes in more seismically active regions, that the risk of 100% instantaneous failure of a PAFF tank due to earthquake is adequately represented within the derived 100% instantaneous failure frequency within the EIA.

2.1.5.1 Other Points Related to Seismic Failures

In Section 4-1.1 of their comments HSL [1] also produce photographs of the tank farm fire at Izmit refinery in Turkey. These show fires and late tank failures in a fire due to an earthquake and do not represent 100% instantaneous failures. Such fire scenarios are included elsewhere in the EIA, as is a loss from the top of the tanks such as the one described by HSL [1] due to sloshing.

In suggesting that the statement in the EIA report that "*There remains a small possibility that an earthquake could lead to an instantaneous failure of the tank, but this would be at a much lower frequency than indicated by the two earthquake failures reviewed in Appendix H4*", "*is not supported in any way in the EIA report*", HSL [1] are ignoring the foregoing discussion in the EIA report and that the seismic risk in Hong Kong is lower than in regions such are California.

HSL [1] appear to agree with the statement in the EIA report that "*Also, from ESR's experience, the magnitude of the ground acceleration would need to be sufficient that the level of damage elsewhere in the vicinity would also be massive*" (EIA report 10.6.2.20). However HSL's suggestion that this is being used as "*a reason for accepting failure in the PAFF*" (HSL 4-1.2 [1]) is entirely untrue; the EIA report does not claim that this is a reason for accepting failure in the PAFF.

2.1.6 Typhoon Events and Aircraft Impact

HSL state that "*the probability and consequence of typhoon events should have been included in the 2007 EIA Report*" (HSL 4-1.2 [1]). As stated in the EIA Report, the basis of design includes typhoon conditions. The tanks are also anchored. HSL [1] have identified two losses of oil from tanks in the area affected by Hurricane Katrina; one 4000 m^3 and one 5400 m^3 (i.e. about 15% of the capacity of one of the PAFF tanks). There are several large refineries in this area and the limited nature of the losses reported, provides added confidence in the durability of such tanks in very high winds. HSL [1] do not identify any 100% instantaneous losses resulting in overtopping of the bund due to momentum surge due to typhoons/hurricanes. Given the severity of Hurricane Katrina and the damage caused then this would appear to provide strong support for the strength of such tanks against typhoons and that typhoon events are adequately included within the overall 100% instantaneous failure frequency.

HSL [1] question the assessment of aircraft impact noting that it seems "*wholly unrealistic to suggest that the wings of an aircraft that could be as large as an Airbus A380, flying out of control, would not cause massive immediate damage to several tanks*". It should be noted that the frequency of aircraft impact on the PAFF tanks is less than once per billion years, allowing for 700,000 aircraft movements per year in 2040. The number of Airbus A380 aircraft flying in and out of HKIA is a matter for speculation, but it would be expected that this would be only a small fraction of the total aircraft movements. The impact frequency for an Airbus 380 on the PAFF tanks would therefore be extremely small. It is also notable that HSL [1] use the term "*massive immediate damage*" rather than 100% instantaneous failure and there is no dispute that damage to the tanks impacted would occur. However, as can be seen in HSL's Figure 3.3 [1] for an MTBE tank following an internal explosion, for example, atmospheric pressure steel storage tanks such as the ones at the PAFF can withstand major impacts and deformation without leading to 100% instantaneous failure. A more detailed investigation, that covered the size and type of aircraft, more detailed impact calculations and included more up to date (and less conservative) impact frequencies (see EIA Para H3.6.1.9) would be expected to confirm the results of the EIA or reduce the predicted risks from aircraft impact, which are already below the axis of the technical memorandum criteria. ESR do not think that such an analysis is warranted here.

2.2 POOL SPREADING OUTSIDE BUND

This is discussed in HSL comments section 5 (5-1.1 and 5-1.2) [1].

HSL Item 5-1.1 [1]: Security of wall construction. It is agreed that a breeze block type wall is not appropriate to provide a high level of integrity for the security walls. The comment on breeze block type construction in Paragraph 10.5.13.5 of the EIA was erroneously retained from the previous EIA. Elsewhere (10.1.2.8, 10.5.13.5, 10.10.1.8) the walls are referred to as "impervious". The two security walls are in fact both reinforced concrete and this is depicted in the approved drawings [11]. The drawings also show details of the gates and the sealing provided for any Jet A1 spill.

In terms of bund integrity, it may be noted that the bund wall is sunken in, providing a high degree of integrity due to the buttressing affect of the ground behind it, in addition to the reinforced concrete construction. Thus the strength suggestions from the identified Paragraph 143 of the UK HSE guidance on storage of flammable liquids (HSE 1998) have all been implemented in the PAFF design both for the bund wall and the additional security walls.

Item 5-1.2 [1]: Bund overtopping volumes. HSL [1] do not dispute the adequacy of the physical modelling on which the assessment has been based. However there appear to be a number of misinterpretations of the results in this section:

- The second paragraph of this HSL comment suggests that a lesser scenario of 10% loss from the top of a tank (T14 see EIA 10.5.15) would result into a flow of 700 m^3 onto the SWS site. In the EIA, no flow of Jet A1 is predicted onto the SWS site for this scenario. 350 m^3 is however predicted to flow to the sea via the stormwater drains with a small proportion of this via the drainage system between the outer security wall and the landscape bund.
- The sealing of the access gates has been considered in the design and the assessment, noting that there is an elevation change, sealing and stormwater drainage immediately outside the gate. Hence there is a means of both sealing to contain any liquid and a means of draining any leakage through the gates.
- The recent improvements made by AAHK to the layout of the PAFF (Table 3.2) (namely additional security wall, landscaping bund and 'wave wall' design) are

stated to have been ineffective in materially reducing the hazard to neighbouring sites. HSL [1] provide no valid basis for this statement. These specific features were incorporated within the 1/30 scale tests conducted and the results of the tests (Table 10.49 of the EIA) clearly show substantial retention of liquid between the primary and tertiary walls. These features therefore do make a material difference.

- The comment related to the cost benefit analysis is taken out of context as the positioning of any further wall would be close to the existing ones and hence would be expected to make little difference. It should also be noted that the normal practice for a tank farm is to have a single bund wall and a site fence. The two security walls and landscape bund are in addition to normal practice. Contrary to the bullet points raised by HSL [1], the PAFF is employing inherently safer design in having a bund capacity greatly exceeding the standards, bunds partly sunken below ground level, additional "passive" protection such as the two security walls and landscape bund. It is also inherently safer than many tank farms because it stores only Jet A1, which is much less hazardous than petrol, for example.

It may also be noted that there are only a small number of events, even within the idealised and pessimistic modelling of a 100% instantaneous failure scenario used, that would result in a flow that could impact the SWS hot metal route. This is because the flow from a 10m wide spilt up the tank wall directly opposite SWS is assumed to be constrained by the rest of the tank remaining in position. In fact, as happened in the Ashland tank collapse (see EIA 10.6.7.5), the tank wall will open out and be pushed backwards which would lead to less flow into SWS.

It may also be noted that the Dutch guidelines on risk assessment specifically state "*If a spill of liquid occurs in a bund, its characteristics have to be taken into account. If the walls of the bund are sufficiently high, the bund prevents the spreading of the liquid pool and the dimensions of the pool are restricted to those of the bund.*" (Section 4.5 of [3]). It is not therefore always the case, that bund over-topping due to momentum surge is considered in a QRA, although it is in the UK.

Overall, we can find no sound basis for HSL's three criticisms of the integrity of the secondary and tertiary containment (HSL 5 [1]) and consider that the assessment remains a reasonable, and in ESR's view very pessimistic, assessment of the potential flows of Jet A1 outside the PAFF from a 100% instantaneous failure.

2.3 IGNITION PROBABILITY

HSL comment on the ignition sources identified outside the PAFF within the Shiu Wing Steelworks (HSL 2 [1]). This is treated extensively within the EIA (Appendix H5 of the EIA) including analysis of the potential ignition sources within both Shiu Wing Steelworks and the EcoPark. It is agreed that if Jet A1 flows into certain areas within Shiu Wing steelworks then there is a strong chance of ignition and in some cases an ignition probability of 1 is used within the EIA to reflect this. This has been fully incorporated in the assessment in the EIA.

In their 2002 analysis [6] HSL used a global ignition probability of 0.6 in their assessment of 100% instantaneous failures, based on information that was considered to overestimate the probability by the authors of the paper [12] and which was based mainly on releases of highly flammable or liquefied gases, capable of generating potentially large flammable gas clouds. This leads to further pessimism in HSL's 2002 assessment [6], but in their comments on the EIA [1], their revised results are based on the more appropriate modelling of ignition, taking specific account of the potential ignition sources surrounding the PAFF, in the EIA.

2.4 PORTLAND PUBLIC INQUIRY

This case cited by HSL (HSL 6 [1]) concerned the refusal of Weymouth and Portland Borough Council in the UK to grant consent for the storage of flammable substances at an existing tank farm, because HSE advised that the use was considered incompatible with the adjacent use by Weymouth & Portland National Sailing Academy (WPNSA – then called Weymouth & Portland Sailing Academy (WPSA)). The WPNSA is a major facility, directly adjacent to tank farm boundary, intended to attract large numbers of the public including the disabled and children. For example, WPNSA will host the sailing events for the London 2012 Olympic Games [21].

HSL state that the Public Inquiry into the Portland Port Ltd (PPL) hazardous substances consent application "*has striking similarities to the PAFF case.*" (HSL 6-1.1 [1]). Although it concerned the storage of kerosene at a tank farm, there are also a number of striking differences between this case and the PAFF:

- The inquiry was under UK planning regulation. In this, the planning authority is the local authority, which is advised by HSE (and will take HSE's views into account but does not have to abide by them).
- The UK land use planning system does not require a QRA for flammable storage facilities, whereas the Hong Kong EIAO does. Therefore there was no requirement to consider a QRA for the facility.
- As noted in the Inquiry conclusions, in land use planning advice for flammable storage, HSE do not normally consider the frequency with which an incident may occur, but only consider the potential extent of the worst case event based on bund overtopping. For the PAFF a QRA was specifically required to compare with the individual and societal risk criteria in the Technical Memorandum. No such requirement exists in the UK which has no specific societal risk criteria (although there is some guidance).
- The HSE's concerns were related to the adjacent land use for WPNSA and its use "*by the public, including the disabled and children, on a potentially large scale on occasions*" This is an entirely different land use to that adjacent to the PAFF which is treated differently by HSE for land use planning purposes.
- The tanks were sited much closer to the site boundary than the PAFF tanks are to the PAFF boundary and the WPNSA buildings were also close to the site boundary.
- The HSE did not express a concern over the adjacent land use for a boat yard, which would potentially include hot works and a large number of workers being present, but which falls under a different category of land use which is much more similar to the steelworks and EcoPark.

- The location of the tank farm and sailing academy are quite unusual in that it is at the end of a sandbar with a main road connecting Portland to the mainland. The WPNSA location meant that large numbers of people could be gathered on a narrow strip of beach between the tank farm and the sea, which could make rapid escape very difficult. This is not the case for the PAFF.
- The tanks considered at Portland were old tanks (believed to be at least 50 years old) of riveted/bolted construction. As discussed in Section 2.4.1, there are specific issues with these types of tank and ESR have previously assessed this type of tank as having higher release frequencies than the general tank population.

In summing up Tester (Para 12.16 of Annex A of HSL comments on EIA [1]) says:

"*I have given careful consideration to the Appellant's arguments concerning the inevitability of the predicted consequences occurring if a protection concept approach is adopted (11.6). I do not accept that the approach means that the predicted consequences are inevitable, but recognize that it relies on judgement as to whether an event is credible, <u>and that a QRA is to be generally preferred in this respect</u>. However, in this case, for the reasons I have explained, I can see no justification for overriding the HSE advice that the adjacent land uses would be incompatible.*" (underlining added for emphasis).

It is clear that the Inquiry concluded that a QRA was the preferred approach, as is the requirement under the Hong Kong EIAO, but that it did not see a justification for overriding HSE's advice on this occasion. It is also clear that the land use considered incompatible adjacent to the storage was very different from that of the Shiu Wing Steelworks or the EcoPark and involved large scale outdoors public gatherings, including children and the disabled, in a location where escape from any incident could be very difficult.

Although superficially there may appear to be similarities with the adjacent land uses for the PAFF, EcoPark and Shiu Wing Steel, the details, and the reasons for the decision are in fact very different. For an adjacent industrial land use no objection was raised by HSE.

2.4.1 Note on tanks of bolted/riveted construction

The tanks considered at Portland were old tanks (believed to be at least 50 years old) of riveted/bolted construction. These tank types are substantially different to those proposed for the PAFF and it is quite surprising to see generic tank failure frequencies being cited for this tank type in the Inquiry.

For example, in assessing the probability of a major failure for an old 10,000 bbl (~1500 m^3) cone roof tank of bolted construction, ESR recently assessed the probability of a major failure at 2×10^{-3} /yr based on an examination of the details of the tank [14]. This compares to HSL's major failure frequency of 1.1×10^{-4} /yr (Glossop [9]), i.e. ESR assessed the risks of a specific type of tank similar to those at Portland as being over 10 times greater than HSL suggest. The comparison is not ideal since the tank in question contained crude oil, which would also raise the risk level if considered in detail, but was not adjacent to public facilities such at the boating club at Portland (it was neither in UK nor Hong Kong). Nonetheless, this underlines the importance of treating the specific type and circumstances of the tank.

2.5 BUNCEFIELD

HSL discuss the Buncefield incident (HSL 7 [1]) and suggest that "*It is premature to even consider approving the construction of the PAFF at TMA 38 at this stage*", because the UK HSE is conducting a review of its policy and land use planning procedures. Aside from the fact that the UK HSE's land use planning procedures will apply in the UK and not Hong Kong (Hong Kong has completely different procedures based on the Environmental Impact Assessment Ordinance (EIAO)), it is also clear that the main incident (explosion) at Buncefield was associated with petrol storage and not Jet A1, which would behave significantly differently. This has been reviewed already in the EIA Report (Section H4.8 of the EIA) and it may also be noted that the HSE has recently issued a consultative document specifically on development control around petrol depots [20], not flammable liquid storage such as Jet A1 at the PAFF.

In terms of HSL's assertion that: "*The above is relevant to the PAFF as aviation fuel comes under the category of 'flammable liquids'. In the case of the PAFF the concern is aviation fuel spilling off-site where it could be heated by the numerous hot surfaces present at SWS and the EcoPark, leading to the formation of a vapour cloud and possible explosion.*" [1], The following should be noted:

- Whilst Jet A1 at the PAFF is categorised as a flammable liquid, petrol is categorised as a highly flammable liquid and there is a significant difference in their behaviour, as discussed in the EIA (e.g. Section 10.2.1 of the EIA).
- Flammable vapour production is expected to be very limited, as discussed in the EIA Report (Section H5.3.2). Although, if large quantities of Jet A1 are raised to high temperatures (e.g. 90^{o}C) then a flammable vapour will be formed above the surface and the Jet A1 would be easy to ignite, it is first necessary to transfer sufficient heat to the flowing Jet A1. As discussed in Section H5.3.2 this is unlikely.

Although it is always appropriate to exercise caution and to review past incidents in aiming to improve on future safety, there does not appear to be a sound basis for suggesting that "*It is premature to even consider approving the construction of the PAFF at TMA 38 at this stage*". For the PAFF, appropriate lessons have been learned from Buncefield, in particular regarding the specification of the sealant materials for the bund walls – another item noted by HSL [1].

2.6 COMPLIANCE WITH RELEVANT CODES

HSL state that "*The PAFF does not comply with the recommendations of current international good practice in tank farm design*" (HSL 8 [1]). In particular HSL cite guidance that the total quantity of fuel held within a bund should not exceed 60,000 m^3 in Part 2 of the IP model code of safe practice.

Guidance from relevant standards is cited in the EIA report where appropriate. The guidance on total storage capacity in a bund for distribution terminals in IP MCSP Part 2 as noted by HSL [1] is permitted to be exceeded under both the Hong Kong code of practice for oil storage installations (Ref 5 of EIA S10), and the part of the IP Model Code of Safe Practice most relevant to the PAFF, i.e. Part 19, “Fire precautions at petroleum refineries and bulk storage installations” (Ref 26 of EIA S10). The PAFF is different to a typical distribution terminal in that it stores a single product (Jet A1) imports only via its own marine jetties and exports via a dedicated single product pipeline; the PAFF does not distribute Jet A-1, it receives it for, stores it for, and supplies it to HKIA only. Part 2 of the cited IP Model Code of Safe Practice covers distribution terminals that may store multiple products, import and export by multiple routes including, road and rail loading facilities, single and multi-product pipelines, in addition to the types of facilities that will be present at the PAFF. IP Part 19 is therefore the more appropriate IP code to consider, and Fire Services Department (FSD) has been satisfied after having given in-depth consideration to this matter.

The recommendation of the total capacity in the bund in IP Part 19 is a general recommendation and covers all product classes I, II and III. Jet A1 is classed as Class II(1) within the IP code and as such represents a lower risk than Class I, Class II(2) or Class III(2) product and accordingly relaxation of the recommendations is permitted as indicated in IP Part 19 clause 3.4.2.1.

The Hong Kong code of practice for oil storage installations (Ref 5 of EIA S10) is more specific in differentiating between the classes of product and places a similar limit on Class I products only. No limit is placed on the volume of Class II products.

Also note that National Fire Protection Association (NFPA) 30 Flammable and Combustible Liquids Code places no restriction on the maximum quantity of any class.

The normal recommendation for total capacities of tanks in a single compound of 60,000 m^3 for a bulk storage site in IP Part 19 may be exceeded provided that an assessment indicates no significant increased risk of pollution or hazard to people. This restriction has been discussed with FSD as part of the review and FSD has been satisfied.

The EIA report provides a quantitative assessment of the hazard to life and the results lie well within the acceptable region of the criteria in the EIAO-TM, satisfying the requirement for an assessment.

With regard to HSL’s suggestion [1] that the risk levels are increased due to exceeding 60,000 m^3 in a bund, the assumptions made by HSL [1] do not appear reasonable, since the facility bunds might then also be of smaller capacity relative to a single tanks and may also be closer to the site boundary without further intervening security walls to accommodate the additional land area required for storage. HSL [1] have not compared like facilities since they suggest a significantly reduced overall capacity for the tank farm and movement of tanks which may not in practice occur. It is certainly not clear that there would be any change in the numbers of tanks near the eastern and western boundaries, as suggested by HSL [1].

The layout of the Denver facility is cited by HSL [1] as good practice. However, there are vast amounts of open land available in Colorado compared to Hong Kong and it is therefore to be expected that the PAFF will be more economically laid out. Nonetheless, the spacing of the tanks and the boundary at the PAFF exceed the relevant codes and the risk levels are well within the acceptable region of the technical memorandum criteria.

3 Conclusions

In conclusion, the HSL assessment [1] is considered grossly pessimistic. However, even using HSL's assessed 100% instantaneous failure frequency of 2.8×10^{-6} /yr, the initial development would still fall entirely within the acceptable region of the Technical Memorandum criteria and the final development would only enter the lower part of the ALARP region only.

HSL's higher 100% instantaneous failure frequency of 1×10^{-5} /yr [1] is considered to have no valid basis since it is based on an erroneous interpretation of earthquake failure data.

The overall differences in HSL's assessment [1] of 100% instantaneous failure frequency and the estimate in the EIA are:

- A factor of ~6 for the different estimates of US tank population.
- A factor of ~4 for the not including any tanks outside the US.
- A factor of ~30 for the inclusion of events not applicable to100% instantaneous failure of the PAFF tanks.

All of these three factors need to be included together to produce a societal risk level that significantly enters the ALARP region of the Technical Memorandum criteria.

4 References

[1] PA#01323 Comments on Environmental Impact Assessment for Permanent Aviation Fuel Facility, 15 03 07.

[2] The Hong Kong EIAO Technical Memorandum Annex 4: Criteria for evaluating air quality impact and hazard to life (http://www.epd.gov.hk/epd/eia/english/legis/memorandum/annex4.html) (accessed 4/12/02).

[3] Guideline for quantitative risk assessment, 'Purple book', CPR 18E, Publication Series on Dangerous Substances (PGS 3).

[4] Bund overtopping - the consequence following catastrophic failure of large volume liquid storage vessels, A Wilkinson, SRD/HSE R530, October 1991.

[5] Effects of secondary containment on source term modelling, HSE Contract Research Report CRR 324/2001, S O Clark, D M Deaves, I G Lines and L C Henson, W S Atkins, Appendix C, Incident I-13.

[6] Independent Review of Hazard Assessment of Proposed Permanent Aviation Fuel Facility for Hong Kong International Airport, A report for Shiu Wing Steel Limited, Marc McBride, Health and Safety Laboratory (HSL), 12 June 2003, HSL Job No. JC400115, HSL Registry File FR/04/2003/21369, FS/03/11.

[7] Judgement in the Court of Final Appeal of the Hong Kong Special Administrative Region, Final Appeal No. 28 of 2005 (Civil) (on appeal from CACV No. 350 of 2003), Between Shiu Wing Steel Limited (Appellant) and Director of Environmental Protection Respondent), Airport Authority Hong Kong (Interested Party), 17 July 2006.

[8] Aboveground storage tank survey, API Publication Number 301, 1991.

[9] Failure rates for atmospheric storage tanks for land use planning, RAS/01/06, Michael Glossop, Health and Safety laboratory, May 2001.

[10] The Ashland Tank Collapse, Prokop, J., Hydrocarbon Processing, 1988, Vol 67, Part 5, pp105-108.

[11] R.C. details for security wall Type I & II and gate details – Drawing PAFF/BA/02/DWG/C/1727 A, May 2006.

[12] Bund effectiveness in preventing escalation of tank farm fires, T Davies, A B Harding, I P McKay, R G J Robinson, A Wilkinson, Process Safety and Environmental protection, 74, Part B, 88-93, May 1996. (Note: the authors of this paper are listed alphabetically - the address for correspondence is Dr A Wilkinson).

[13] Fire in bunds, A B Harding, AEA/CS/HSE R1004/R, February 1994.

[14] ESR Technology (then AEA Technology) confidential report AEAT/LRSB/10717001/002(R) Issue 3 (Final), May 2005.

[15] CEDD Information Note 6/2001 "Earthquake risk in Hong Kong", http://www.cedd.gov.hk/eng/publications/information_notes/info_0106.htm

[16] U.S. Geological Survey Fact Sheet-183-96 1996. http://quake.usgs.gov/prepare/factsheets/RiskMaps/

[17] Quantitative Probabilistic Seismic Risk Analysis of Storage Facilities, Antonio Di Carluccio, Iunio Iervolino, Gaetano Manfredi, Giovanni Fabbrocino, Ernesto Salzano www.aidic.it/CISAP2/webpapers/7%20Di%20Carluccio.doc

[18] San Francisco Earthquake History 1915-1989, http://www.sfmuseum.org/alm/quakes3.html

[19] Seismic Hazard Analysis of the Hong Kong Region, Geo Report No. 65, C.F. Lee, Y.Z. Ding, R.H. Huang, Y.B. Yu, G.A. Guo, P.L. Chen & X.H. Huang, Geotechnical Engineering Office, Civil Engineering Department, The Government Of The Hong Kong Special Administrative Region. http://www.cedd.gov.hk/eng/publications/geo_reports/doc/er65_english.pdf

[20] Proposals for revised policies for HSE advice on development control around large-scale petrol storage sites, CD211, 02/07. http://consultations.hse.gov.uk/inovem/gf2.ti/f/4194/126533.1/PDF/-/cd211.pdf

[21] Weymouth & Portland National Sailing Academy (WPNSA) website, http://www.wpnsa.org.uk/index.htm

[22] MHIDAS. Major Hazards Incidents Data Service developed by AEA Technology plc on behalf of the Major Hazards Assessment Unit of the United Kingdom Health and Safety Executive (HSE).

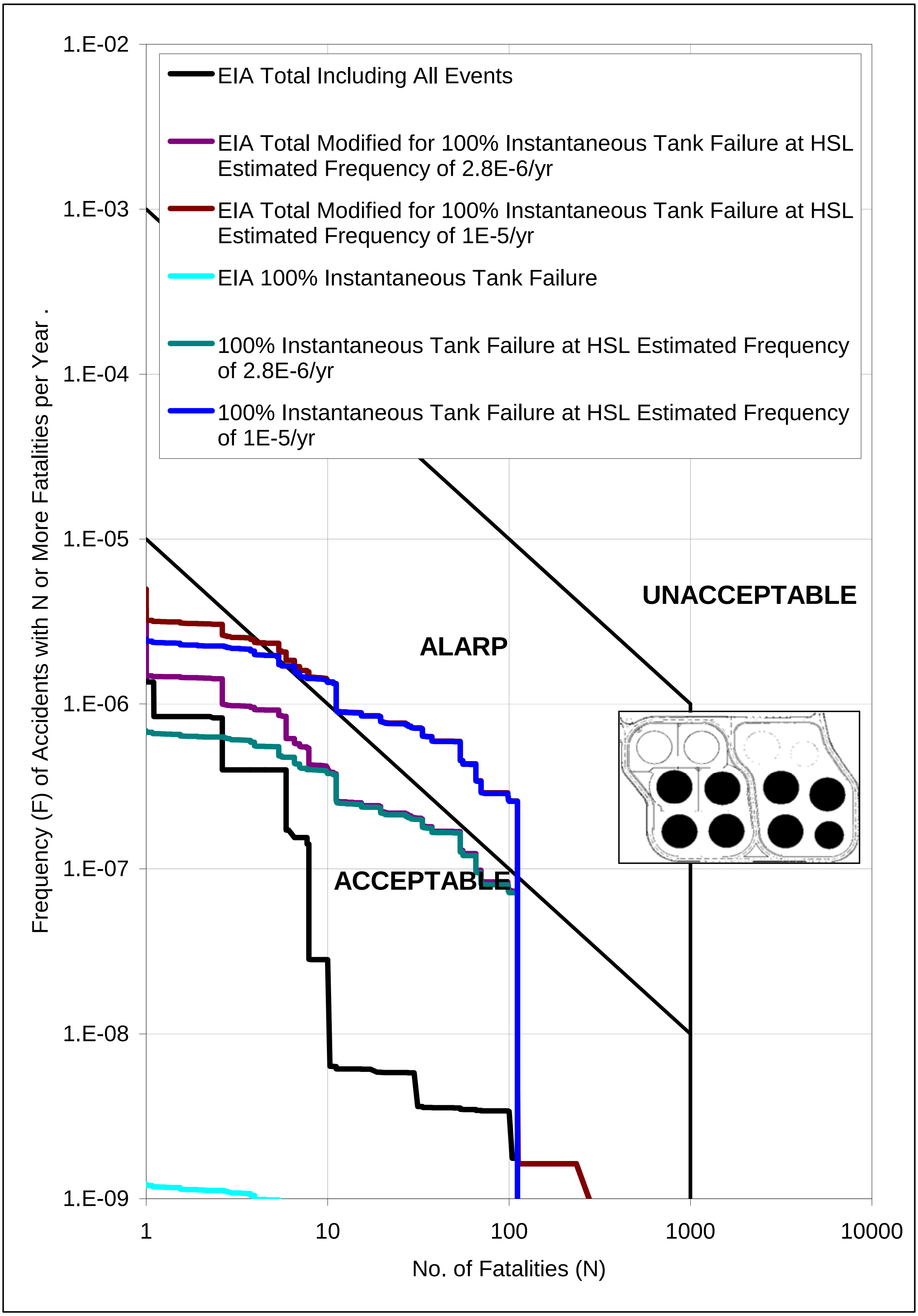


Figure 2: Comparison of EIA and HSL Societal Risk Estimates For Initial PAFF Development

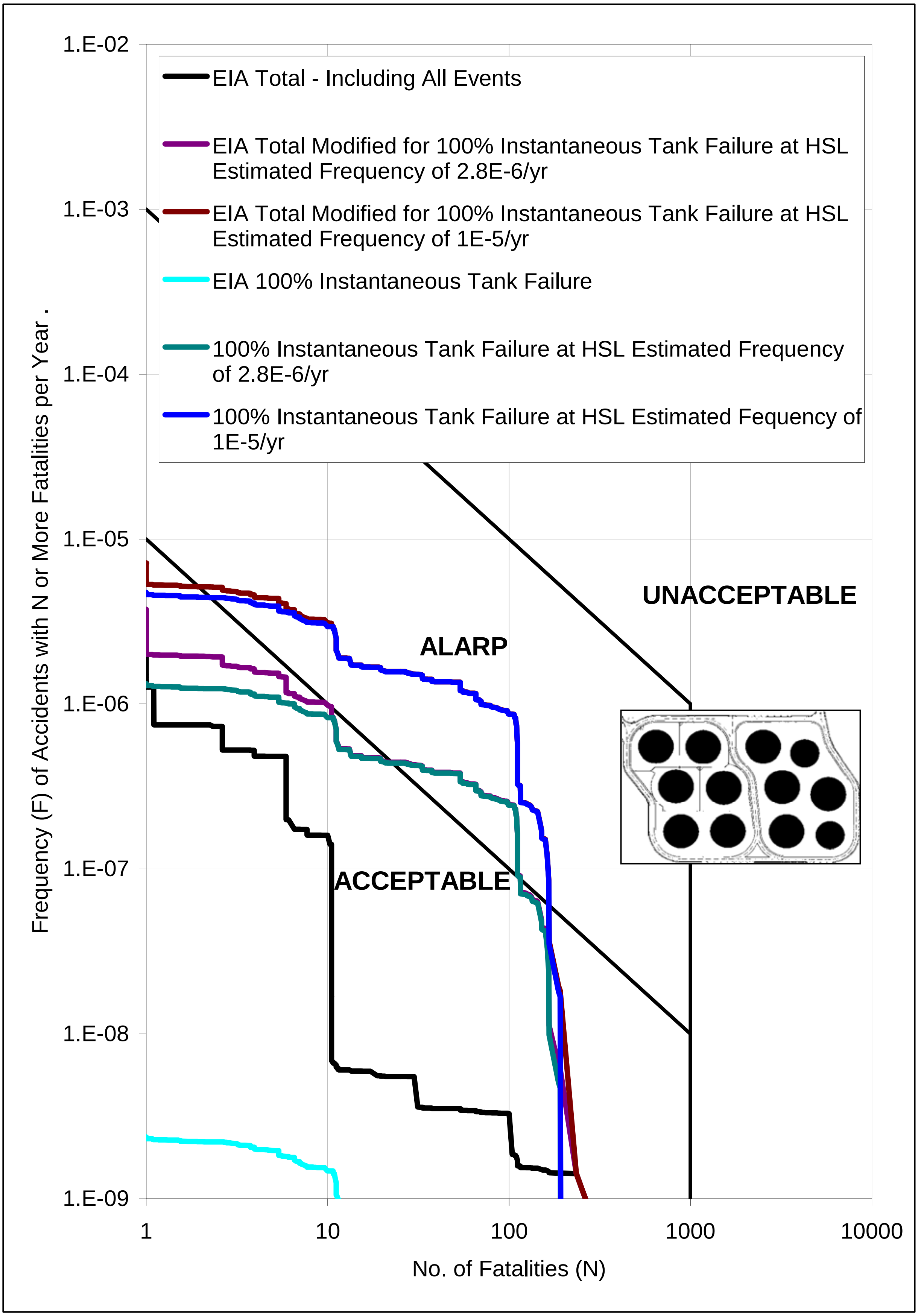


Figure 3: Comparison of EIA and HSL Societal Risk Estimates For Final PAFF Development

Environmental Impact Assessment Report on Permanent Aviation Fuel Facility for Hong Kong International Airport

Responses to Public Comments related to Hazard Assessment

	Comments	Responses
1	**PA#00001**	
	Reasons for objection:	
	1. Fuel depot should not be placed between the steel mill (hot works) and EcoPark (open flame) as it will increase the chance of explosion.	There are many cases where fuel depots storing relatively hazardous fuels like petrol and LPG are located next to industrial areas and even in the proximity of high temperature works, like furnace. Location of PAFF next to steel mill and EcoPark therefore is not uncommon.
	2. The steel mill and EcoPark are located less than 100 metres away from the PAFF. If there is any explosion at PAFF, thousands of injuries or casualties will be caused. EIA should give human life prime consideration.	International and local codes only require a safety distance of 10m to 15m between the tanks and PAFF fuel depot boundary. In almost all cases of accidents, fuel could be contained within the site. Likelihood of accidents causing offsite fatalities is extremely low. EIA has already given human life prime consideration by undertaking extensive analysis.
	3. Numbers of severe oil depot incidents happened in the past few years. Having the PAFF in the area is like installing a bomb which would threaten the lives to the people around.	In order to compare various incidents, it is necessary to first understand the various characteristic of fuels, the surrounding environment and causes of accident. It should be noted that Jet A-1 cannot ignite easily and does not give off a flammable vapour that could lead to an explosion i.e. it is relatively less hazardous than other fuels, such as LPG and petrol. In addition, Hong Kong ambient environment is different from say UK, thus generalization of stating that fuel depot will threaten the lives of people is not appropriate.
	4. Large oil tankers which pass through Ma Wan Channel and Tuen Mun waters would pose impact to the already busy marine traffic and the people living along the coast line. This is the reason why Tuen Mun was not chosen before, but why it is acceptable now?	Currently about 1000 number of vessels transit through Ma Wan Channel and Urmston Road to transport aviation fuel from Tsing Yi to Sha Chau. When PAFF is operational, the number could be reduced to about 150 as larger vessels which are double hull and with pilot will be used. It is a reduction of 80% of current marine traffic.
	5. If explosion happens at the PAFF, it would cause significant impact and damage to not only TM but also HK direct. It will cause unrecoverable damages and loss of human life and	See responses 1 and 2 and 3 above.

*Public comments which are repeat of the ones in here are not included in this Table.

	Comments	Responses
	economy. Therefore, it should be isolated from open flame operation and residents.	
	6. PAFF was ruled non-compliance to EIAO and thus illegal. AA should respect CFA judgment and find another location for PAFF.	PAFF was ruled non-compliant on the ground that a QRA for 100% instantaneous loss of a tank's content was not included.
2	**PA#00004**	
	Reasons for objection:	
	1. Building the PAFF next to the heavy industrial facilities with open flame and high temperature operations is a very severe mistake as it threatens the lives of thousands of people around and ignores the fact that fuel and fire could not be located adjacent to each other.	See responses 1 and 2 to Comment No. 1.
	2. Although AA emphasizes that the design of the PAFF meets the international safety standards, incidents did happen at other oil depots in the world recently. This proves that similar incidents could happen even if the oil depots have met the international safety standards. Therefore, to prevent serious injuries and causalities in case of any incidents, PAFF should be away from any ignition sources, away from steel mill and EcoPark. Being a special industries area, TMA 38 is not compatible with the development of PAFF.	The definition of Special Industries Area includes fuel depot because PAFF is compatible with such land uses.
	3. The safety of PAFF does not only affect the TM residents but would also affect the economy and reputation of HK. Therefore, the process should be done with thorough assessment and consideration and thus cannot be based on the urgency of the PAFF. ACE Members should ensure the EIAO is strictly enforced and be accountable for the responsibility entrusted by people to protect the life of general public.	Safety is of paramount important to the aviation industry and in particular to AAHK, thus AAHK is proceeding with the PAFF because the risks posed by PAFF are extremely low.

*Public comments which are repeat of the ones in here are not included in this Table.

	Comments	Responses
3	**PA#00355** (Very similar to Comment No. 2 (PA#00004), except it has the following additional comments)	
	• AA proposes to develop one of the largest fuel depots at heavy industrial area at TMA38 and located just between the steel mill and EcoPark. This obviously violates the principle that fuel and fire can not be co-exist. It is a serious mistake. We emphasize "no risk" should be acceptable. How about the lives of thousand working at the steel mill and the EcoPark. Just this single argument would be strong enough for EPD to reject AA application.	It is not true that PAFF is the largest fuel depot. There are many larger fuel depots in the world and there are two depots in Tsing Yi, 95% of the size of PAFF.
	• We believe TM residents (as well as the Chinese White Dolphins) will not be willing to accept this high risk and dangerous facility as a new year gift. We hope DEP will not repeat the mistake made before and reject the application for the PAFF.	Risks posed by PAFF are extremely low. PAFF will be one of the safest fuel facilities in the world.
4	**PA#00861**	
	• Clause 10.2.3 regarding the "Potential Hazardous Scenarios" did not comply with the requirements of Clause 1.2.5 (ii) and (ix) of EIA study brief which require the identification of the risks and hazards to life related to the transport and storage of the aviation fuel and the impact to the environment (or vice versa). For example, the accident at the power station in 1992 caused the death of two engineers and the fragments of the explored hydrogen tanks did reach the road near TMA38; incident at SWS at Tseng Kwan O in 1995; fires did happen in recycling parks in other countries. Thus the hazard to life section has to fully comply with the requirements if the Study Brief and Technical Memorandum and undertaking the QRA. The whole EIA Report lacks such assessment. The answer why PAFF cannot be built at the airport is simply because it poses threat to the aircraft movement.	All potential hazards scenarios identified have been assessed, whatever the cause leading to the scenario. The offsite explosion and its impact on PAFF have already been covered in the assessment of the scenarios. The only scenario which can cause significant offsite impact is 100% instantaneous release of a tank's content (100% QRA). The causes stated in the comment would not lead to a 100% QRA and would therefore not have any off-site risk.

*Public comments which are repeat of the ones in here are not included in this Table.

Comments	Responses
5 **PA#01097**	
It is always AA plan to have the huge fuel depot next to the steel mill and EcoPark. Before the final investigation report of the Buncefield incident, AA has submitted the revised EIA Report and start the public inspection process.	Three interim reports and an initial report on the Buncefield incident make the nature and causes of the incident clear. These have been reviewed and discussed in the EIA.

6 **PA#01099**

	Content of EIA Report	Marks	Comments
10 & 11	Hazard to Life Assessment and Fuel Spillage Risk Assessment	0 Mark - Not Passed	● The Report has not identified the hazards to life per the requirements of the EIAO ● Seriously violate the safety principle that fuel and fire (ignition sources) cannot be adjacent to each other ● Fuel vessels will pose adverse impact to the Ma Wan Channel and the water outside Tuen Mun

Responses:

- Because the EIA Report had met the requirements of the Study Brief and the Technical Memorandum of the EIAO, that is why EPD allowed the EIA Report to be subjected to public inspection.
- There are many examples where fuel depots are located next to industrial facilities with furnaces.
- See response 4 to Comment No. 1.

Comments	Responses
7 **PA#01154** (tabled in TMDC meeting of 13 March 2007)	Response circulated to ACE EIA Subcommittee on 19 March 2007 and attached herewith as Part 3B to Annex C.
8 **PA#01319**	
● TM is a very populated community. Fuel depot should not be placed close to the residential area. Power plant and fuel depot will significantly increase the potential danger. It is the reason why the depots at Tsing Yi have to be removed.	PAFF will be located well away (2 to 3km) from residential developments with intervening terrain, posing no risk to Tuen Mun residential community.

*Public comments which are repeat of the ones in here are not included in this Table.

No.	Comments	Responses
9	**PA#01320**	
	Continuous explosions of fuel depots were happened repeatedly in other countries. Who will be responsible for the accident in case it did happen? AA? Planning Department or EPD?	Explosions in fuel depots do occur because of various causes, that is why hazard to life assessment is vital. PAFF will pose extremely low risk to neighboring facilities. If there is an accident, the party causing the accident would be responsible.
10	**PA#01323** (It is the comprehensive comments submitted by SWS with HSL inputs)	See Part 2 to Annex C attached
11	**PA#02658**	
	1. AA is planning to conduct the third runway. The aircraft impact frequency in Appendix H3.6 should take into account of the possible runway.	The aircraft impact frequency has already been considered in the long term growth of the airport. 3rd runway will not increase traffic, it will facilitate traffic.
	2. A serious accident (an explosion) occurred at CLP's power plant 10 years ago. The explosion caused some large objects to fly away for more than 1km. If there is similar incident, some large objects may fly away to the PAFF which is less than 1km from the power plant and destroy the tank, causing 100% instantaneous release from a storage tank and/or catastrophic explosion/fire. Thus Section 10 should include a QRA of incidents of similar nature.	See response to Comment No.4.
	3. There are also other industrial establishments in the vicinity of the PAFF such as EcoPark and steel mill, causing explosion of same kind and leading 100% instantaneous release from a storage tank and/or catastrophic explosion/fire. Section 10 should also include a QRA of incidents of similar nature.	See response to Comment No.4.

*Public comments which are repeat of the ones in here are not included in this Table.

	Comments	Responses
	4. An accident occurred some 10 years ago involved a helicopter which carried out construction/maintenance works for CLP's pylon. The helicopter fell to the ground and kill people in the helicopter. As the PAFF is only some 800m away from CLP's pylon, there is a risk that similar accident will occur and the helicopter may strike the fuel tank and destroy it, causing 100% instantaneous release from a storage tank and/or catastrophic explosion/fire. Section 10 should also include a QRA of incidents of similar nature.	See response to Comment No.4.
	5. The PAFF is just 1km from the Castle Peak Firing Range. There is a risk that the fuel tank is accidentally shot from the firing range, 100% instantaneous release from a storage tank and/or catastrophic explosion/fire. Section 10 should also include a QRA of incidents of similar nature.	See response to Comment No.4.
	6. The individual risk and societal risk in Section 10 should take account of the scenario in items 2 to 6 above and should also take account of other hazard or potential hazard installations in the vicinity, including the CLP's power station, the industrial establishment in the EcoPark, as well as a possible chlorine storing facility in Area 40, Tuen Mun.	The hazard to life assessment has already taken into account the causes in items 2 to 6.
12	**PA#01343**	
	The EIA Report did not address the potential danger toward the steel mill and the power plant. It also do not comply with the requirements of Clause 1.2.5 (ii) and (ix) of EIA study brief. If the site is surrounded by potentially hazard installation, the hazard to life section has to fully comply with the requirements if the Study Brief and Technical Memorandum and undertaking the QRA. The whole EIA Report lacks of such assessment.	PAFF is not a potentially hazardous installation and the risks posed by it are extremely low. It is not incompatible with the neighboring facilities.
	The proposed PAFF is located at TMA38 and close to the high temperature operated facility. Airport Authority repeatedly proclaims that the design of PAFF has met the international standards. However,	The conclusion of the EIA Report shows that the risks posed by PAFF are extremely low.

*Public comments which are repeat of the ones in here are not included in this Table.

	Comments	Responses
	large tank explosions did happen in recent years. This has demonstrated that even though the facility has met the international standards, catastrophic accident cannot be avoided. As a result, aviation fuel storage facility must be located away from the high temperature operation facility to reduce the casualties in the event of accident.	
13	**PA#01391**	
	As you will be aware, we and our workers are extremely concerned at the PAFF and the implications for our safety.	
	We are currently preparing our comments on the EIA Report. We are aware that certain members of the community believe that in conducting their review of the EIA Report, they should simply review those sections that relate to the QRA carried out in respect of the 100% loss scenario. This is apparently on the basis that the remainder of the EIA Report has already been approved by the EPD.	
	However, in the judgment of June 2006, the CFA quashed the EPD's decision to approve the previous EIA Report. The effect of this is that the previous approval no longer stands. It is for that reason that the AA has had to submit a new EIA Report, the entirety of which has been issued for public consultation.	CFA judgment stated that issues other than 100% QRA have been addressed, comments have been obtained and evaluated, and hence there was no need to go back to square one.
	We are, of course, confident that the Sub-Committee will not share the views of the community as expressed above and that it will consider all aspects of the EIA Report and the AA's proposals. We are also certain that in so doing, the Sub-Committee will appreciate the serious defects in the EIA Report (over and above those that relate to the 100% loss scenario) which according to the estimate by AA, could have potentially fatal consequences for those working at our mill and the other facilities adjacent to the PAFF.	

	Comments	Responses
	In this regard, the Sub-Committee should be aware that we have been advised by our expert (HSL in England) that the EIA grossly underestimates the likelihood of realization of the 100% loss scenario; and when considering the above in the context of the serious potential consequences of the 100% loss scenario (up to 189 fatalities at our premises), this invalidates AA's choice of TMA 38 as the appropriate site for the PAFF (Section 2 of the EIA Report). We would therefore urge the Sub-Committee to ensure that it considers all elements of the EIA Report (including issues of site selection).	See Part 2 to Annex C which is an assessment undertaken by AA's consultant ESR Technology, identifying how the HSL assessment has exaggerated the risks and showing why the assessment made in the PAFF EIA remains valid.
14	**PA#01598** Our comments are:	
	1. AA proposes to develop one of the largest fuel depots at heavy industrial area at TMA38. This obviously violates the safety principle that fuel and fire can not be co-existed. It is a serious mistake.	See response 1 to Comment No.1.
	2. Please consider the safety and hazard to life for people living in Tuen Mun.	Safety and hazard to life of the people in Tuen Mun have been considered.

*Public comments which are repeat of the ones in here are not included in this Table.

Environmental Impact Assessment Report on Permanent Aviation Fuel Facility for Hong Kong International Airport

Responses to comments tabled by Shiu Wing Steel Limited in 13 March 2007 TMDC Meeting, which may have been brought to ACE Members' attention

Comments	Responses
1. Clause 10.2.3 regarding the "Potential Hazardous Scenarios" of the EIA Report has not complied with Clauses 2.1 (ii) and (ix) of EIA Study Brief which state: *ii) to identify and describe elements of community and environment likely to be affected by the Project and/or likely to cause adverse impacts to the Project, including natural and man-made environment and the associated environmental constraints; and* *ix) to identify the risk due to the transportation and storage of the aviation fuel and to propose measures to mitigate the impact.* The EIA report has not identified clearly the risk and hazards associated with the transport and storage of aviation fuel and its impact towards the current environment and it also fail to address how the current environment will impact to PAFF. For example, the Report did not identify the potential risk/hazard toward PAFF from the steel mill, EcoPark, cement plant, and power station. Similarly, the Report also did not identify the same with respect of the marine risks/hazards. Because of the lack of consideration to this important aspect, the Report cannot fully reflect the risks associated with PAFF at TMA38 and thus lead to the wrong decision on the site selection.	The EIA Report has identified and considered all potential scenarios, stated in Table 10.2 (attached). In doing so, it has complied with the scope of the Study Brief which required consideration of the hazardous scenarios associated with the receiving, storage and export of Jet A-1. Although the surrounding environment was reviewed, no risks to the PAFF from the surrounding facilities in particular steel mill and EcoPark were identified which would affect the quantification of the risks from the identified hazardous scenarios or contribute any further hazardous scenarios, except features of the surrounding land, ignition sources and populations. These are all covered in detail ins Section 10 of the EIA Report. The EIA Report has clearly identified the risks due to the transportation and storage of the aviation fuel for the facilities within the scope of the Study Brief, as noted in Para 10.2.3.1 and as discussed further in paras 10.2.3.2 to 10.2.3.4. In the opinion of AA and their consultant, the risks associated with the PAFF at TMA 38 are fully reflected in the EIA report and no risk levels have been identified that would lead to any question over the site selection.

Comments	Responses
2. As PAFF will be the largest fuel depot in the world and according to EIA Annex H9.3 regarding Event Tree for Tank 003, the anticipated casualties would be 189. This also violates Clause 3.3.1.1 of EIA Study Brief which states *3.3.1.1"The EIA study shall take into consideration with clear and objective comparison of the environmental benefits and disbenefits of different sitings and alignment options, and also with or without the proposed developments. The applicant shall compare the main environmental impacts and provide reasons for selecting the proposed system and the part environmental factors played in the selection shall be described. This is particularly relevant to the size and location of the facility, submarine pipeline alignment, construction method, number and size of the fuel tanks and pier.* ***In formulating the preferred options, the Applicant shall seek to avoid adverse environmental effects to the maximum practicable extent.*** *"*	Fuel farms for aviation fuel and other fuels vary in size according to the requirements of the facility and the local circumstances. HKIA is one of the largest airports in the world and it is to be expected that a large fuel tank farm will be required. However, it is not the largest fuel depot in the world: even at Tsing Yi the storage capacity is about 3 times as great as the PAFF and two of the individual depots at Tsing Yi have capacities of about 95% of the PAFF and store a variety of fuels. The size of the PAFF is not therefore particularly unusual. The event trees cover even extremely improbable events. The frequency of the event leading to the 189.2 potential fatalities in the Event Tree for Tank 003 unzipping is 6.74×10^{-11} /yr. This is well below the acceptable criteria in the EIAO-TM and also well below the axis of the criteria plot. Risks at this level are of no significance in the evaluation of siting options. Section 2 of the EIA Report covers site selection, which provides environmental comparisons for all sites considered. See Table 2.1b attached.
3. To assess the effectiveness of the relevant measures, could AA please provide the detailed information on the design of the tanks (Permanent Aviation Fuel Farm PAFF/LC/01/DSG/G/0201 cRev.D by Leighton Contractor (Asia) Ltd.)	Reference in the EIA report is only made to identify that certain design features noted in the EIA report are also already identified in the design documents for the PAFF. Relevant information is already included in the EIA Report.

Comments

4. The high temperature areas and potential ignition sources inside SWS and EcoPark

EIA Report has identified in Annex H5 Table 2.1, the high temperature areas and ignition sources at steel mill and EcoPark. Although aviation fuel is less hazardous than petrol, AA did acknowledge in Annex H.5.3.4.4 that if aviation fuel did spill into the steel mill and reach the over 1000°C steel piles, the fuel would be ignited (see Dig. 1.1 below). However, AA did not further assess the consequences of that particular event but rely only on the subjective judgment from ESR stating that "by no means certain to happen".

According to the simulation experiment done by the Health and Safety Laboratory (UK), a subsidiary of Health and Safety Executive, flammable cloud could be formed in this event. When this flammable cloud meets the high temperature point in the steel mill, it would be ignited and flash back which will lead to pool fire (see Diagram 1.2 below). History proved that no designer can predict all the accidents. Therefore, all regulations and standards have to be continuously revised after different accidents. How can people ensure the safety to human life just based on the current design?

Table 1: The high temperature areas and potential ignition sources inside SWS and EcoPark

Location	Hot Temperature / Ignition Sources	Temperature
SWS (HSL, 2003a) (HSL,	Reheat furnace Steel Cutting Area	1100°C 1000°C

Responses

In paras H5.3.2.4 to H5.2.3.8 the situation of hot-works in the steel mill coming in contact with Jet A-1 is analysed and it is concluded that, it may be possible for the hot metal route to ignite a pool of Jet A1 below it. The conclusion applies specifically to a static pool of Jet A1 under the worst circumstances identified that being for Jet A-1 to instantaneously flow into the mill from unzipping of the tank, the probability of which is extremely low. It is noted in para H5.3.2.8 that various factors including the flow of Jet A1 which is inherent to the scenario of concern will make it less likely that the Jet A1 will ignite. Nevertheless, a probability of ignition for Jet A1 in this location of 0.5 has been used in the assessment (see Item B in table under H5.3.4.5) to reflect the uncertainty. The consequences and frequency of an event being ignited in this area have been fully incorporated within the assessment.

The analysis of the potential for ignition by the hot metal route in the EIA report appears entirely consistent with the results from HSL as stated in the comment provided.

The update of standards is a continuing process. A risk assessment, based on identification and quantification of hazardous scenarios may reveal that additional measures to those in the standards are appropriate for a particular facility, or that the location of a facility is unacceptable. This is not the case for the PAFF, where the safety measures in place are in excess of the requirements of the relevant standards and the risk levels are well within the acceptable region of the EIAO-TM criteria.

Comments

2003b)	Welding Area Cooling Bed Steel storage (East of the mill) Electric arc Goods Vehicles General electric equipment	1200 ^{o}C <610 ^{o}C >90 ^{o}C -- -- --
EcoPark (EIA Report Note1)	Kitchen, venting, generator Heating reduction facilities for element mercury phosphor powder Melting pot for glass Burning equipment for glass product Electric arc Reheating / rolling channel Aluminum /copper/ Zinc recovery Furnace	370-480 ^{o}C 375-1200 ^{o}C 1500 ^{o}C 500 ^{o}C 1540 ^{o}C 1200 ^{o}C 327-1083 ^{o}C 125-175 ^{o}C

5. Site selection and comparison of the alternatives

Site	**No of people within 200 m of PAFF**
Tai O	None
East of Soko Islands	None
Kau Yi Chau	None
Sham Shui Kok	Roads
Sham Wat	Sham Wat Village
Tsing Yi	Existing employees: Shell = 137 Caltex = 155 Esso = 97 CPRC = 160 Mobil = (don't know) If PAFF is located adjacent to the above facilities, the max no of people affected would be 315
TMA 38	Steel Mill = 529 PAFF road = 2 Lung Mun Road = 14 Eco Park = 1200 (max)*Note 1 Total = 1745
TM West	None

Responses

The site selection is fully covered in Section 2 of the EIA report.

The site selection process is necessarily made based on a less detailed analysis than the assessment for the site that is selected. Nonetheless, nothing in the detailed assessment for the selected PAFF site, including the assessment of hazard to life, raises any doubts over the adequacy of the site selection. Furthermore, ACE has been updated on the PAFF site selection in 1995, 1998, 2000 and 2001.

The issue of concern to the CFA was that '*the EIA report did not contain a quantitative risk assessment ("QRA" – a term to be examined presently) which embraced the scenario of a catastrophic failure of a fuel storage tank with instantaneous or almost instantaneous loss of a 100% of the tank's contents.*' (Para 16 of the CFA judgment). The CFA judgment did not envisage

Comments

*Note 1: About 9 hectares of EcoPark is within 200m of PAFF (EIA104/2005). The estimation is based on the population density of HK of which each worker in every 75m^2. PAFF EIA Report estimates that there would be 750 workers in EcoPark Phase I and II.

Responses

'*going back to square one*' for the hazard to life assessment, noting that '*issues other than the QRA for "all hazardous scenarios" have already been addressed, comments have been obtained and evaluated*' (Para 93 of the CFA judgment).
A revised EIA has therefore been produced including an appropriate QRA for the scenario of 100% instantaneous tank failure. In line with the CFA judgment, the revised EIA does not go back to square one to revisit issues, such as site selection, that were addressed, and for which comments received were evaluated, during the original EIA process. The CFA judgment does not call such issues in the original EIA into question, only the lack of a QRA for a 100% instantaneous tank failure.

The EcoPark population is based on the best available information at the time the revised EIA was prepared rather than a simple average population density (para H8.2.1.1)

6. Weighting in the Site Selection

According to EIA Report Table A33, hazard to life constitutes 19.75% of the total weighting, water quality/marine ecology constitute 50% of the total. If these two elements constitute together, i.e. each will constitute about 35%. With this revised weighting, TM38 would be the 2nd highest in risk category. It implies that the EIA report is just a manipulation of number and does not take 'human life' as the prime consideration.

The site selection process is necessarily made based on a less detailed analysis than the assessment for the site that is selected. Nonetheless, nothing in the detailed assessment for the selected PAFF, including the assessment of hazard to life, site raises any doubts over the adequacy of the site selection. Weightings of various environmental factors were made based on careful consideration and for hazards to life on the fact that in case of accident at the tank farm, Jet A-1 would be contained within the PAFF site in almost all of the hazardous scenarios.

Please see also the answer to Point 5 above.

Comments	**Responses**
	Safety is of paramount importance to the aviation industry and AAHK is totally committed to the safety of the PAFF.
7. International examples quoted in the EIA Report All the examples of aviation fuel depots of international airport quoted in the EIA Report are located far from residential area and industrial area without any flame fire and high temperature operation near by. One of the examples is the aviation fuel farm of Denver International Airport which has a capacity of 63,000m^3 located in a 3.8 hectares area (see Diagrams. 2.1 and 2.2) while PAFF has a capacity of 388,000m^3 within 6.75 hectares. It shows that PAFF area is less than 2 times of Denver's area but having 6 times of capacity over Denver's.	Compared to Colorado where vast amount of open land is available compared to Hong Kong, it is to be expected that the facility in Hong Kong will be more economically laid out. Even then, the spacing of the tanks and the boundary at the PAFF exceed the relevant codes. The size of the PAFF, its layout and proximity to flame, fire and high temperature are not particularly unusual and occur commonly for storage in refineries around the world. A Jet A1 fuel depot will in general present a much lower risk to its neighbours than a similar depot storing petrol due to the nature of the product. The EIA report hazard to life assessment does not quote examples of aviation fuel depots (only incidents have been quoted) and the effects of the adjacent facilities have been fully accounted for in the hazard to life assessment. The resulting risk levels are well within the acceptable region of the criteria in the EIAO-TM. In addition to the safety distance of the tanks from the PAFF boundary, PAFF design meets and exceeds HK and international standards, in particular: i) containment capacities of the bunds; ii) by having two additional impervious security walls; iii) a landscape bund (a bund plus fence is usual) and the bunds are sunken, thus improving integrity; and iv) comprehensive security, shutdown and fire fighting systems. Please see also the answer to Question 2.
Although EIA report follows the Model Code of Safe Practice of Institute of Petroleum, it does not comply with clause	Guidance from relevant standards is cited in the EIA report where appropriate. The guidance on total storage capacity in a bund for

Comments	**Responses**
2.4.12 of IP205 which says "*the total capacity of tanks in a bund should not exceed 60,000m^3.*" Each tank with over 60,000m^3 should have individual bund as a mitigation measure. PAFF has only two bunds of which each contains 6 oil tanks. This is obviously a violation of the current safety standards.	distribution terminals in IP MCSP Part 2 as noted is permitted to be exceeded under both the Hong Kong code of practice for oil storage installations (Ref 5 of EIA S10), and the part of the IP Model Code of Safe Practice most relevant to the PAFF, i.e. Part 19, "Fire precautions at petroleum refineries and bulk storage installations" (Ref 26 of EIA S10). The PAFF is different to a typical distribution terminal in that it stores a single product (Jet A1) imports only via its own marine jetties and exports via a dedicated single product pipeline; the PAFF does not distribute Jet A-1, it receives it for, stores it for, and supplies it to HKIA only. Part 2 of the cited IP Model Code of Safe Practice covers distribution terminals that may store multiple products, import and export by multiple routes including, road and rail loading facilities, single and multi-product pipelines, in addition to the types of facilities that will be present at the PAFF. IP Part 19 is therefore the more appropriate IP code to consider, and Fire Services Department (FSD) has been satisfied after having given in-depth consideration to this matter. The recommendation of the total capacity in the bund in IP19 is a general recommendation and covers all product classes I, II and III. Jet A1 is classed as Class II(1) within the IP code and as such represents a lower risk than Class I, Class II(2) or Class III(2) product and accordingly relaxation of the recommendations is permitted as indicated in IP19 clause 3.4.2.1. The normal recommendation for total capacities of tanks in a single compound of 60,000 m^3 for a bulk storage site in IP19 may be exceeded provided that an assessment indicates no significant increased risk of pollution or hazard to people. This restriction has been discussed with FSD as part of the review and FSD has

Comments	**Responses**
	been satisfied. The EIA report provides a quantitative assessment of the hazard to life and the results lie well within the acceptable region of the criteria in the EIAO-TM, satisfying the requirement for an assessment. The Hong Kong code of practice for oil storage installations (Ref 5 of EIA S10) is more specific in differentiating between the classes of product and places a similar limit on Class I products only. No limit is placed on the volume of Class II products. Also note that National Fire Protection Association (NFPA) 30 Flammable and Combustible Liquids Code places no restriction on the maximum quantity of any class.

Table 10.2 Potential Hazardous Scenarios for the PAFF

ID	Scenario
	Marine Transport (Within ~500m of the Jetty)
M1	Fire due to rupture/leak of Jet A1 from loaded vessel
M2	Vessel collision involving tanker with subsequent fire and sinking
M3	Cargo explosion on tanker
	Jetty Transfer
J1	Fire due to rupture/leak of Jet A1 from loaded vessel
J2	Fire due to rupture/leak of loading arm during unloading
J3	Fire due to rupture/leak of jetty equipment
J4	Fire due to rupture/leak of jetty riser
J5	Fire due to rupture/leak of submarine pipeline from jetty to Tank Farm ESDV
	Tank Farm Storage
T1	Fire due to discharge from tank vent
T2	Tank head fire / explosion in tank head space
T3	Multiple tank head fires
T4	Tank failure due to overpressure
T5	Explosion in empty tank (under maintenance)
T6	Bund fire
T7	Fire outside bund due to rupture/leak of pumps, pipework and fittings
T8	Fire on sea due to release through drainage
T9	Fire due to instantaneous tank wall failure, subdivided as follows: T9As Instantaneous release from bottom seam failure with tank 90-100% full T9Bs Instantaneous release from bottom seam failure with tank 60-90% full T9Cs Instantaneous release from bottom seam failure with tank 35-60% full T9Ds Instantaneous release from bottom seam failure with tank <35% full T9Az Instantaneous release from tank unzipping with tank 90-100% full T9Bz Instantaneous release from tank unzipping with tank 60-90% full T9Cz Instantaneous release from tank unzipping with tank 35-60% full T9Dz Instantaneous release from tank unzipping with tank <35% full T9Aa Instantaneous release due to aircraft impact with tank 90-100% full T9Ba Instantaneous release due to aircraft impact with tank 60-90% full T9Ca Instantaneous release due to aircraft impact with tank 35-60% full T9Da Instantaneous release due to aircraft impact with tank <35% full
T10	Fire due to multiple tank failure
T11	Boilover
T12	Fire due to release from top of tank due to overfilling
T13	Vapour cloud explosion / flash fire
T14	Fire due to 10% instantaneous release from the top of a tank
	Pipeline Transfer
P1	Fire on sea due to release/leak from submarine pipeline

Table 2.1b Operational Phase Environmental Comparison

Criteria		Weighting	Site 1 Bluff Point	Site 2 East of Soko Islands	Site 3 Kau Yi Chau	Site 4 Sham Shui Kok	Site 5 Sham Wat	Site 6 Tsing Yi	Site 7 Tuen Mun Area 38	Site 8 Tuen Mun West
Air Quality	Max Score	**5**								
Operational Air Quality Impacts		5.00	Very low (1.0)	Very low (1.0)	Very low (1.0)	Low (0.75)	Very low (1.0)	Very low (1.0)	Very low (1.0)	Very low (1.0)
	Score out of 5		**5.00**	**5.00**	**5.00**	**4.00**	**5.00**	**5.00**	**5.00**	**5.00**
Noise	Max Score	**10**								
Above Ground Nose Impacts		2.00	Very low (1.0)	Very low (1.0)	Very low (1.0)	Low (0.75)	Very low (1.0)	Very low (1.0)	Very low (1.0)	Very low (1.0)
Underwater Noise Impacts		8.00	Low (0.75)	Very low (1.0)	Low (0.75)	Low (0.75)	Medium (0.5)	Very low (1.0)	Very low (1.0)	Very low (1.0)
	Score out of 10		**8.00**	**10.00**	**8.00**	**7.50**	**6.00**	**10.00**	**10.00**	**10.00**
Water Quality	Max Score	**15**								
Water Quality Impacts		15.00	Low (0.75)	Low (0.75)	Low (0.75)	Low (0.75)	Medium (0.5)	Very low (1.0)	Very low (1.0)	Low (0.75)
	Score out of 15		**11.25**	**11.25**	**11.25**	**11.25**	**7.50**	**15.00**	**15.00**	**11.25**
Ecology	Max Score	**20**								
Marine Faunal Impacts		20.50	Low (0.75)	Very high (1.0)	Low (0.75)	Low (0.75)	Medium (0.5)	Very low (1.0)	Very low (1.0)	Low (0.75)
	Score out of 20		**15.00**	**20.00**	**15.00**	**15.00**	**10.00**	**20.00**	**20.00**	**15.00**
Risk	Max Score	**35**								
Hazard of Life		19.25	Very low (1.0)	Very low (1.0)	Very low (1.0)	Low (0.75)	Very low (1.0)	High (0.25)	Low (0.75)	Low (0.75)
Environmental Risk		15.75	Medium (0.5)	High (0.25)	Low (0.75)	Low (0.75)	Medium (0.5)	Low (0.75)	Low (0.75)	Low (0.75)
	Score out of 35		**27.13**	**23.19**	**31.06**	**26.25**	**27.13**	**16.63**	**26.25**	**26.25**
Landscape and Visual	Max Score	**15**								
Landscape Resource		6.00	High (0.25)	Medium (0.5)	Low (0.75)	Low (0.75)	High (0.25)	Low (0.75)	Very low (1.0)	Low (0.75)
Visual Impacts		9.00	High (0.25)	Medium (0.5)	Low (0.75)	High (0.25)	High (0.25)	Low (0.75)	Low (0.75)	Low (0.75)
	Score out of 15		**3.75**	**7.50**	**11.25**	**6.75**	**3.75**	**11.25**	**12.75**	**11.25**
Maximum Score		**100**								
Score(out of 100)			**70.13**	**76.94**	**81.56**	**70.75**	**59.38**	**77.88**	**89.00**	**78.75**
RANKING			**7**	**5**	**2**	**6**	**8**	**4**	**1**	**3**